

Antibacterial Activity of Mucoadhesive Gastroretentive Drug Delivery System of Alginate Beads Containing Turmeric Extract - PVP Solid Dispersion

Hakim Bangun^{1*}, Anayanti Arianto¹, Yuni Sari Bangun¹, Marline Nainggolan²

¹Department of Pharmaceutical Technology, Faculty of Pharmacy, Nanomedicine Centre of Innovation, University of Sumatera Utara, Medan, Indonesia; ²Department of Pharmaceutical Biology, Faculty of Pharmacy, University of Sumatera Utara, Medan, Indonesia

Abstract

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***Correspondence:** Hakim Bangun. Department of Pharmaceutical Technology, Faculty of Pharmacy, Nanomedicine Centre of Innovation, University of Sumatera Utara, Medan, Indonesia. E-mail: Hakimb17@yahoo.com

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BACKGROUND: Turmeric extract is less effective because the main ingredient of curcumin has a low solubility. Therefore, it is necessary to convert turmeric extract into a solid dispersion form to increase the dissolution of curcumin.

AIM: To determine the antibacterial activity of mucoadhesive gastroretentive drug delivery system of alginate beads containing solid dispersion of turmeric extract.

METHODS: Turmeric powder was macerated with 96% ethanol for 8 days. The macerate was evaporated with a rotary evaporator at 50°C to obtain concentrated extract. Solid dispersion of turmeric extract was prepared by solvent method by using polyvinylpyrrolidone (PVP) K30 with a ratio of 1: 1 and 1: 2. The solid dispersion of turmeric extract was encapsulated with alginate gel by gelation method. The antibacterial of alginate beads containing solid dispersion of turmeric extract was tested by using hole agar plate diffusion method against *Staphylococcus aureus* and *Escherichia coli* as bacterial models.

RESULTS: The size of alginate beads containing turmeric extract-PVP solid dispersion was about 1.3 mm. Antibacterial activity test against *Staphylococcus aureus* and *Escherichia coli* showed that alginate beads containing turmeric extract-PVP solid dispersion gave stronger antibacterial activity than those containing turmeric extract without solid dispersion. The antibacterial activity of alginate beads turmeric extract-PVP (1: 2) solid dispersion was stronger than those containing turmeric-extract (1: 1) solid dispersion.

CONCLUSION: Based on the results of this study it can be concluded that alginate beads containing turmeric extract-PVP solid dispersion gives the stronger antibacterial activity than those containing turmeric extract without solid dispersion.

Introduction

Peptikum ulcer is a disease due to disorders of the upper gastrointestinal tract caused by the excessive of acid and pepsin secretion [1]. Peptikum ulcers can occur due to an imbalance between aggressive factors (such as *Helicobacter pylori* infection, NSAIDs and stomach acid) and stomach defence factors (such mucin, bicarbonate and prostaglandins) resulting in damage of the gastric mucosa [2].

Turmeric (*Curcuma longa* Linn or *Curcuma*

domestica Val.) included in the family of Zingiberaceae has long been known by the community as plant many has benefits such as antiinflammation [3], anticancer [4], antioxidants [5], antiulcer [6], and antibacterial [7].

Pharmacological effect of curcumin is limited due to its low solubility and has a fast metabolism in gastrointestinal tract [8]. A low bioavailability (1%) and the degradation in alkaline intestine pH cause very limiting its clinical application [9]. Therefore, due to the instability of curcumin in alkaline intestine pH, then it is necessary to prepare curcumin in gastroretentive drug delivery system to prolong the residence time of

turmeric extract in the stomach.

One approaches to targeting drugs into the stomach is a mucoadhesive gastroretentive drug delivery system. Alginate is a negatively-charged polysaccharide which is non-toxic, biocompatible and biodegradable, included in anionic bioadhesive polymer, forming hydrogen bond with hydroxyl group in polyosaccharide chain in mucose glycoprotein and its chemical bond was noncovalent [10]. Previous study was also reported the bioadhesive properties of alginate beads [11], [12]. Alginate interacts with organic diacidic base piperazine and calcium salts [13]. Lamivudine sodium alginate beads which were prepared by ionotropic gelation method showed prolonged drug release (~12 h) and the release was controlled by diffusion from alginate beads that was slow and spreads over an extended period of time depending upon the drug polymer ratio [14]. Our previous study showed the anti-gastric activity of alginate bead containing turmeric extract [15].

As mentioned above, the low bioavailability of curcumin is due to the low solubility of curcumin. One approach to increase the dissolution of curcumin contained in turmeric extract is to convert turmeric extract into solid dispersion form. In this paper will be discussed the dissolution of curcumin and the antibacterial activity of turmeric extract-PVP solid dispersion entrapped in alginate beads.

