Cashew gum and maltodextrin particles for green tea (Camellia sinensis var. Assamica) extract encapsulation

Francisca Silva, Lucilcélia Torres, Larissa Silva, Raimundo Figueiredo, Deborah Garruti, Tamara Araújo, Antoniella Duarte, Débora Brito, Nágila Ricardo

ABSTRACT

Cashew gum and maltodextrin microcapsules containing green tea leaf extracts were made using a spray-dryer. Green tea extracts were subjected to cytotoxicity analysis and characterization of bioactive compounds. Three formulations of microcapsules were performed, which were then submitted to characterization through morphological study, particle diameter and distribution, zeta potential, and differential Calorimetry, entrapment efficiency, dissolution test and X-ray diffraction. The extract had a high bioactive compound content and no cytotoxicity was observed. The amorphous microcapsules presented irregular shapes with a circular predominance and dentate surface, mean diameters varying from 2.50 to 3.64 μm, solubility ranging from 63% to 72.66%. Low values of microencapsulation efficiency, zeta potential and dissolution profile were observed. The microparticles based on the dry extract of green tea present potential as a food ingredient and as a promoter of health benefits.

1. Introduction

Green tea originates from China and is cultivated and consumed in China and is cultivated and consumed in 160 countries due to its aroma, flavor characteristics and medicinal properties (Kumudavally, Phanindrakumar, Tabassum, Rakhadhrakrishna, & Bawa, 2008). It is obtained from the leaves of the Camellia sinensis herb, and has been extensively studied for its antioxidant activity, as well as anticancer, immunostimulatory, thermogenic and assistance in reducing cholesterol levels (Luo et al., 2014), as well antiviral properties (Falcó et al., 2018), antibacterial activity (Gupta & Kumar, 2017) and as neuroprotective, prevents memory deficits (Martins et al., 2017).

The cultivation of this plant in Brazil occurs especially in the Ribeira Valley in the State of São Paulo, with the C. sinensis cultivar Assamica IAC 259 mainly being used (De Moura et al., 2015). The favorable properties related to tea consumption are due to its composition being rich in polyphenols, flavonoids and catechins. Catechins and other derivatives are able to act directly as radical scavengers and exert indirect antioxidant properties through the activation of transcription factors and antioxidant enzymes. Epigallocatechin gallate (EGCG) has been identified as the main catechin responsible for the beneficial effects of green tea, as well as increased thermogenesis (Khan; Mukhtar, 2007; Wiseman and Balentine, 1997).

Microencapsulation is defined as a technology of packaging solids, liquids, or gaseous materials in miniature, sealed capsules that can release their contents at controlled rates under specific conditions (Tylkowski et al. (2017)). In the food area has been widely used to protect compounds such as antioxidants, vitamins, flavorings, dyestuffs, antimicrobials and preservatives against unfavorable environmental conditions (Fathi, Mozafari, & Mohebbi, 2012; Drosou, Krokida, & Biladeris, 2017). Thus, since bioactive compounds present rapid degradation under different conditions (light, air and heat), losing their nutritional value, biological and even technological properties, it is necessary to study microencapsulation techniques aimed at their commercial use.

The properties of encapsulated products depend largely on capsule size, wall materials, active ingredients and production techniques (Wani, Masoodi, & Wani, 2017). The wall material may consist of compounds such as polymers, starches, gelatins and gums (cashew gum, for example), and generally has hydrophilic and/or hydrophobic groups.
(Turchiuli et al., 2005). Cashew gum and maltodextrin are polysaccharides which have been widely used for different purposes in the food industry.

Cashew gum is considered as a native raw material in the Brazilian Northeast, it has been highly researched, presenting an increasing possibility of commercial production (Cunha, Feitosa, & Paula, 2009).

Motivated by the lack of time of the population, it is increasingly common to study and elaborate new products that bring the consumer the possibility of acquiring a product that combines practicality with a healthier life expectancy. The development of green tea extract microcapsules and its characterization aims to provide industries with a new way of incorporating bioactive compounds into foods that will benefit their health.

