การใช้แป้งข้าวเหนียวดัดแปรด้วยเทคนิคไมโครเวฟเป็นสารยึดเกาะในยาเม็ด
Microwave-treated Glutinous Rice Starch as A Tablet Binder

นิพนธ์ต้นฉบับ

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วารสารไทยเภสัชศาสตร์และวิทยาการสุขภาพ2563;15(2):75-80.

Original Article

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Thai Pharmaceutical and Health Science Journal 2020;15(2):75-80.

บทคัดย่อ

วัตถุประสงค์: เพื่อศึกษาการใช้แป้งข้าวเหนียวที่ดัดแปรด้วยไมโครเวฟ (GRMi) เป็นสารยึดเกาะในการผลิตยาเม็ดที่เตรียมด้วยวิธีแกรนูลเปียก **วิธีการศึกษา:** เตรียมยาเม็ดด้วยวิธีแกรนูลเปียกที่ประกอบด้วยไมโครคริสทัลไลน์เซลลูโลส (MCC) หรือแลคโตสโมโนไฮเดรต (Lac) โดยใช้สารยึดเกาะในปริมาณร้อยละโดยน้ำหนักดังนี้ 1) ร้อยละ 0, 2) GRMi ร้อยละ 2.5 และ 3) แป้งข้าวเหนียวที่ให้ความร้อนโดยตรง (GRB) ร้อยละ 2.5 และใช้แมกนีเซียมสเตียเรตร้อยละ 1 โดยน้ำหนักโดยตอกอัดยาเม็ดด้วยแรงที่ต่างกัน (40, 60 และ 80 kgf/cm^2) แล้วประเมินสมบัติของยาเม็ด **ผลการศึกษา:** ยาเม็ดที่ใช้ MCC มีความต้านแรงอัดแตกในช่วง 9.52 - 17.72 kgf ซึ่งสูงกว่า Lac (1.10 - 5.98 kgf) เวลาในการแตกตัวและสภาพกร่อนของยาเม็ดที่ใช้ MCC อยู่ในช่วง 11.40 - 59.40 วินาที และร้อยละ 0.08 - 0.41 โดยน้ำหนัก ตามลำดับ ซึ่งต่ำกว่ายาเม็ดที่ใช้ Lac ที่อยู่ในช่วง 70.80 - 5,170.20 วินาที และร้อยละ 0.88 - 3.89 โดยน้ำหนัก ตามลำดับ และยังพบว่าการเพิ่มแรงตอกอัดทำให้ยาเม็ดมีค่าความต้านแรงอัดแตกและเวลาในการแตกตัวเพิ่มขึ้น แต่มีสภาพกร่อนลดลง เมื่อเพิ่มแรงอัดให้แก่ยาเม็ดที่ใช้สารยึดเกาะ GRMi และ GRB พบว่าสามารถทำให้ยาเม็ดมีค่าความแข็งแรง (CSFR) และดัชนีชี้วัดคุณภาพยาเม็ด (CSFR/DT index) เพิ่มมากขึ้นได้ แสดงถึงความสามารถในการยึดเกาะที่ดีและสมบัติการเป็นยาเม็ดที่ดีขึ้น **สรุป:** สามารถใช้แป้งข้าวเหนียวที่ดัดแปรด้วยไมโครเวฟเป็นสารยึดเกาะในการเตรียมยาเม็ดด้วยวิธีแกรนูลเปียกได้

คำสำคัญ: แป้งข้าวเหนียว, แป้งดัดแปรด้วยไมโครเวฟ, การเตรียมด้วยวิธีแกรนูลเปียก, สารยึดเกาะ

Editorial note
Manuscript received in original form on October 16, 2019;
revised December 28, 2020;
and accepted in final form on January 7, 2020