Material and Methods

Materials

The materials used in this research was turmeric rhizome obtained from Medan Central Market, Indonesia. Ethanol and Tween 80 obtained from Brataco. Polyvinylpyrrolidone (PVP) K30 was product of Nacalai Tesque. Curcumin as standard for release study was obtained from Sigma-Aldrich. Calcium chloride and hydrochloric acid were product of Merck. Sodium alginate was the product of Wako Pure Chemical Industries, Ltd., Japan. Mueller-Hinton agar (MHA), Nutrient Broth (NB), and Nutrient Agar (NA) media were the product of Difco. *Staphylococcus aureus* ATCC 6538 and *Escherichia coli* ATCC 8939 obtained from Laboratory of Microbiology, Faculty of Pharmacy, University of Sumatera Utara.

Preparation of turmeric extract

Turmeric powder was macerated with ethanol 96% for 8 days. Then, the macerate was evaporated with rotary evaporator to obtain concentrated turmeric extract.

Preparation of solid dispersion

Turmeric extract-PVP solid dispersion was prepared by solvent method. The ratio of turmeric extract and PVP was 1: 1 and 1: 2. Turmeric extract and PVP were dissolved in ethanol. Then, ethanol was evaporated. The resulting turmeric extract-PVP solid dispersion were scraped and sifted using a sieve no. 12.

Preparation of alginate beads containing turmeric solid dispersion

Sodium alginate solution was prepared by adding sodium alginate (1.5% w / v) in distilled water. Turmeric extract or turmeric solid-PVP solid dispersion was crushed with addition of ethanol until dissolved and it was mixed with Tween 80, then added into the alginate solution and stirred until the mixture became homogenous. The mixture was dropped wise through a syringe with 21G size into 0.15 M calcium chloride solution with curing time 4-5 minutes [15]. Then, the beads formed were separated from the solution by filtration and rinsed with distilled water. Finally, the beads containing turmeric acid were dried at room temperature and stored in a desiccator. The various formula used is shown in Table 1.

Table 1: The formula preparations alginat beads

Materials	FI	FII	FIII
Alginat sodium	1.5 %	1.5%	1.5%
Turmeric extract	15%	-	-
Turmeric extract solid dispersion	-	30%	45%
Twen 80	1.5%	1.5%	1.5%
Distilled water until	50 ml	50 ml	50 ml

FI: Beads contained turmeric extract-PVP (1: 1) solid dispersion, equivalent to 15% of turmeric extract; FII: Beads contained turmeric extract -PVP (1: 2) solid dispersion, equivalent to 15% of turmeric extract; FIII: Beads contained turmeric extract 15% (without solid dispersion).

Determination of calibration curve of curcumin

Calibration curve of curcumin was determined in simulated gastric fluid of pH 1.2 at maximum wave length at 428 nm.

Release of curcumin from alginate beads

The in vitro release of curcumin from alginate beads was carried out using a jacketed glass containing 100 ml of simulated gastric fluid of pH 1.2 at $37 \pm 0.5^\circ\text{C}$. Two hundred milligram of beads was put into the medium. The medium was stirred using a magnetic stirrer at 50 rpm. The amount of curcumin released from alginate beads at interval of time was determined spectrophotometrically at 428 nm.

Antibacterial activity test

The antibacterial activity of alginate beads containing turmeric extract-PVP solid dispersion was tested by using hole agar plate diffusion method

against *Staphylococcus aureus* and *Escherichia coli* as bacterial models. Inoculum as much as 0.1 ml was inserted into the Petri dish, then added 15 ml sterile Mueller-Hinton agar (MHA) media that has been thawed and wait until the temperature reached 45°C, homogenized and remained until solidified. After that, holes were made with a diameter of 6 mm. Each hole was filled with seven particles of alginate beads containing turmeric extract or turmeric extract-PVP solid dispersion. Then, it was incubated at 36-37°C and observed for 7 days. After incubation, the zones of inhibition (ZOI) were measured with a calliper in mm scale.

Results

Beads specifications

Determination of an alginat beads specifications was done by observing the shape, diameter and weight of the beads. The diameter and weight of beads is shown in Table 2.