2. Materials and methods

2.1. Materials

Green tea was obtained in the local market of Fortaleza-CE. Cashew nuts were obtained of native cashew trees of the state of Ceará. Maltodextrin (Maltogill® 20) was purchased from Cargill with dextrose equivalent lower than 20%. Non-ionic surfactant Tween 40 (Polyoxyethylene sorbitan monooleate) was provided by Vetec. The standards of caffeine (CF) and (+)-catechin (C) were purchased from Sigma-Aldrich and (−)-epicatechin (EC), (−)-epicatechingallate (EGC) and (−)-epigallocatechingallate (EGCG) were purchased from Extrasynthesis. The solvents were either of analytical or technical standards of ca.

2.2. Preparation of cashew gum

The cashew gum was obtained following the methodology adapted of Torquato et al. (2004), from the purification of cashew exudate (Anacardium occidentale L.). 50 g of cashew exudate was solubilized in distilled water (150 mL), filtered and a precipitated was formed using a ethanol in the proportion 1:5 v/v (filtered:alcohol). After 20 h under refrigeration, the precipitate (cashew gum) was separated by vacuum filtration, washed with 100 mL of acetone and dried. The cashew gum was purified by dialysis for one week and dried using Mini Spray Dryer B-290 (Büchi, Switzerland). The operational yield for sample was 75%.

2.3. Preparation of green tea dry extract

The green tea dry extract was obtained following the methodology of Jacques et al. (2010) with adaptations, where green tea leaves (5 g) were added in 50 mL of EtOH/H2O (75/25) and homogenized for 20 min in an ultrasonic bath (Quimis, Brazil). The ethanol was removed under reduced pressure at 50 °C and the green tea extract was dried by freeze-drying (13.40%).

2.4. Preparation of microcapsules

For microcapsules preparation, the samples were performed following the method suggested by Paula et al. (2012). 2.1 L wall material solutions (cashew gum/maltodextrin) were prepared in different proportions (Table 1), homogenized for 20 min using an ultrasonic bath.

The green tea dry extract was added into each formulation in a ratio 1:4 w/w (extract: wall material) and submitted to the ultrasonic bath for a further 30 min. To stabilize the mixtures, it was added 3 drops of Tween40 in each 10 mL of sample. The mixtures were homogenized in a Turratec ultra homogenizer TE-102 (Tecnal, Brazil) for 5 min at 14,000 rpm. 30% solids were used in the emulsion formulations for the walls of the microcapsules, as suggested by Heinzlmann and Franke (1999).

The resulting solutions were filtered and processed in a Mini Spray Dryer B-290 (Büchi, Switzerland), operating with the inlet temperature at 170 °C, outlet temperature at 95 °C, pump feed flow 3 mL/min⁻¹, air flow of 37 M³·h⁻¹ and air pressure of 600 mBar (≈0.6 atm). The operational yield for all samples (white powders) was 35%.

2.5. Characterization of green tea dry extract

The green tea dry extract was submitted to analysis of cytotoxicity, antioxidant activity and quantification of phenolic compounds, flavonoids, catechins and caffeine.

For cytotoxicity analysis, the extract was evaluated by assays based on MTT [3-(4,5-dimethylthiazol,2-yl)-2,5-diphenyl-2-] in Krebs’s medium, at 37 °C for 20 min (protected from light). After the incubation time, the form azan crystals, resulting from MTT reduction, were dissolved in a solution of 0.04 N HCl in isopropanol. The absorbance value was measured at a wavelength of 570 nm and fractions were compared with the positive (Clostridium difficile cytotoxin A) and negative (cell culture only in culture medium) control, the latter being considered as 100% cell viability.