Abstract

Objective: To investigate microwave-treated glutinous rice starch (GRMi) used as a binder in wet granulation tablets. **Methods:** Being prepared with wet granulation method, each tablet consisted of filler (microcrystalline cellulose (MCC) or lactose monohydrate (Lac)), binder (0% w/w, 2.5% w/w of GRMi, or 2.5% w/w of heated glutinous rice starch (GRB)) and 1% w/w of magnesium stearate. All tablet formulations were compressed by various compression forces (40, 60, and 80 kgf/cm^2) and tablet properties were evaluated. **Results:** The MCC-tablets had a crushing strength (CS) of 9.52-17.72 kgf. which was higher than that of Lac-tablets (1.10 - 5.98 kgf.). The disintegration time (DT) and friability (F) of MCC-tablets (11.40 - 59.40 sec and 0.08 - 0.41%, respectively) were lower than those of Lac-tablets (70.80 - 5,170.20 sec and 0.88 - 3.89%, respectively). The increase of compression force resulted in increased CS and DT and decreased F. When compression force was increased to tablets using GRMi and GRB as a binder, the higher crushing strength-friability ratio (CSFR) and crushing strength-friability/ disintegration time ratio (CSFR/DT index) in both tablets were observed. These results indicated better binding capability with improved tablet properties. **Conclusions:** microwave-treated glutinous rice starch could be used as a binder in wet granulation tablets.

Keywords: glutinous rice starch, microwave-treated starch, wet granulation method, binder

Journal website: http://ejournals.swu.ac.th/index.php/pharm/index

Introduction

Tablets are widely used pharmaceutical products since they are stable, convenient for storage and transport, easy to use, and uncomplicated and less costly manufacture.[1] In formulating tablets, individual ingredients have to be considered for specific purposes or functions. Fast release tablets need ingredients to help achieve a fast tablet disintegration; sustained release tablets need to be slowly disintegrated or even not disintegrated at all. However, since tablets need to have a high crushing strength and low friability, quality binder is required. Binder is mixed with water or appropriate solvent to form viscous liquid. Synthetic binders include hydroxypropylmethylcellulose and polyvinypyrolidone and natural binder are starch and gelatin, for example.

Starch is a natural polymer consisting of anhydroglucose monomer unit linked together with glycosidic linakge to form two complex carbohydrates, namely amylose and amylopectin.[2] Starch has low toxicity and low cost. Widely used starch includes corn starch, potato starch, tapioca starch (or cassava starch), rice starch, and glutinous rice starch.[3] Since starch is not swelling or water soluble at room temperature, modification to improve starch quality for pharmaceutical purposes is needed. Starch modification could be done by either thermal, pressure and mechanical methods. These physical modifications have some advantages. Since no chemicals are needed, negative impacts on consumers and environments are negligible.

A study modified rice starch by alcoholic alkaline to use as a binder for fast release tablet formulation by wet granulation method.[4] It was found that the tablet had a high crushing strength with low friability and short disintegration time. The study confirmed that alcoholic alkaline treated rice starch could be used as a binder in the tablet formulation.[4]

Glutinous rice starch has crystalinity and gelatinization properties based on temperature. This gelatinization endothermic temperature (Tg) of glutinous rice starch is 68.27 $\pm$ 0.28 ºC.[5] There is a need to modify glutinous rice starch to be swollen, water soluble and a viscous liquid. A study modified physical property of glutinous rice starch by sprinkling the starch to the water and heated the mixture by direct heating. The starch was was then swollen and water soluble, and became a viscous liquid.[5] This method has a limitation since temperature and time need to be perfectly controlled. There has been modification of glutinous rice starch by microwave technique to make the starch swollen, water soluble and viscous.[6,7]

Microwave method is less time-consuming and more convenient than the direct heating method. With certain advantage of glutinous rice starch, we expected that microwave-treated glutinous rice starch could be used as a binder for tablet formulation. This study aimed to examine binder properties of microwave-treated glutinous rice starch in tablet formulation using wet granulation method. Properties of the tablets prepared by the microwave-treated glutinous rice starch were examined.

Methods

Chemicals used in this study included microcrystalline cellulose or MCC (Avicel® PH 101, FMC BioPolymer, Ireland), lactose monohydrate (Lac, B200 MEGGLE, Germany), glutinous rice starch (Cho-Heng Company, Thailand), and magnesium stearate (Fluka Chemika, Switzerland).

To prepare the glutinous rice starch treated with microwave technique (microwave-treated glutinous rice starch or GRMi), glutinous rice starch was sprinkled to the water to achieve a concentration of 10% w/w. Once stirred to homogenously distributed, this starch slurry was irradiated in a microwave (MW83Z, Samsung®, Thailand) with the power of 800 watts for 3 minutes.