Table 2: Average diameter and weight of beads

Formula	Diameter average (mm)	Weight average (mg)
F1	1.34 ± 0,11	37.33 ± 0,52
FII	1.35 ± 0,12	43.67 ± 0,82
FIII	1.28 ± 0,06	34.83 ± 1,47

Alginate beads containing turmeric extract or solid dispersion of turmeric extract showed a round shape as shown in Figure 1A, 1B, and 1C. Microphotograph of scanning electron microscopy (SEM) of alginate beads containing turmeric-PVP (1: 1) solid dispersion is shown in Figure 1D.

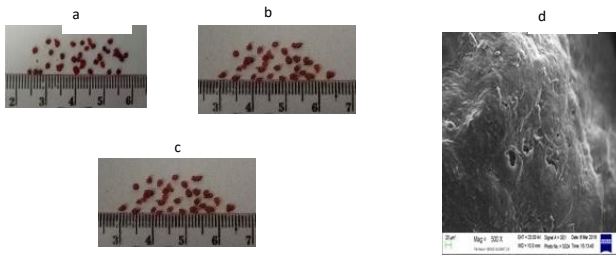


Figure 1: Photographs of alginate beads contained turmeric extract-PVP (1: 1) solid dispersion A); Contained solid dispersion of turmeric extract-PVP K30 (1: 2) B); Contained turmeric extract only C); and microphotograph of SEM of alginate beads contained turmeric extract-PVP (1: 1) solid dispersion D)

Effect of turmeric extract-PVP solid dispersion on the release of curcumin from alginate beads

Release of curcumin from alginate beads containing turmeric extract-PVP solid dispersion in the medium of simulated gastric fluid of pH 1.2 is shown in Figure 2. This Figure shows that the amount of curcumin released from alginate beads containing

turmeric extract-PVP solid dispersion is higher compared to curcumin released from alginate beads containing turmeric extract (without solid dispersion). Curcumin released was faster from alginate beads containing turmeric extract-PVP (1: 2) solid dispersion than alginate beads containing turmeric extract-PVP (1: 1) solid dispersion.

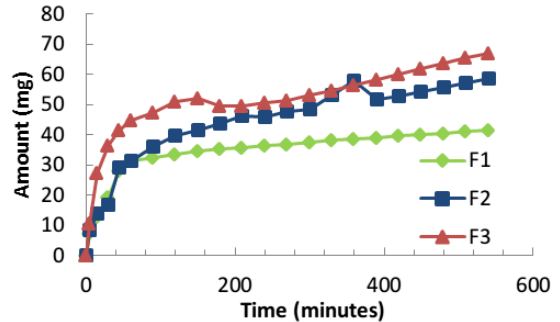


Figure 2: Release of curcumin from alginate beads in the medium of simulated gastric fluid of pH 1.2 at 37°C; F1: Turmeric extract without solid dispersion; FII: Turmeric extract-PVP (1: 1) solid dispersion; FIII: Turmeric extract-PVP (1: 2) solid dispersion

Effect of turmeric extract concentration on antibacterial activity of turmeric extract

Antibacterial activity of turmeric ekstrak against *Staphylococcus aureus* and *Escherichia coli* for incubation at 37°C for 24 hours is shown in Table 3.

Table 3: Effect of turmeric extract concentration on ZOI of turmeric extract against *Staphylococcus aureus* and *Escheria coli*

Turmeric Extract (%)	Zone of inhibition (mm)	
	<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>
6.25	6.45	6.45
12.5	7.35	7.15
25	9.10	8.15
50	11.65	10.5
75	12.35	11.55

The higher concentration of turmeric extracts the higher of ZOI. The photograph of zone of inhibition (ZOI) is shown in Figure 3.

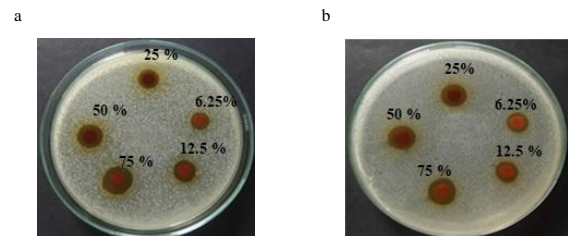


Figure 3: Photograph of ZOI of various concentration (%) of turmeric extract against *Staphylococcus aureus* A) and *Escheria coli* B) after incubation for 24 hours

Antibacterial activity of alginate beads containing turmeric extract

The ZOI of alginate beads containing turmeric extract (without solid dispersion) against

Staphylococcus aureus and *Escherichia coli* is listed in Table 4 and the photographs of ZOI are shown in Figure 4.