The free radical quenching capacity of the extract and antioxidant activity by iron reduction test (FRAP) and by abscission capacity of the radical cation (ABTS⁺) were determined by the methods described by Benzie and Strain (1999) adapted by Rufino et al. (2010).

Total extractable polyphenol content of the extracts was determined according to the Folin-Ciocalteu method (Larrauri, Rupérez, & Saura-Calixto, 1997). Determination of yellow flavonoids followed the methodology of Francis (1982). All analyses were done in triplicate.

The catechins and caffeine of the green tea dry extract quantification was performed using a Acquity Ultra Performed Liquid Chromatography (UPLC) System® (Waters, Brazil) coupled to a Waters Micromass LCT (Waters Micromass LCT) mass spectrometer Electro spray (ESI). Separations were performed on Acquity UPLC BEH C18 (Waters, Brazil).

The green tea dry extract was subjected to a clean-up process to obtain an extract without interference of low or high polarity, in order to meet the analysis requirements in liquid chromatography systems. Approximately 10 mg of the extract was dissolved in 1 mL of MeOH/H2O (80:20) and further chromatographed on a solid phase extraction (SPE, 500 mg, Sigma-Aldrich) cartridge. The cartridge was preconditioned with 6 mL of methanol and equilibrated with 6 mL of distilled water, followed by application of the sample. The cartridge was then washed with 6 mL of MeOH/H2O (5:95) and then eluted with 6 mL of 100% methanol, with each resulting fraction being collected in test tubes. The eluate was evaporated in a rotary evaporator, redissolved in 1 mL of MeOH/H2O (80:20) and filtered through a 0.22 μm PTFE filter for UPLC-QToF-MS analysis.

The elution in gradient had, as the mobile phase, the solvents A (water with 0.1% formic acid) and B (acetonitrile with 0.1% formic acid). The exploratory gradient followed the conditions of (0-15) min (2-95%) of B; (15.1-17) min (100%) of B; (17.1-19.1) min (2%) of B.
flow of 0.4 mL·min⁻¹ and sample injection volume of 5 μL. The ESI source was used in negative ionization mode with the mass range being in the range of 5–1180 Da, fixed source temperature of 120 °C, desolvation gas temperature of 350 °C, desolvation gas flow of 500 L·h⁻¹, extraction cone of 0.5 V, and capillary voltage of 2.6 kV. The ESI⁻ mode was purchased in the range of 110–1180 Da, fixed source temperature of 120 °C, desolvation temperature of 350 °C, desulphation gas flow of 500 L·h⁻¹, and the capillary voltage was 3.2 kV. Leucine enkephalin was used as the internal calibration standard. At low scan, the cone voltage was 35 V for ESI⁻, collision energy of 5 eV (trap). The acquisition mode was MS⁶. The instrument was controlled by Masslynx 4.1 software (Waters Corporation). All analyses were done in triplicate.

2.6. Microcapsule characterization

2.6.1. Morphological study

A morphological study of the microspheres was performed using Scanning Electron Microscopy FEI Inspect S50 (CAE, Texas). The samples were mounted with carbon tape on steel support and covered with gold.

2.6.2. Particle size

Determination of particle diameter and polydispersity index (PDI) were performed using Zeta Plus Analyzer (Brookhaven Instruments Corporation, USA) by photon correlation spectroscopy (Gomes, 2011). The particles diameters were calculated from statistical means and expressed as D [4,3] (mean diameter of De Brouckere), which indicates the center point around which the volume frequency of the distribution rotates.

2.6.3. Zeta potential and water solubility

The Zeta potential of the samples was obtained by measurements of electrophoretic mobility at 25 °C. The solubility in water was calculated by the difference of mass and the results were expressed as percentage of solubility, based on the methodology described by Cano-Chauca, Stringheta, Ramos, and Cal-Vidal (2005).