On the other hand, binder of glutinous rice starch modified by direct heating (heated glutinous rice starch or GRB) was prepared by sprinkling glutinous rice starch to the water to achieve a concentration of 10% w/w and heated on the water bath at 95 ºC and stirred for 18 minutes.[5]

In this study, blank granules (granules with no active ingredient) were prepared by the formula shown in Table 1. By mixing diluents with binder, either GRMi or GRB, with ion-free water as the comparative binder in the mortar until achieving damp mass. This damp mass was pressed through 14 mesh sieve (ASTM) to get wet granules. These wet granules were dried in a hot air oven (LD0-080F, Daihan Labtech®, Korea) at 60 ºC for one hour. The dried granules were screened through 18 mesh sieve (ASTM) then mixed with magnesium stearate in bottle mixer for 5 minutes before the tablets were compressed.

Table 1 Ingredients of the blank granule (no active ingredients) using GRB (Lac-GRB, MCC-GRB) and GRMi (Lac-GRMi, MCC-GRMi) as binders with ion-free water as the comparative binder.

Tablet ingredients	Weight (mg/tablet)					
	Lac	MCC	Lac-GRB	Lac-GRMi	MCC-GRB	MCC-GRMi
Lactose monohydrate (Lac)	346.5	-	337.75	337.75	-	-
MCC (Avicel® PH 101)	-	346.5	-	-	337.75	337.75
GRB	-	-	8.75	-	8.75	-
GRMi	-	-	-	8.75	-	8.75
Ion-free water	87.5	87.5	-	-	-	-
Magnesium stearate	3.5	3.5	3.5	3.5	3.5	3.5
Total weight (mg)	350	350	350	350	350	350

Note:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

The blank tablets were prepared by hydraulic tablet compression (Shimadzu®, Japan) with punch and die of a diameter of 10 mm, 350 mg of tablet weight, and various compression forces (40, 60, and 80 kgf/cm^2).

To evaluate the thickness (T), 10 tablets were sampled and measured by the thickness gauge (OXD3300100K, Oxford®, UK). The thickness was recorded, averaged and presented as mean with standard deviation (SD).

Crushing strength (CS) of the tablet was assessed by testing the 10 sampled tablets with a tablet hardness tester (VK-200, Vankel®, USA). The crushing strength was recorded, averaged and presented as mean with SD.

Tablet friability (% friability; F) was tested by sampling at least 6.5 gm of tablets. Once accurately weighed (W_0), the sampled tablets were tested for friability using a friability tester (Friabilator, Vankel®, USA) at 25 $\pm$ 1 rpm with 100 times of drum rotation.[8] Loose dust was removed and the tablets were

accurately weighed (W_t). Friability was calculated as percentage with equation 1.1.

$$\%\ Friability = [\frac{(W_0 - W_t)}{W_0}] \times 100 \qquad 1.1$$

Disintegration time (DT) was evaluated with a disintegration apparatus (QC-21, Hanson Research®, USA) using ion-free water as the medium, at 37 ± 2 ° C.[8] Disintegration time was recorded, averaged (n = 6), and presented as mean with SD.

Crushing strength-friability ratio (CSFR), as the measure of tablet strength and weakness, was calculated from crushing strength (CS) and friability as in equation 1.2.[9] Crushing strength friability/disintegration time ratio (CSFR/DT) as a function of relative density and disintegration time could offer a better index of tablet quality.[9] CSFR/DT index could be calculated as shown in equation 1.3.

$$CSFR = \frac{CS}{F} \qquad 1.2$$

$$CSFR/DT\ \ index = (60 \times CS)/(F \times DT) \qquad 1.3$$

Tablets with high CSFR value has high strength or resistance to crushing since the friability (F) is low. In addition, higher CSFR/DT index value suggests the tablets have a high strength or resistance to crushing but at the same time take a short time to disintegrate which is a desirable property of regular to fast disintegrating tablets.[9] However, since there has been no criteria indicating appropriate CSFR and CSFR/DT, this present study used CSFR and CSFR/DT index of the tablet for discussions of the experiment results.

Data analysis

Results were presented as mean with standard deviation (SD). Differences between groups were tested using one-way analysis of variance (ANOVA) with Tukey method for post hoc pairwise comparisons. All statistical significance was set at a type I error of 5% (or *P*-value < 0.05). All statistical analyses were performed using SPSS for Windows version 24.