Table 4: ZOI of alginate bead containing turmeric extract and those containing solid dispersion of turmeric extract-PVP against *Staphylococcus aureus* and *Escherichia coli* after incubation for 7 days (n = 3)

Formula	Zone of inhibition (mm)	
	<i>Staphylococcus aureus</i>	<i>Escherichia coli</i>
F1	11.15 ± 0.39	10.70 ± 1.07
FII	14.01 ± 0.47	13.26 ± 0.78
FIII	14.51 ± 0.67	13.76 ± 1.09

F1: Alginate beads containing turmeric extract (without solid dispersion); FII: Alginate beads containing solid dispersion of turmeric extract-PVP (1: 1); FIII: Alginate beads containing solid dispersion of turmeric extract- PVP (1: 2).

The ZOI for *Staphylococcus aureus* is 11.15 ± 0.39 mm dan for *Escherichia coli* is 10.70 ± 1.07 mm.

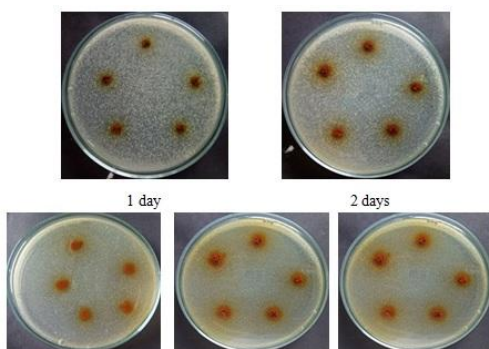


Figure 4: ZOI of alginate beads containing turmeric extract against *Staphylococcus aureus* after 1 until 7 days

Antibacterial activity of alginate beads containing turmeric extract-PVP solid dispersion

The ZOI of alginate beads containing turmeric extract-PVP solid dispersion against *Staphylococcus aureus* and *Escherichia coli* is shown in Table 4 (above) and the photographs of ZOI are shown in Figure 4, 5, 6, 7, 8, and 9.

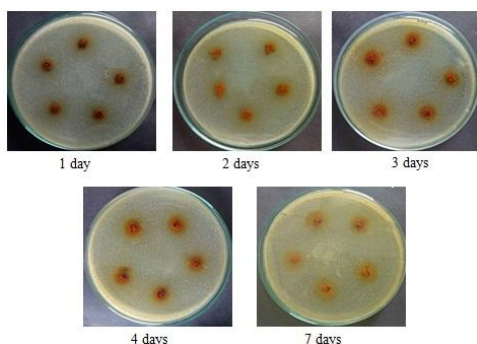


Figure 5: Photograph of alginate beads containing turmeric extract against *Escherichia coli*

Table 4 shows that the alginate beads containing solid dispersion of turmeric extract-PVP gives stronger bacterial activity which seen from the wider ZOI (FII) than alginate beads containing turmeric extract (without solid dispersion (F1)).

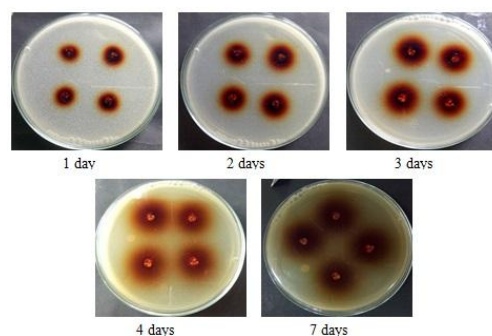


Figure 6: Photograph of alginate beads alginat containing solid dispersion of turmeric extract-PVP (1: 1) against bacteria *Staphylococcus aureus*

Zones of inhibition by alginate beads containing turmeric extract-PVP (1: 1) solid dispersion for *Staphylococcus aureus* and *Escherichia coli* were 14.01 ± 0.47 mm and 13.26 ± 0.78 mm, respectively.

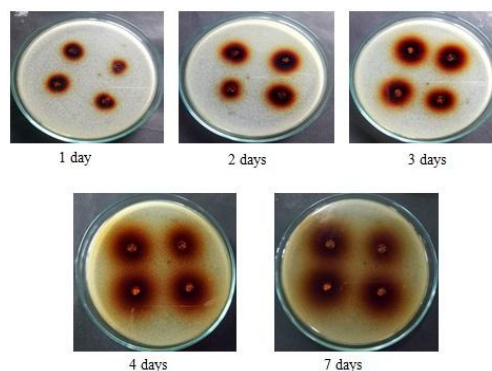


Figure 7: Photograph of alginate beads containing solid dispersion of turmeric extract-PVP (1: 1) against *Escherichia coli*

But, Zones of inhibition by alginate beads containing turmeric extract (without solid dispersion) for *Staphylococcus aureus* and *Escherichia coli* were 11.15 ± 0.39 and 10.70 ± 1.07 mm, respectively.

