Disciplinarum Scientia. Série: Naturais e Tecnológicas, Santa Maria, v. 18, n. 3, p. 515-529, 2017.
Recebido em: 21.08.2017. Aprovado em: 04.10.2017.

ISSN 2176-462X

DEVELOPMENT AND STUDY OF THE STABILITY OF NANOSTRUCTURED SYSTEMS CONTAINING GINGER OIL[1]

DESENVOLVIMENTO E ESTUDO DA ESTABILIDADE DE SISTEMAS NANOESTRUTURADOS CONTENDO ÓLEO DE GENGIBRE

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ABSTRACT

In this study, the compatibility tests between poly-ε-caprolactone (PCL) polymer and ginger essential oil, the studies on development, characterization and stability of nanostructured nanocapsule and nanoemulsion systems were performed. The importance of the choice of the polymer is essential as it plays a crucial role in the preparation of nanocapsules, protecting the active, improving the bioavailability and often reducing its toxicity. Providing safety in the pharmaceutical production. Poly-ε-caprolactone (PCL) is a biodegradable polymer widely used in nanotechnology. Ginger oil have medicinal properties that can be optimized through nanostructured systems, and can be applied as lipid nanocarrier or associated with several systems for biomedical use as antioxidant, anti-inflammatory, among others. The results indicate that PCL is compatible with the essential ginger oil, considering that no loss of mass or degradation of the polymer was observed. Therefore, nanocapsules and nanoemulsions were produced, characterized and analyzed through the stability parameters: pH, average diameter, zeta potential and polydispersion index for 60 days, stored at 2-8 °C. The average size of the systems produced was between 199 to 237nm, the average zeta potential found was between -13 and -21mV and the polydispersity index found in the range of 0.13 to 0.34. These results are in agreement with the literature for biomedical application. The nanostructured systems remained stable in the refrigerator during the period evaluated. The results obtained contribute to increase the studies of plant products in nanotechnology applied to health.

Keywords: nanocapsules, nanoemulsions, nanosciences.

RESUMO

Neste estudo foram realizados testes de compatibilidade entre o polímero poli-ε-caprolactona (PCL) e o óleo essencial de gengibre, e o desenvolvimento, caracterização e estudos de estabilidade de sistemas nanoestruturados do tipo nanocápsula e nanoemulsão. A importância da escolha do polímero é essencial pois este desempenha um papel crucial no preparo de nanocápsulas, protegendo o ativo, melhorando a biodisponibilidade e muitas vezes reduzindo sua toxicidade, proporcionando segurança na produção farmacêutica. A poli-ε-caprolactona (PCL) é um polímero biodegradável muito usado em nanotecnologia.

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O óleo de gengibre por sua vez, têm propriedades medicinais que podem ser otimizadas por meio de sistemas nanoestruturados, podendo ser usado como nanocarreador lipídico ou associado a diversos sistemas para utilização biomédica como antioxidante, anti-inflamatório entre outros. Os resultados obtidos indicam que o PCL é compatível com o óleo essencial de gengibre, pois não foi observada perda de massa ou degradação do polímero. A partir dessa constatação, nanocápsulas e nanoemulsões foram produzidas, caracterizadas e analisadas através dos parâmetros de estabilidade: pH, diâmetro médio, potencial zeta e índice de polidispersão durante 60 dias, conservados entre 2-8 °C. O tamanho médio dos sistemas produzidos foi entre 199 a 237nm, o potencial zeta médio encontrado ficou entre -13 e -21mV e o índice de polidispersão encontrado na faixa de 0.13 a 0.34. Estes resultados estão de acordo com a literatura para aplicação biomédica. Os sistemas nanoestruturados permaneceram estáveis, em geladeira, durante o período avaliado. Os resultados obtidos contribuem com o ascendente estudo de produtos de origem vegetal na nanotecnologia aplicada a saúde.