Results and Discussions

It was found that once compression forces had been increased, tablet thickness was reduced (Table 2). More compressure forces made granule particles form more dense compact, hence thinner tablet. Among tablets with no glutinous rice binder, thickness of tablets with MCC was greater than those with lactose at the compression forces of 40 kgf/cm^2 (3.79 ± 0.05 vs. 3.56 ± 0.03 mm, respectively) and 60 kgf/cm^2 (3.49 ± 0.03 vs. 3.40 ± 0.03 mm, respectively) with statistical significance for both compression forces (*P*-value < 0.05) . Compression forces at 40 and 60 kgf/cm^2 were considered low and medium level, respectively. The greater thickness found in tablets with MCC was consistent with the tapped density of MCC which was lower than that of lactose.[10,11]

When compression force of 80 kgf/cm^2 was applied, thickness of tablets with MCC and lactose with GRMi and GRB as binder (3.33 ± 0.02 vs. 3.32 ± 0.04 mm, respectively for MCC and 3.37 ± 0.01 vs. 3.36 ± 0.01 mm, respectively for lactose), and that with no binder (3.30 ± 0.03 vs. 3.31 ± 0.01 mm, for MCC and lactose respectively) were not statistically different (*P*-value > 0.0.5). At a high compression force, the space between particles decreases. For tablets with the use of MCC and lactose without binders, at the high compression force of 80 kgf/cm^2, the inter-particle space was extremely decreased therefore the densities of the tablets with MCC and lactise were comparable. In addition, these densities found in our study were almost identical to the true density of MCC in the study of Rojas and colleagues[10] and of lactose in the study of Kaialy and co-workers.[11]

It was found that lactose tablets with GRMi and GRB as binder had a greater thickness than those of lactose tablets with no binder and those of MCC tablets with and without binder. This was because lactose tablets with GRMi and GRB as binder had longer and bigger granules than lactose tablets with no binder and MCC tablets with or without binder. As a result, granules of lactose with GRMi and GRB as binder had a higher crushing strength and hence a high thickness.

Table 2 Thickness of tablets made with lactose and MCC with GRB and GRMi as the binder and ion-free water as the comparative binder at various compression forces.

Compression force (kgf/cm^2)	Thickness (mm, mean ± SD)					
	Lac	Lac-GRB	Lac-GRMi	MCC	MCC-GRB	MCC-GRMi
40	3.56 ± 0.03^{f}	3.71 ± 0.05^{h}	3.69 ± 0.01^{h}	3.79 ± 0.05^{i}	3.63 ± 0.06^{g}	3.71 ± 0.03^{h}
60	3.40 ± 0.03^{d}	3.49 ± 0.01^{e}	3.49 ± 0.01^{e}	3.49 ± 0.03^{e}	3.38 ± 0.01^{d}	3.46 ± 0.03^{e}
80	3.31 ± 0.01^{a}	3.36 ± 0.01^{bcd}	3.37 ± 0.01^{cd}	3.30 ± 0.03^{a}	3.32 ± 0.04^{ab}	3.33 ± 0.02^{abc}

Note:

Different supercript letters indicated statistical significance (*P*-value < 0.05) between the two values in each compression force.

Abbreviations:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

Once the compassion force was increased, crushing strength was increased accordingly (Table 3). This was because the increase in compression forces made the granules packed more densely. Tablets with MCC as diluent had the crushing strength higher than that of those with lactose. This was because MCC has compactability superior to lactose.[12] Tablets using lactose and MCC as diluent with GRMi and GRB as binder also had a significantly higher crushing strength than those without binder (*P*-value < 0.05). This is because binder molecules penetrate and form the bonds between diluent particles so the tablets have more crushing strength which is proportional to the increasing compression forces. At a given compression force, tablets with GRMi and GRB had comparable crushing strength (*P*-value > 0.05).

Table 3 Crushing strength of tablets with lactose and MCC as diluent and GRB and GRMi as binder, and ion-free water as the comparative binder at various compression forces.

