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INTRODUCTION

Thai traditional medicine (TTM) has been used as cardiotonic agent included anti-Fee-Mareng-Suang (anti-FMS); TTM formula is included in classical medical book called Tam Ra Pat Sart Songkraow, in the chapter of Kam Pee Thip Ma La. This formula composed of 12 medicinal plants: *Senna tora* (L.) Roxb., *Derris scandens* Benth., *Maclura cochichinensis* (Lour.) Corner., *Alpinia officinarum*, *Smilax corbularia* Kunth., *Smilax glaba* Roxb., *Tarenna hoaensis* Pitard., *Dracaena lourieri* Gagnep., *Thyrsostachys siamensis* Gamble., *Angiopteris evecta* Hoffm., *Globba malaccensis* Ridl., and *Pinus* spp. Anti-FMS is prepared by boiling with water and ethanol, the original method for herbal medicines preparation in the practice of TTM. The extracted composition of medicinal plants within a boiled solution depends on boiling procedure of each person. However, this traditional preparation has some disadvantages, such as the time to preparation and difficult to prescribed dose these can be troublesome for patients. In pharmaceutical industry, spray drying is common procedure for change liquid to solid especially for herbal extract solution [1]. This process is cost-effective, flexible and improving the properties of extracted anti-FMS. It is necessary to develop new dosage forms for extracted anti-FMS powder and/or easy to use that improving patient compliance.

The aim of this study was to evaluation the effect of type and concentration of spray drying carriers (colloidal silicon dioxide and maltodextrin) on physical properties of spray dried anti-FMS extract powder.

MATERIALS AND METHODS

Materials The all herbs are shown in Table 1 was purchased from Charoensuk Osod, Nakorn Pathom province, Thailand. Colloidal silicon dioxide was purchase from Changzhou Kaide Import and Export Co.Ltd, China. Maltodextrin was purchased from TTK Sciences, Thailand. 95% Ethanol was purchased from Samchai Chemical Co.Ltd., Thailand.

Table 1 Ingredients of anti-FMS herbal formula.

No.	Scientific name	Family	Parts used	Weight ratio
1	*Senna tora* (L.) Roxb.	Leguminosae-Caesalpinoidae	Twig & leaves	5 parts
2	*Derris scandens* Benth.	Leguminosae-Papillionoidae	Vine	5 parts
3	*Maclura cochichinensis* (Lour.) Corner.	Moraceae	Wood	2 parts
4	*Alpinia officinarum*	Zingiberaceae	Rhizome	2 parts
5	*Smilax corbularia* Kunth.	Smilacaceae	Rhizome	2 parts
6	*Smilax glaba* Roxb.	Smilacaceae	Rhizome	2 parts
7	*Tarenna hoaensis* Pitard.	Rubiaceae	Wood	2 parts
8	*Dracaena lourieri* Gagnep.	Dracaenaceae	Wood	2 parts
9	*Thyrsostachys siamensis* Gamble.	Gramineae	Root	2 parts
10	*Angiopteris evecta* Hoffm.	Marattiaceae	Root	2 parts
11	*Globba malaccensis* Ridl.	Zingiberaceae	Rhizome	2 parts
12	*Pinus* spp.	Pinaceae	Wood	2 parts

Extraction procedure The extraction procedure was based on original procedure since ancient time. Anti-FMS crude drug (15 kg) was wetted with 6.5 L of 40% ethanol for 15 minutes. 10 L of water was then added into anti-FMS crude drug and boiled for 15 minutes, for three times. All fractions of extracted anti-FMS was filtered and combined. The combined extract was concentrated until the extract remains a half of initial volume. The different types and concentrations of spray drying carrier: no carrier, colloidal silicon dioxide (0.1%, 0.5%, and 1.0%), and maltodextrin (10.0% and 20.0%), was added into extracted anti-FMS solution, the concentration of carrier was calculated on dried weight basis of anti-FMS crude drug (Table 2).

Table 2 Percentage yield of spray dried anti-FMS herbal extract.

Formula	Spray drying carrier	Percentage yield (%)
F1	No carrier	1.43
F2	0.1% colloidal silicon dioxide	3.10
F3	0.5% colloidal silicon dioxide	5.62
F4	1.0% colloidal silicon dioxide	6.58
F5	10.0% maltodextrin	5.48
F6	20.0% maltodextrin	9.76

Spray drying procedure The extracted anti-FMS mixture was spray dried using factory scale spray dryer (Model:LPG, Changzhou Kaide Import and Export Co.Ltd, China). The mixture was stirred by magnetic stirrer and fed into spray drying chamber through a peristaltic pump with speed of 25 rpm. The inlet and outlet air temperature were 170 °C and 80 °C, respectively. The mixture was sprayed through a nozzle with atomizer pressure of 3 bars throughout the spray drying process. The spray dried products were collected and weighed. Percentage yield was calculated on dried weight basis of crude drug and carrier. The spray dried extracts were kept in desiccator until use.