Palavras-chave: *nanocápsulas, nanoemulsões, nanociências.*

INTRODUCTION

Nowadays, essential Ginger oil has been highlighted considering its range of pharmacological properties, among them the protective effect against non-alcoholic fatty liver disease in mice induced to obesity by high fat diet (LAI et al., 2016). It was observed the growing number of researches in Biotechnology searching of materials with therapeutic potential to overcome the limitations regarding pharmacokinetics (FERNANDES, 2006; GEIGER, 2005; SACCHETTI, 2004; ZHOU et al., 2011). In addition, *Zingiber officinale* has benefits in the treatment of musculoskeletal disorders, nausea, vomiting, inflammation, osteoarthritis, migraine, cancer, hyperlipidemia and hyperglycemia (MORAKINYO; AKINDELE; AHMNED, 2011). The essential oil of ginger furnishes a great variety of substances, having alpha-zingiberene, in the higher concentration, with around 50 volatile compounds in its composition (LAI et al., 2012). The use of essential oils, extracts and concentrates of *Zingiber officinale* is described in the pharmacopoeia and traditional medicine and increase the interest of the pharmaceutical industry in developing laboratory tests to identify and prove the active principles and their functions in the human body (MORAKINYO; AKINDELE; AHMNED, 2011).

The main limitation for application in biological environment, for therapeutic purposes, is the fact that the compounds present in the essential oil demonstrate high toxicity in previous experiments (SIMPSON; OGORZALY, 1995).

Nanotechnology has emerged as a scientific-technological advance, opening up numerous possibilities affecting the biotechnological scenario with prospects of unlimited advances for the whole society. Nanostructured systems are a promising alternative for medical applications. Some of the main reasons for the use of drug delivery systems are the improvements in the concentration of the active in the action site due to its longer location time (TORCHILIN, 2007).

The nanocapsules are vesicular systems in which the drug is confined in an oily core and/or adsorbed to the polymer wall (COUVREUR et al., 2002). One of its most significant advantages is

that in contact with biological fluids, they are more stable than other systems (RONEY et al., 2005). In addition to presenting these qualities, nanocapsules can be produced by simple, fast, efficient and low-cost method (TORCHILIN, 2000). The efficiency of these systems is directly related to their ability to protect the drug from degradation during the drug transport to the organ target, reducing side effects. The ability to cell penetration, and release in a controlled manner, optimizing its action (SOPPIMATH et al., 2001).

Nanoemulsions may be defined as a nanometric dispersion of oily droplets in an external aqueous phase, stabilized by a suitable surfactant system. The particle size ranges mainly from 100 to 500 nm. They are presented like white milky liquids, reduced droplet diameter, and low viscosity. The delivered drug is preferably dispersed and/or adsorbed on the oily nucleus of the nanostructure. These particles can also exist in the form of water-oil emulsion when the dispersing phase is oil (FRONZA; CAMPOS; TEIXEIRA, 2004).

In nanoparticle formulations, a single polymer may be used or combined with other polymers. Poly-ε-caprolactone (PCL) is among the most widely used in drug encapsulation (WANG et al., 2011) considering its biodegradability. Due to its hydrophobicity and its crystallinity, the *in vitro* degradation of PCL is slower, turning this polymer suitable for devices that require long periods of drug release or which modulates the release, as compatible polymer (SINHA et al., 2004). According to Reis et al., (2006), the choice of the methodology for the production of polymer nanoparticles depends on the polymer to be applied, the solubility of the drug to be encapsulated and the interaction of the polymer with other products employed in the formulation, especially with the Aqueous or organic oil core. The association of natural products such as ginger oil is sometimes limited by poor solubility and low bioavailability. To overcome such limitations, the development of nanostructured systems becomes a valuable strategy on this field of research. Otunola et al. (2017) developed silver nanoparticles containing Ginger for use as an antioxidant. Copper nanoparticles (CuNPs) using *Zingiber officinale* for antimicrobial action in food were synthesized associated with nisin forming stable systems and showed efficacy against microorganisms associated with food deodorization (PANDIT et al., 2017), and lipid nanocarriers where the active of interest is associated with ginger oil, reducing side effects in the treatment of inflammatory bowel processes. (ZHANG et al., 2017). Thus, the objectives of this study were to produce and characterize nanostructured systems containing ginger essential oil, using the principles of nanotechnology to optimize biological activities, reduce toxicity. As well as to determine the stability of the systems through parameters like pH, zeta potential, polydispersity index and average diameter of the particles during the period of 60 days, under refrigeration at 2 -8° C.