Compassion force (kgf/cm^2)	Crushing strength (kgf, mean ± SD)					
	Lac	Lac-GRB	Lac-GRMi	MCC	MCC-GRB	MCC-GRMi
40	1.10 ± 0.20^{a}	2.87 ± 0.16^{b}	3.35 ± 0.19^{bc}	9.52 ± 0.47^{g}	12.88 ± 0.29^{hi}	12.58 ± 0.41^{h}
60	1.90 ± 0.24^{a}	4.00 ± 0.57^{cd}	4.75 ± 0.60^{de}	13.60 ± 0.57^{i}	15.92 ± 0.35^{j}	15.57 ± 0.35^{j}
80	3.05 ± 0.26^{b}	5.27 ± 0.45^{ef}	5.98 ± 0.33^{f}	15.78 ± 0.68^{j}	17.72 ± 0.44^{k}	17.63 ± 0.34^{k}

Note:

Different supercript letters indicated statistical significance (*P*-value < 0.05) between the two values in each compression force.

Abbreviations:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

More compression force led to less friability (Table 4). Tablets with MCC as diluent had lower friability than those with lactose since MCC has a better compactability and binding property than lactose. Tablets with MCC and lactose using GRMi and GRB as binder had comparable friability, and lower friability than those using no binder. These starch binders penetrate into space between particles and strengthen the bonds between particles, and ultimately less friability of the tablet. Our finding was consistent with the study of Reza et al where starch was used as binder and MCC as diluent[13] and the study of Patel and colleagues where semisynthetic binder (HPMC) and lactose as diluent were used.[14] These two studies used wet granulation method.[13,14]

In terms of disintegration time, the increase in compression force resulted in an increase in disintegration time (Table 5). Tablets using lactose and MCC as diluent and GRMi and GRB as binder had longer disintegration time than tablets with no binder. This is because binder molecules strengthen the bond between particles in the tablet which result in a longer disintegration time. Our finding was consistent with the study of Reza et al[13] and Patel et al[14] where starch and HPMC were used as binder, respectively, and MCC and lactose as diluent, respectively. In these two studies, the use of binder led to longer disintegration time.[13,14]

Lactose is one of the brittle materials which mean that lactose particle is completely broken once pressed. As a result, space between particles is reduced and it is less likely for water to penetrate and destroy the bond between particles. This property allows tablets with lactose to hold longer (greater disintegration time) than those with MCC. In addition, since MCC has disintegrant property, the disintegration time is shorter once exposed with water.[15] At any given compression force, tablets with GRMi an GRB had comparable disintegration time with no statistical significance (*P*-value > 0.05).

Table 4 Friability of tablets with lactose and MCC as diluent and GRB and GRMi as binder, and ion-free water as the comparative binder at various compression forces.

Compression forces (kgf/cm^2)	Friability (%)					
	Lac	Lac-GRB	Lac-GRMi	MCC	MCC-GRB	MCC-GRMi
40	3.89^{q}	2.13^{o}	1.96^{n}	0.41^{h}	0.27^{g}	0.25^{f}
60	3.02^{p}	1.35^{l}	1.03^{k}	0.25^{f}	0.18^{e}	0.15^{d}
80	1.82^{m}	0.93^{j}	0.88^{i}	0.10^{c}	0.09^{b}	0.08^{a}

Note:

Different supercript letters indicated statistical significance (*P*-value < 0.05) between the two values in each compression force.

Abbreviations:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

Table 5 Disintegration time of tablets with lactose and MCC as diluent and GRB and GRMi as binder, and ion-free water as the comparative binder at various compression forces.

Compression forces (kgf/cm^2)	Disintegration time (second, mean ± SD)					
	Lac	Lac-GRB	Lac-GRMi	MCC	MCC-GRB	MCC-GRMi
40	70.80 ± 2.40^{g}	3,480.00 ± 227.40^{j}	3,580.20 ± 213.60^{j}	11.40 ± 1.80^{a}	17.40 ± 1.80^{b}	22.20 ± 2.40^{c}
60	115.80 ± 3.00^{h}	5,089.80 ± 205.80^{k}	5,089.80 ± 222.60^{k}	17.40 ± 1.80^{b}	31.20 ± 3.60^{d}	33.00 ± 1.80^{d}
80	124.80 ± 2.40^{i}	5,080.20 ± 213.60^{k}	5,170.20 ± 171.60^{k}	24.00 ± 1.20^{c}	47.40 ± 1.80^{e}	59.40 ± 3.60^{f}

Note:

Different supercript letters indicated statistical significance (*P*-value < 0.05) between the two values in each compression force.