2.6.4. Entrapment efficiency (EE)

Entrapment efficiency (EE) was performed from the total encapsulated caffeine concentration, in view of its high content present, following the Santos (2014) methodology with adaptations. First, 0.2 g of each formulation (A, B and C) of microcapsules was weighed and added to a Disintegrator (SP Labor 301) and 250 mL of distilled water was added. The total disintegration time was 10 min. After this time, an aliquot of 2 mL was filtered in 0.45 μm filters and quantified by UV–VIS spectroscopy through Genesys 10S (Thermo Scientific™, USA), and the EE% was determined using Eq. (1):

\[
\text{%EE} = \frac{\text{CT} - \text{CM}}{\text{CT}} \times 100
\]  

where CT represents the total caffeine concentration and CM, the concentration of encapsulated caffeine.

2.6.5. Dissolution profile

The dissolution test of the microcapsules was carried out in distilled water at 37 ± 0.5 °C under sink conditions for 30 min using dissolver (Erweka, model DT 800), a stirring speed of 50 rpm and 250 mL of the dissolution medium. The microcapsule dissolution test was carried out following the methodology adapted from Azvedo, Ribeiro, and Araújo (2008). Aliquots of 10 mL dissolution medium were drawn at the time of 3, 5, 10 and 30 min. Each capsule formulation (200 mg) was diluted in distilled water, and the spectrophotometer readings (Genesys, model 10 UV) were made at 272 nm. The microcapsule dissolution profiles were determined based on caffeine, as this compound was distinguished from the others regarding its concentration in the dry extract of green tea quantified by UPLC.

2.6.6. X-ray diffractometry (XRD)

X-ray diffraction was performed using a D2 Phaser (Bruker, Germany) with an electrical potential of 30 kV, electric current of 20 mA and CuKα radiation with a wavelength of 0.154 nm. The analysis was based on the methodology of Wu, Chen, Li, and Wang (2010), with scanning range of the diffraction angle between 3° and 40°, step of 0.02 and rate of 1°/min.

2.6.7. Thermal analyses

The DSC curves were obtained through DSC Q20 (TA Instruments, USA) under dynamic nitrogen atmosphere with a flow rate of 50 mL·min⁻¹; a heating rate of 10 °C/min, from room temperature to 250 °C; hermetically sealed aluminum capsule and 1.5–2 mg sample mass. The DSC cell was calibrated prior to the tests on the temperature axis using standards of indium (melting point = 156.6 °C) and zinc (melting point = 419.5 °C) metals with a purity of 99.99%. The ΔH fusion of metallic indium (28.7 J·g⁻¹) was used for the amount of heat (Bazzo and Segatto Silva, 2005).

Thermogravimetric data (TG/DTG) were obtained by simultaneous analysis in equipment TGA Q50, V20.13 model, using 10 mg of sample in synthetic air atmosphere, and temperature range of 0–300 °C.

2.7. Statistical analysis

The cytotoxicity analysis results were submitted to the Bonferroni’s multiple comparison test and the results expressed in mean and standard deviation. The microparticle characterization data were submitted to analysis of variance (ANOVA) and F test with a level of 5% of significance for comparison of means, using Statistical Analytical Systems.

3. Results and discussion

3.1. Extract characterization

3.1.1. Cytotoxicity analysis

A direct relationship between the physical and functional integrity of the plasma membrane and the mitochondrial metabolism of the cells exposed to different concentrations (100 and 50%) of the green tea extract studied was observed through the MTT test. No cytotoxic action was found for the studied samples comparing the negative and positive control absorbances with those obtained for the culture exposed to the dry green tea extract (Fig. 1). The absorbance determined for the Bonferroni’s positive control (Clostridium difficile toxin A) was on average 0.024 ± 0.001, which was almost 98% lower than that observed for the negative control of 1.058 ± 0.124. The extracts at concentrations of 100% and 50% showed similar values of 0.750 ± 0.038 and 0.725 ± 0.024, respectively.