MATERIAL AND METHODS

MATERIAL

Essential Ginger oil was purchased from Sigma-Aldrich Co (São Paulo, BRAZIL), crodamol, sorbitan monostearate (Span 60), PCL polymer, acetone, ultrapure water, polysorbate (Tween 80), reagents were purchased from Sigma Brazil, all in analytical grade and the solvent purchased from Synth (lot 195898). The quantities used are listed in table 1.

METHODOLOGY

Characterization of ginger essential oil

The samples were injected in two replicates, by gas chromatography (GC) using a GC/MSD system **(**Agilent 6890N**)** equipped with DB-5 MS capillary column (30 m x 0.25 mm x 0.25 μm film thickness) connected to a mass spectrometer detector. The injector and detector temperatures were set at 250 °C. Helium was used as the carrier gas, at a flow rate of 1.3 mL/min. The thermal programmer was 100-280 °C at a rate of 10 °C/min. Main components (*Zingiber officinale*) were identified on the basis of retention times of the peaks. The analysis of the substances was performed by the multidimensional statistical method (GIONGO et al., 2016).

Polymer swelling test

PCL films were obtained by complete dissolution of 125 mg of the polymer in 10 mL of chloroform and subsequent total evaporation of the organic solvents. The films were immersed in ginger oil at 0, 2, 3, 6, 9, 12, 16, 19, 22, 26 and 30 days. Afterwards, they were removed from the contact with the oil, dried gently on absorbent paper and weighted on analytical balance. The procedure was performed in triplicate (RIGO et al., 2014).

Production of nanocapsules and nanoemulsions

The method used to obtain suspensions of ginger polymer nanocapsules (NPG) was the interfacial deposition of the preformed polymer described by Fessi, Puisieux and Devissaguet (1988). To obtain nanoemulsions containing ginger oil (NEG), the polymer was excluded. The composition of the formulations is described in table 1.

The organic phase components were weighted, transferred to beaker and kept under magnetic stirring in a water bath at 35 °C for 60 minutes. The organic phase was poured onto the aqueous phase and kept under moderate mechanical stirring. The suspension was stirred for 1 hour and concentrated to a final volume of 100 mL on a Fisatom-Model 801 (Brazil) rotavapor, to remove the organic solvent and adjust the final concentration of ginger oil to 3%. Blank polymer nanocapsules (NPB) and blank nanoemulsions (NEB) were prepared in the same manner, exchanging the ginger oil with crodamol® without the addition of the polymer in the nanoemulsions.

Table 1 - Composition of the nanoparticle formulation of this study.

COMPONENTS	NPB	NPG	NEB	NEG
ORGANIC PHASE				
Ginger Essential Oil (g)	-	3	-	3
Crodamol (g)	3	-	3	-
Monoestiarato de sorbitano (Span 60) (g)	0,77	0,77	0,77	0,77
Polymer- PCL (g)	1	1	-	-
Acetone (mL)	276	276	276	276
AQUOSA PHASE				
Ultrapure water (mL)	533	533	533	533
Polissorbato (Tween 80) (g)	0,77	0,77	0,77	0,77

Source: author's construction.

NPB - blank polymer nanocapsules; NPG - ginger polymer nanocapsules;
NEB - blank nanoemulsions and NEG - nanoemulsions containing ginger oil.

Characterization of nanoparticles

Nanocapsules suspensions and nanoemulsions were characterized in terms of their physical appearance, pH, average particle size distribution, polydispersity index and zeta potential. The parameters of primary characterization of the suspensions are determinant to evaluate the shelf life of the formulations produced, making possible their safe storage.