Abbreviations:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

In terms of crushing strength-friability ratio (CSFR) and crushing strength friability/disintegration time ratio (CSFR/DT) (or quality index) of the tablet, CSFR and CSFR/DT were increased with the increasing compression force. This finding reflected the stronger bonds between particles in the tablet

Table 6 Crushing strength-friability ratio (CSFR) and crushing strength friability/disintegration time ratio (CSFR/DT) (or quality index) of tablets with lactose and MCC as diluent and GRB and GRMi as binder, and ion-free water as the comparative binder at various compression forces.

Compression forces (kgf/cm^2)	CSFR and CSFR/DT Index											
	Lac		Lac-GRB		Lac-GRMi		MCC		MCC-GRB		MCC-GRMi	
	CSFR	CSFR/DT	CSFR	CSFR/DT	CSFR	CSFR/DT	CSFR	CSFR/DT	CSFR	CSFR/DT	CSFR	CSFR/DT
40	0.28^{a}	0.24^{F}	1.35^{c}	0.02^{A}	1.71^{e}	0.03^{B}	23.51^{j}	123.72^{I}	47.88^{k}	165.11^{K}	51.77^{l}	139.92^{J}
60	0.63^{b}	0.33^{G}	2.97^{f}	0.03^{B}	4.59^{g}	0.05^{C}	55.28^{m}	190.64^{M}	90.97^{n}	174.95^{L}	109.65^{o}	199.36^{N}
80	1.68^{d}	0.81^{H}	5.69^{h}	0.07^{D}	6.79^{i}	0.08^{E}	153.20^{p}	383.01^{O}	206.05^{q}	260.82^{P}	231.97^{r}	234.32^{O}

Note:

Different supercript letters indicated statistical significance (*P*-value < 0.05) between the two values in each compression force.

Abbreviations:

Lac = tablets with lactose as diluent with ion-free water as comparative binder; MCC = tablets with MCC as diluent with ion-free water as comparative binder; Lac-GRB = tablets with lactose as diluent and GRB as binder; MCC-GRB = tablets with MCC as diluent and GRB as binder; Lac-GRMi = tablets with lactose as diluent and GRMi as binder; MCC-GRMi = tablets with MCC as diluent and GRMi as binder.

where MCC tablets had a higher CSFR than that of lactose tablets. This was because MCC tablets had a higher crushing strength and lower friability than the lactose tablets as shown in Tables 3 and 4, respectively.

Lactose tablets with GRMi and GRB as binder were associated with the increased CSFR since the tablets had better binding property when compared with tabltes with no binder (Table 6). However, lactose tablets with GRMi and GRB had lower CSFR/DT since these tablets needed more time for disintegration. On the other hand, tablets with MCC as diluent and GRMi and GRB as binder had a high CSFR/DT value when compared with tablets with no binder. This was because the tablets were stronger while disintegration time was shorter. MCC tablets with GRMi and GRB as biner were appropriate to be fast disintegrated tablets. At a given compression force, MCC tablets with GRMi and GRB as binder possessed slighty different CSFR and CSFR/DT values with no statistical significance (*P*-value > 0.05). Since both microwave-treating and direct heating modification methods were operated at the temperature higher than the gelatinization temperature (Tg)[5,6], glutinous rice starch modified by the two methods became swollen and water soluble, and form a viscous liquid. Therefore CSFR and CSFR/DT of GRMi and GRB biners were similar.

Conclusion

GRMi and GRB as binder with wet granulation method resulted in tablets with more crushing strength, longer disintegration time, and less friability, when compared with no binder. The increase in compression force heightened the crushing strength and disintegration time, and decreased friability. At any given compression force, MCC tablets had a higher crushing strength, shorter disintegration time, and lower friability compared with those with lactose.

Physical properties of tablets with GRMi and GRB as binder were not different. Both GRMi and GRB could improve the strength of both tablets with lactose and MCC as seen in CSFR and CSFR/DT values. In addition, both GRMi and GRB offered MCC tablets a better fast disintegration profile. In conclusion, GRMi could be used as binder for wet granulation tablets as GRB. GRMi binder was more appropriate than GRB since it took less time-consuming and more practical to prepare than the direct heating method. However, other excipients may be needed to further improve desirable tablet properties.

Acknowledgements

The author would like to thank Faculty of Pharmaceutical Sciences, Khon Kaen University, for laboratory facilities and materials.

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