Fig. 1. Cytotoxicity assay of the dry green tea extract against epithelial cell cultures. Epithelial cells (IEC 6 culture) exposed to solutions containing 100% concentration and 50% of the dry green tea extract.
0.621 ± 0.010, respectively. All the concentrations showed higher absorbances than the negative control, indicating that the extract did not present an inhibition percentage, meaning the samples are not cytotoxic.

3.1.2. Quantification of bioactive compounds present in green tea extract

The green tea extract presented high bioactive compound content (Table 2). It is possible to determine the potential to be exploited in the dry green tea extract as a source of compounds of interest (Silberberg et al., 2006). No studies were found in the literature that determine yellow flavonoids in green tea extracts, characterizing the importance of this analysis in the present study, since catechins belong to this class of flavonoids. The value found for yellow flavonoids was 191.40 mg/100 g, a value considered relevant based on fruits rich in yellow flavonoids such as cashews and myrtle.

For the antioxidant activity determined by the ABTS+ method, the value found was 8816.43 μM of Trolox·g⁻¹ of dry green tea extract. Similar results were found by Manian, Anusuya, Sidduraju, and Manian (2008), who evaluated the antioxidant activity of green tea extracts obtained from two different solvents, and obtained 8076.9 μM of Trolox·g⁻¹ for the extract obtained with 100% methanol, and 13499.9 MM of Trolox·g⁻¹ for the extract obtained with 70% acetone.

In another study, Cai, Luo, Sun, and Corke (2004) found values of 5268.6 μM of Trolox·g⁻¹ in Camellia sinensis extracts obtained from extraction using 80% methanol, which is lower than the one found in the study in question that used 75% ethanol. The antioxidant activity result by iron reduction for the dry green tea extract was 9484.28 μM Fe²⁺/g extract. In studying the antioxidant activity of green tea infusions obtained from leaves harvested at different seasons of the year, Ku et al. (2009) found values of 784 μM Fe²⁺/g for samples collected in April and 1006 μM Fe²⁺/g for samples harvested in July of the same year. The lower results found by these authors demonstrate the efficacy and importance of optimizing the extraction method of antioxidant compounds. Catechins with the highest levels were ECG and EGCG with 31.16 and 17.95 mg·g⁻¹, respectively. Pelillo et al. (2002) found higher levels for ECG and EGCG, although the latter had a higher content than ECG. Like the present study, Shao, Powell, and Clifford (1995) also found ECG as the main catechin followed by EGCG; however, these authors obtained higher values than the present study. Caffeine (CAF) was the compound with the highest concentration with 56.03 mg·g⁻¹, being very close to the value of 60.04 mg·g⁻¹ found by Pelillo et al. (2002). Because it is in greater quantity, the caffeine could probably present greater impact under the thermogenic capacity of the studied extract.

Table 2

<table>
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<tr>
<th>Analysis</th>
<th>Results</th>
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<tr>
<td>Total extractable polyphenols (mg GAE/100 g)</td>
<td>84233.85 ± 1060.01</td>
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<tr>
<td>Yellow flavonoids (mg/100 g)</td>
<td>191.40 ± 5.72</td>
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<tr>
<td>Antioxidant activity/ ABTS+ (μM of Trolox·g⁻¹)</td>
<td>8816.43 ± 121.82</td>
</tr>
<tr>
<td>Antioxidant activity/ FRAP (μM of Iron Sulfate·g⁻¹)</td>
<td>9484.28 ± 109.06</td>
</tr>
<tr>
<td>C (mg·g⁻¹ of dry leaves)</td>
<td>2.63 ± 0.10</td>
</tr>
<tr>
<td>EGCG (mg·g⁻¹ of dry leaves)</td>
<td>17.95 ± 0.19</td>
</tr>
<tr>
<td>EGC (mg·g⁻¹ of dry leaves)</td>
<td>31.16 ± 0.43</td>
</tr>
<tr>
<td>EC (mg·g⁻¹ of dry leaves)</td>
<td>13.74 ± 0.73</td>
</tr>
<tr>
<td>CAF (mg·g⁻¹ of dry leaves)</td>
<td>56.03 ± 2.73</td>
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Fig. 2. Micrographs obtained by SEM of microcapsules A (10% cashew gum + 20% maltodextrin + 7.5% dry green tea extract); B (15% cashew gum + 15% maltodextrin + 7.5% dry green tea extract) and C (20% cashew gum + 10% maltodextrin + 7.5% dry green tea extract).
3.2. Microcapsule characterization