Average particle diameter and polydispersity index

The measurements of the average particle size and polydispersity index were performed by dynamic light scattering method. The samples were diluted 500-fold in Milli-Q® water and analyzed on Zetasizer® equipment, Nano-ZS from Malvern instrument (United States of America). Each sample was measured 10 (ten) times, and the average and standard deviation were recorded for further statistical treatment (factorial design). The test conditions were as follows: scattering angle, 90 °; Temperature 25 °C; Laser wavelength, 660 nm. Additionally, based on the same sample, the polydispersity index was recorded, which was as average and standard deviation (n = 3).

Determination of pH

The determination of the hydrogen potential (pH) was performed directly on the suspensions, in a Digimed® potentiometer previously calibrated with pH 4.0 and 7.0 buffer solutions. The suspensions were conditioned in amber glass, stored at temperatures of 2-8° C and analyzed at times of 1, 3, 7, 20, 30 and 60 days stablishing the average of three determinations.

Determination of the zeta potential

Zeta potential was determined using the electrophoretic mobility technique in the Zetasizer® apparatus, Nano-ZS from Malvern instrument (United States of America). The samples were diluted 500 fold in 10mM sodium chloride and filtered through a 0.45 μm membrane. The results were expressed in millivolts (mV) from the average of three determinations.

Stability of suspensions

The suspensions were conditioned in amber glass, stored at temperatures of 2- 8 °C and analyzed at times of 1, 3, 7, 20, 30 and 60 days in relation to pH, PDI, potential Zeta and average diameter of the particles, stablishing the average of three determinations.

RESULTS AND DISCUSSION

CHARACTERIZATION OF ESSENTIAL GINGER OIL

Liju, Jeena and Kuttan (2015) reported that essential oil of ginger has a gastroprotective effect, which can reduce or eliminate gastric ulcers in rats, as well as oxidative stress induced by oral ethanol administration. Ginger is notable for its application in the industry as a natural conservative (BEAL, 2008). It is also used in the diet due to health-promoting properties such as anti-inflammatory, antiemetic, anti-nausea, antimutagenic, food detoxifying, antiulcer, hypoglycemic and bactericidal. (DABAGUE et al., 2013; POLASA, 2003; YOSHIKAWA; YAMAGUCHI; KUMINI, 1994).

Although they possess many medicinal properties, ginger essential oils are unstable, sensitive to light, heat, humidity, air, oxidizing, reducing agents and metals (BAKKALI et al., 2008). They are complex compositions synthesized by plants, usually as a defense activity. In general, in essential oils, their constituents may be present in expressive numbers, ranging from 20% to 60%. However, some constituents (between 20% and 70%) are determinant of their biological activities (SIMÕES et

al., 2007). The major constituents found in the essential oil sample, analyzed by gas chromatography, are listed in table 2 and their respective chromatogram presented in figure 1.

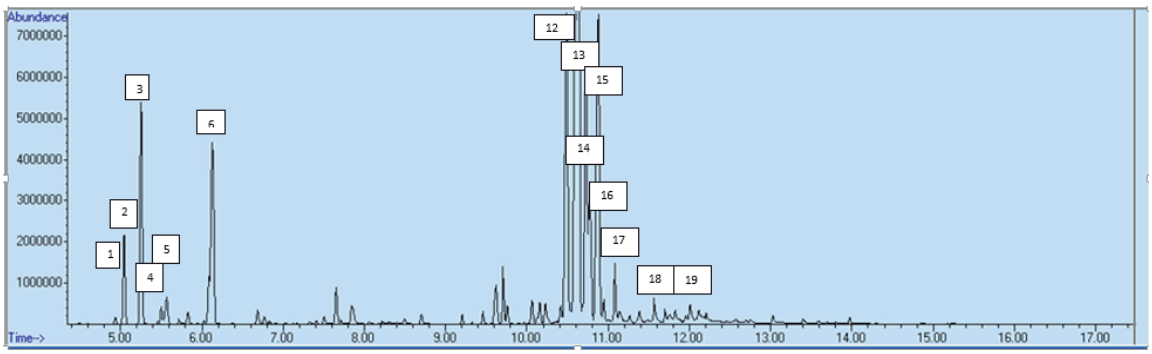
Table 2 - Major constituents of the ginger essential oil sample.