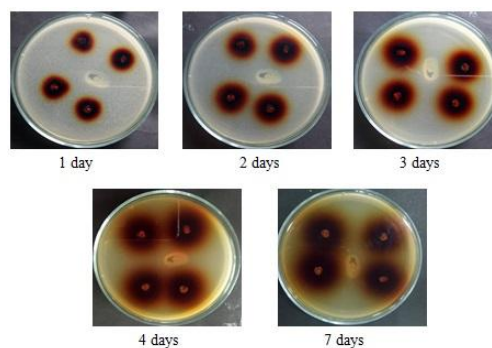


Figure 8: Photograph of alginate beads containing solid dispersion of turmeric extract-PVP (1: 2) against *Staphylococcus aureus*

The ZOI of alginate beads containing turmeric extract-PVP (1: 2) was wider than alginate beads containing turmeric extract-PVP (1: 1).

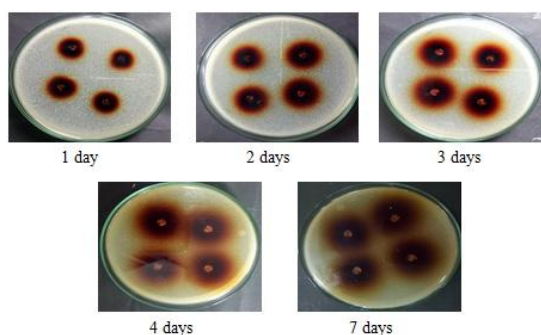


Figure 9: Photograph of alginate beads containing solid dispersion of turmeric extract-PVP (1: 2) against *Escherichia coli*

Discussion

Beads specifications

Alginate is a linear natural polysaccharide consisting of β -D-mannuronic acid and α -L-guluronic acid. Divalent cations, such as calcium ions, can bind to guluronat residues to form "egg box" structures and cause gelation to form calcium alginate gel [16], [17]. In this research, turmeric extract-PVP solid dispersion was entrapped in calcium alginate gel beads. In the preparation of the beads, the alginate beads containing solid dispersion of turmeric extract-PVP (1: 1) and (1: 2) had a bigger size than beads containing turmeric extracts (without solid dispersion) as listed in Table 2. This is due to the addition of PVP, while the amount of turmeric extract was the same for all of beads. Beads containing PVP were heavier than beads without PVP.

Release of curcumin from alginate beads

Figure 4 shows that the amount of curcumin released is higher from solid dispersion form of turmeric extract-PVP than from turmeric extract without solid dispersion form in the medium of simulated gastric fluid of pH 1.2. The higher of the amount of PVP the higher amount curcumin released. In turmeric extract-PVP solid dispersion form, the dissolution rate of curcumin increases because PVP is a water-soluble polymer that enhance the wetting process of curcumin. In addition, the modification of turmeric extract to turmeric solid dispersion form reduces the particle size of curcumin so that the rate of curcumin dissolution increases, thereby the antibacterial activity increase.

The previous researchers observed that the curcumin-PVP solid dispersion increased the dissolution of curcumin [18]. Therefore, the turmeric extract-PVP solid dispersion increased the dissolution of curcumin contained in turmeric extract.

Antibacterial activity of turmeric extract

ZOI increased with increasing of turmeric extract concentration (Table 3). ZOI for *Staphylococcus aureus* slightly higher than *Escherichia coli*. The bactericidal activity of curcumin is due to its bacterial membrane damaging property [19]. If we compared the bacterial activity between turmeric extract and turmeric extract that entrapped in alginate beads, the antibacterial activity of turmeric extract was faster than turmeric extract that entrapped in alginate beads. In turmeric extract the ZOI reached maximum after 24 hours, while in entrapped turmeric extract the ZOI reached maximum after 7 days. This result was due to in beads the turmeric extract was entrapped in alginate gel matrix, so curcumin was blocked out and caused the slow release of curcumin, thereby the antibacterial activity was slower than turmeric extract only.

Antibacterial activity of alginate beads containing turmeric extract-PVP solid dispersion

The antibacterial activity of alginate beads containing turmeric extract-PVP solid dispersion was stroger than alginate beads containing turmeric extract without solid dispersion (Table 4). In turmeric extract solid dispersion form, the dissolution rate of curcumin increased because PVP is a water-soluble polymer that enhance the wetting process of curcumin. In addition, the modification of turmeric extract to turmeric extract-PVP solid dispersion form reduces the particle size of curcumin so that the rate of curcumin dissolution increased, thereby the antibacterial activity increased.

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