3.2.1. Morphological study

Micrographs of the obtained green tea extract microcapsules are shown in Fig. 2. All images are displayed with 5000× magnification for better visualization of the microcapsules.

The microcapsules showed similarity to the morphology presenting spherical shape, irregular depressions, concavities, a dentate surface, and mainly did not present cracks, cracks or ruptures. These are fundamental characteristics to guarantee greater protection and retention of the encapsulated green tea extract.

No uniformity in size was observed, ranging from 0.95 to 10 μm. Liang et al. (2017) prepared chitosan nanoparticles (CS NPs) coated with zein for epigallocatechin gallate (EGCG) encapsulation and found spherical nature with smooth surface.

3.2.2. Diameter

The particles produced in the three formulations of microcapsules A, B and C had average diameters of 2.50, 2.55 and 3.64 μm, respectively. The size distribution of microcapsules A and B presented monomodal distribution, showing only a predominant peak suggesting uniform distribution of the particles and better stability of the microcapsules. Microcapsule C presented bimodal behavior with two peaks, and with one of the peaks being more predominant in relation to the other. The mean particle diameters were calculated from statistical means and expressed as D [4,3] (mean diameter of De Brouckere), which indicates the center point around which the volume distribution frequency rotates. The particles synthesized showed PDI values close to 0.36 ± 0.03, 0.28 ± 0.03 and 0.36 ± 0.02, for formulations A, B and C, respectively. The formulation B contained the same proportion of maltodextrin and cashew gum, presenting lower PDI. PDI is a dimensionless measure of the broadness of particles size, where values lower than 0.1 indicate a monodisperse, homogeneous system and higher values (> 0.1) indicate an increasingly heterogeneous, polydisperse system (Zigoneanu, Astete, & Sabliov, 2008). Polydisperse have greater tendency to aggregation than monodisperse system.

3.2.3. Zeta potential

The particles presented negative Zeta potential, presenting values of −0.71, −0.29 and −1.12 mV for the particles A, B and C, respectively. Negative values indicate that the residual charge of the chains present on the wall material is negative, regardless of the proportions used for GC and maltodextrin. It is also observed that the increase in GC concentration leads to an increase in the Zeta potential, indicating the formation of particles with higher surface charge density. The microcapsule samples had significant differences in Zeta potential at 1 and 5% significance for analysis of variance and by the Tukey test. According to Mishra, Al Shaal, Müller, and Keck (2009), in order to obtain a physically stable Zeta potential, the zeta potential should be higher than 30 mV (absolute value), and rapid aggregation of particles at Zeta potential values of −5 mV to +5 mV can be verified.

3.2.4. Solubility

The solubility values of the particles A, B and C were 72.66, 72 and 63%, respectively. An interaction analysis did not detect significant differences (p > 0.05) between the microcapsules. By applying the Tukey test at the 5% probability level, it was verified that the microcapsule C presented a significantly lower value (p > 0.05) when compared to the others. It is known that cashew gum and maltodextrin are water soluble, so the lower solubility found in the present study may be associated in large part with a possible hydrophobicity of the dry green tea extract.