NUMBER	COMPONENT	% (RELATIV)	TR (RETENTION TIME)
1	Tricyclene	0.168	4.938
2	1R-α-Pinene	2.158	5.046
3	Camphene	6.002	5.257
4	α-Pinene	0.853	5.569
5	D-Limonene	1.024	6.09
6	α-Phellandrene	6.406	6.133
7	Borneol	0.904	7.656
8	α-Terpineol	0.848	7.849
9	α-Ylangene	1.333	9.624
10	α-Elemene	1.295	9.713
11	α-Curcumene	10.883	1.492
12	α-Zingiberene	24.119	10.636
13	α-Bisabolene	8.663	10.732
14	ς-Muurolene	4.177	10.775
15	α-Sesquiphellandrene	12.004	10.882
16	(-)-α-Panasinsen	0.719	10.949
17	Elemol	1.56	11.086
18	Cubenol	0.968	11.572
19	α-Eudesmol	0.71	12.012

Source: author's construction.

As shown in table 2, the sample of ginger essential oil used in this study had the following constituents: α-Zingiberene (24.1%), α-Sesquiphellandrene (12.0%), α-Curcumene (10.9%), and α-Bisabolene (8.7%). In the studies conducted by Machado et al. (2003), Sakamura (1987) and Wohlmuth (2006), α-Zingiberene was also the major component.

Figure 1 - Chromatogram of ginger essential oil obtained by gas chromatography.: Chromatogram of ginger essential oil obtained by gas chromatography: (1) Tricyclene, (2)1R-α-Pinene, (3) Camphene, (4) α-Pinene, (5) D-Limonene, (6) α-Phellandrene, (7) Borneol, (8) α-Terpineol, (9) α-Ylangene, (10) α-Elemene, (11) α-Curcumene, (12) α-Zingiberene, (13) α-Bisabolene, (14) ς-Muurolene, (15) α-Sesquiphellandrene, (16) α-Panasinsen, (17) Elemol, (18) Cubenol, (19) α-Eudesmol.



POLYMER SWELL TEST

The compatibility between ginger oil and polymeric material (PCL) was evaluated by the polymer-swelling test, which is part of the pre formulation studies. When the initial weight of the polymer film was compared with the final weight, there was no significant difference (ANOVA, $p > 0.05$) after 30 days in contact with the oil (Table 3). Thus, we assume that ginger oil did not solubilize the polymer during the analysis period, demonstrating its potential use as a new adjuvant in the preparation of nanocapsules for the development of products for both nanomedicine and nanocosmetics.

Table 3 - Results expressed in average and standard deviation, obtained in the study of polymer swelling (PCL) with ginger essential oil.

Time	0	3	6	9	12
Weight (g)	0,025± 0,1	0,025± 0,2	0,025± 0,2	0,025± 0,1	0,03± 0,0
Time	16	19	22	26	30
Weight (g)	0,031± 0,1	0,031± 0,1	0,032± 0,1	0,032± 0,1	0,032± 0,2

Source: author's construction.

CHARACTERIZATION AND STABILITY OF NANOPARTICLES

The analysis of the physical-chemical characteristics of the nanoparticles and their stability in the 60-day period was determined by the average and standard deviation of each of the following parameters: pH, average particle diameter, polydispersity index (PDI) and zeta potential. The samples analyzed at room temperature and in an oven at 40 ºC had their stability compromised in the four parameters analyzed on the third day after their production and were discarded. Thus, the following results refer to the nanoparticles stored in the refrigerator (Table 4, 5, 6 and 7).

Table 4 - Stability of white nanocapsules (NPB) on physical-chemical parameters.

	Days	**pH**	**Average diameter (nm)**	**PDI**	**Zeta potential (mV)**
NPB	0	5.9 ± 0.1	231 ± 1.57	0.21± 0.01	-21±0.5
	3	5.8± 0.05**	199 ± 1.52***	0.21± 0.01	-16 ±2.6
	7	5.33±0.05**	200 ± 1.0***	0.23 ± 0.04	-16 ± 2.6
	20	5.53 ± 0.05**	200 ± 1.0***	0.23 ± 0.04	-16 ± 2.6
	30	5.53 ± 0.05**	200 ± 1.0***	0.28 ±0.01*	-16 ± 2.6
	40	5.53 ± 0.05**	200 ± 1.0***	0.28 ± 0.01*	-16 ± 2.6
	60	5.33 ± 0.15***	202 ± 2.0***	0.28 ± 0.01*	-16 ±2.6

Data represent averege ± standard deviation (n = 3, for each day). They were analyzed by Anova of a pathway, followed by the *Tukey* test. *** p <0.001, ** p <0.01 and * p <0.05 when compared to day 0 (zero). PDI - polydispersity index

Source: author's construction.

Table 5 - Stability of ginger nanocapsules (NPG) on physicochemical parameters.

	Days	pH	Average diameter (nm)	PDI	Zeta potential (mV)
	0	6.0 ±0.05	230 ± 0.57	0.31 ±0.01	-20 ±0.5
	3	5.5 ±0.05***	233 ±0.57**	0.30 ±0.005	-15 ± 2.3
	7	5.5 ±0.05***	233 ±0.57**	0.33 ± 0.01	-15 ± 2.3
NPG	20	5.5 ± 0.05***	233 ±0.57**	0.33 ±0.01	-15 ± 2.3
	30	5.5 ±0.05***	233 ±0.57**	0.34± 0.005*	-15 ± 2.3
	40	5.5 ± 0.05***	233 ±0.57**	0.34± 0.005*	-15 ± 2.3
	60	5.5 ±0.17***	234 ± 0.57***	0.34± 0.005*	-15 ± 2.3

Data represent averege ± standard deviation (n = 3, for each day). They were analyzed by Anova of a pathway, followed by the *Tukey* test. *** p <0.001, ** p <0.01 and * p <0.05 when compared to day 0 (zero). PDI - polydispersity index
Source: author's construction.

Table 6 - Stability of white nanoemulsions (NEB) on physical-chemical parameters.

	Days	pH	Average diameter (nm)	PDI	Zeta potential (mV)
	0	6.3 ± 0.0	198 ± 1.0	0.13 ± 0.02	-20 ± 1.0
	3	6.3 ± 0.0	200 ± 1.0	0.15 ± 0.01	-20 ± 1.0
	7	63 ± 0.0	199,6 ± 0.57	0.15 ± 0.01	-20 ± 1.0
NEB	20	6.3 ± 0.0	201 ± 3.2	0.15 ± 0.01	-20 ± 1.0
	30	6.3 ± 0.0	201 ± 3.2	0.16 ± 0.02	-20 ± 1.0
	40	6.3 ± 0.0	202 ± 2.0	0.16 ± 0.03	-20 ± 1.0
	60	5.9 ± 0.05***	203 ± 2,0	0,16 ± 0.03	-21 ± 1.,0

Data represent averege ± standard deviation (n = 3, for each day). They were analyzed by Anova of a athway, followed by the *Tukey* test. *** p <0.001, ** p <0.01 and * p <0.05 when compared to day 0 (zero). PDI - polydispersity index
Source: author's construction.

Table 7 - Stability of ginger nanoemulsions (NEG) on physicochemical parameters.