3.2.5. Entrapment efficiency (EE)

The microcapsules presented significant differences (p > 0.05), presenting means referring to 33, 30.5 and 28.25% for the A, B and C particles, respectively. It was found that higher maltodextrin content in the formulations is related to greater EE. According to Jafari, Assadpoor, and Bhandari (2008), for a microencapsulation process to be said to be efficient, the material should result in an encapsulated powder exhibiting maximum retention within the core, as well as minimum surface values in the microcapsules. Polysaccharides are readily hydrolyzed in water, and the low molecular weight encapsulated drugs/actives such as green tea extract can be rapidly diffused, and may thus have led to low microencapsulation efficiency. Ballesteros, Ramirez, Orrego, Teixeira, and Mussatto (2017) encapsulated antioxidant phenolic compounds extracted from spent coffee using different coating materials and found that 62% of phenolic compounds present in the original extract were retained in the encapsulated sample. Farias et al. (2018) performed the micro-encapsulation of riboflavin by spray drying with the galactomannan biopolymer and found that the efficiency of encapsulation in micro-particles ranged from 87.14 to 88.53%.

3.2.6. Dissolution profile

Based on the obtained results, the optimized conditions of the caffeine dissolution test contained in the microencapsulated green tea extract are represented in Fig. 3.

The formulations presented basically the same dissolution profile, with stabilization after 5 min.

Sample B showed the highest percentage of dissolution, followed by samples C and A releasing 103.81%, 92.09% and 81.44%, respectively. These high dissolution percentages may be related to the wall thickness, used in the ratio of 4: 1 (wall/core), but also bound to the low molecular weight of caffeine, which is a hydrophilic polymer, thus with rapid dissolution occurring in the Medium. This rapid release can be explained by the hydrophilicity of the polymer network as well as of the active analyzed, in this case, caffeine. The water readily penetrates the microspheres and dissolves all material in the aqueous medium.

Therefore, the results suggest that microencapsulation meets the proposal to increase the stability of the free green tea during storage in the dry state and to promote, during its reconstitution in water, its easy wettability and solubility (Nunes & Ragagnin, 2015).

3.2.7. X-ray diffraction

From the X-ray diffraction analyses, it was observed that all samples analyzed were amorphous, meaning no crystalline region was defined. The microencapsulation process caused a slight shift of the peak in samples A, B and C to smaller values in 2θ, since the main peak in EXT appears around 25.9°, and in the microcapsules A, B and C the main peak appears around 19°.

Fig. 3. Dissolution profiles of A, B and C formulations using distilled water as dissolution medium (37 ± 0.5 °C), dissolver with apparatus II, agitation speed of 50 rpm and spectrophotometric quantification at 272 nm.
3.2.8. Thermal analyses

The green tea dry extract presented two significant endothermic events at 109 and 121 °C, related to the high concentrations of catechin and caffeine present in the extract and an exothermic event at 307 °C (Fig. 4). Microcapsules showed similar thermal behavior for the differential scanning calorimetry (DSC) analysis, presenting a significant endothermic event at 178, 157 and 171 °C, respectively for A, B and C. Thermogravimetric analysis (TGA) (Fig. 4) and thermogravimetric derivative (DTG) showed three stages of decomposition for all analyzed samples (Fig. 4). The microcapsule had the same mass loss behavior (the first stage being around 68 °C), representing the evaporation of water. For all samples we also observed stages two and three occur around 249 and 300 °C, respectively, and a residual percentage between 17.5 and 19.2%. In general, the decomposition of polysaccharides starts at temperatures above 200 °C.

4. Conclusion

Green tea dry extract has cell viability, and did not present cytotoxicity for the studied cells, making its use in the elaboration of new food products feasible. Green tea extract is rich in bioactive and thermogenic compounds, with caffeine being identified in a higher concentration, followed by epicatechingallate, epigallocatechin gallate, epicatechin and catechin. The three formulations of tested microcapsules were able to encapsulate the dried green tea extract, making the substitution of part of maltodextrin for cashew gum viable. The potential for cashew gum/maltodextrin microparticles based on dry green tea extract as a food ingredient presents relevance for food application, aiming to increase the content of bioactive compounds. Further studies should be carried out aiming the application of the particles in vivo and food matrix.

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