	Days	pH	Average diameter (nm)	PDI	Zeta potential (mV)
	0	5.3± 0.01	222 ± 1.7	0.21 ± 0.00	-14 ± 0.34
	3	5.8 ± 0.05*	227 ± 3.6	0.24 ± 0.02	-14 ± 0.34
	7	5.53 ± 0.2	235 ±6.6	0.24 ± 0.02	-14 ± 0.34
NEG	20	5.53 ± 0.2	235 ± 6.6	0.24 ± 002	-14 ± 0.34
	30	5.53 ± 0.2	235 ± 6.6	0.24 ± 0,02	-14 ± 0.34
	40	5.53 ±0.2	235 ± 6.6	0.24 ± 0.01	-14 ± 0.34
	60	5.53± 0.1	237 ± 1.0	0.24 ± 0.01	-13 ± 0.15

Data represent averege ± standard deviation (n = 3, for each day). They were analyzed by Anova of a pathway, followed by the *Tukey* test. *** p <0.001, ** p <0.01 and * p <0.05 when compared to day 0 (zero). PDI - polydispersity index
Source: author's construction.

Regarding the production, physical-chemical characterization and stability of the polymeric nanoparticles, several methods based on the *in situ* polymerization of dispersed monomers (alkyl cyanoacrylate) or precipitation of preformed polymers (GUTERRES et al., 1995) are suitable. In this study, the polymer precipitation method was used. When the precipitation of preformed polymers is used, the presence of the drug in the organic phase before precipitation of the polymer in aqueous media may result on the influence at the average particle diameter (GUTERRES et al., 1995). Thus, the results for

the average nanoparticle diameters are in agreement with the results of the mentioned bibliographic reference. Comparative studies between nanocapsules and nanoemulsions were carried out to propose descriptive models of the organization of these nanoparticles. In the present work, the average diameter of the nanocapsules and nanoemulsions observed was between 198nm and 376nm. Nanoparticles produced with ginger showed an average size of 292.5nm in the study of Zhang et al (2016). In 2016, similar values were observed by Lobato et al. (2013), producing nanocapsules found an average of the diameter of these with about 190 ± 9 nm. Average mean values of 191nm were found by Gonzalez-Reza et al. (2014) in β-carotene nanocapsules using PCL polymer.

Concerning the zeta potential, Calvo, Vila-Jato and Alonso (1996) observed the effects of the composition of the different formulations on the zeta potential values. It was verified that the presence of the oil phase in the nanocapsules and nanoemulsions increase the negative zeta potential (ζ = -41.94 mV and ζ = -42.32 mV, respectively) and in relation to nanospheres (ζ = -16.33 mV). In this study, the zeta potential of the formulations relays between ζ = -21 and ζ = -14, including the formulations of nanocapsules and nanoemulsions, corroborating with the results reported by Zhang et al. (2016), in this same work the researchers found an average pH of the nanocapsules around 6.0 (ZHANG et al., 2016).

The pH change may be indicative of degradation of the polymer, oil or even one of their constituents.

The evaluation of the chemical stability of colloid forming polymers under different storage conditions is fundamental for the choice of storage, considering, for example, “shelf life” in pharmacies (MAGENHEIM; BENITA, 1991).

Suspensions of nanoparticles prepared with PCL showed reduction of pH values over a period of three to five months (SCHAFFAZICK et al., 2002). In this work we demonstrate that these structures offer some advantages, such as greater physical stability in the biological environment, low inherent toxicity and high encapsulation of lipophilic substances in their organic nucleus (LEGRAND et al., 1999; MOSQUEIRA; LEGRAND; BARRAT, 2006). The nanocapsules suspensions showed the same behavior when monitored for 60 days.

FINAL CONSIDERATIONS

According to the data presented, it is undertaken that PCL films in direct interaction with the essential oil of ginger showed no loss of mass and absence of degradation. Thus, it demonstrates being suitable for their widely application in the production of polymeric nanostructured systems. The polymer nanocapsules and nanoemulsions were produced according to the parameters of pH, PDI, zeta potential and average particle diameter and were stable for 60 days in a refrigerator.

Based on these results, we assume that the nanostructured systems produced in this work represent a wonderful potential in nanotechnology studies for biomedical applications.

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