Physical properties evaluation [2,3]

Angle of repose The angle of repose was investigated by the fixed funnel method. 5 g of spray dried powder was poured into a glass funnel. The lower tip of glass funnel was 5 cm from the ground. The height (h) and radius (r) of powder cone was measured, and then calculated using the equation (1). The tests were performed in triplicated.

$$\text{Tan}\,\theta = \frac{h}{r} \qquad (1)$$

Where θ = angle of repose (°), h and r = height (cm) and radius (cm) of powder cone

Bulk density 2.5 g of spray dried powder was accurately weighed and gently poured into a 10 mL glass cylinder without compacting. The volume of unsettled spray dried powder was recorded and then calculated using the equation (2). The tests were performed in triplicated.

$$\text{Bulk density} = \frac{m}{V_0} \qquad (2)$$

Where m = mass (g), V_0 = bulk volume (cm^3)

Tapped density The glass cylinder with the unsettled spray dried powder from bulk density testing, and a tapped density tester (Erweka D-63150 Model:SVM 202, Germany) with 1,250 strokes was used for tapped density testing. The volume of tapped spray dried powder was recorded, and then calculated using the equation (3). The tests were performed in triplicated.

$$\text{Tapped density} = \frac{m}{V_f} \qquad (3)$$

Where m = mass (g), V_f = final tapped volume (cm^3)

Compressibility index and Hausner ratio Compressibility index and Hausner ratio were calculated from bulk volume and tapped volume. They were calculated following equation (4) and (5), respectively.

$$\text{Compressibility index} = \frac{(V_0 - V_f)}{V_0} \times 100 \qquad (4)$$

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$$\text{Hausner ratio} = \frac{V_0}{V_f} \quad (5)$$

Moisture content The extracted and spray dried anti-FMS was tested moisture content using moisture balance (Radwag, MAC 50/NH, Poland). The 1 g of spray dried extract was put into pan and heated up to 105 °C using standard mode, temperature rapidly increased and constant through process. Moisture content was recorded when weight of test sample not change more than 1 mg within 120 seconds. Moisture content was reported in unit of percentage. The tests were performed in triplicated.

RESULTS AND DISCUSSION

Physical appearance Physical appearance of extracted and spray dried anti-FMS of various formulations were dark-brown into light-brown depend on type and concentration of spray drying carriers (Figure 1). Extracted and spray dried anti-FMS without carrier had dark-brown, melting when stored at ambient condition. Nevertheless, carrier-mixed spray dried anti-FMS extract powder were less found.

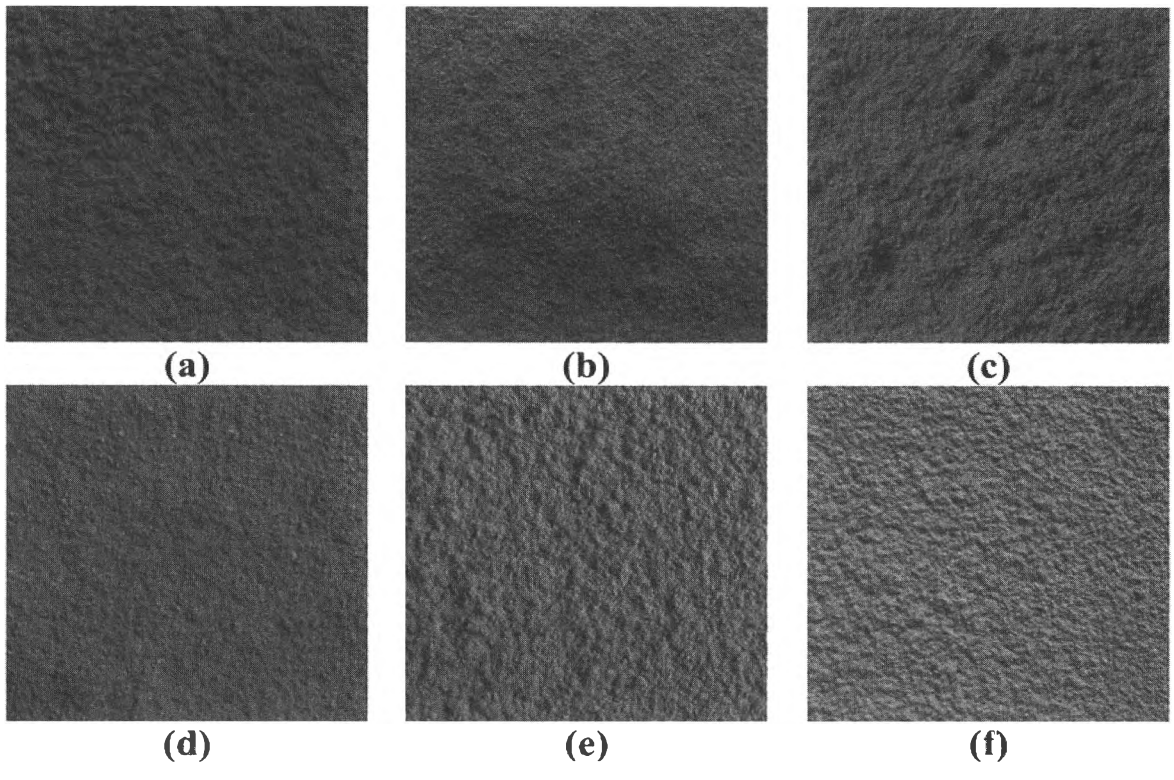

Figure 1 Physical appearance of spray dried anti-FMS herbal extract with different type and concentration of spray drying carriers (a) no carrier (b) 0.1% colloidal silicon dioxide (c) 0.5% colloidal silicon dioxide (d) 1.0% colloidal silicon dioxide (e) 10.0% maltodextrin (f) 20.0% maltodextrin (photographed by camera).

Percentage yield Percentage yield of spray dried extracted powder without carrier (F1) was 1.43%. Increasing the concentration of colloidal silicon dioxide from 0.1% to 0.5% and 1.0% increased the percentage yield that were 3.10%, 5.62%, and 6.58, respectively. In addition, when maltodextrin concentration was increased from 10.0% to 20.0%, percentage yield increased from 5.48% to 9,76% (Table 2).

Physical properties of spray dried anti-FMS herbal extract As results in Table 3, increasing spray drying carrier concentration slightly decreased the angle of repose. According to the USP 33/NF28, the flowability levels classed to 7 levels: excellent, good, fair, passable, poor, very poor and very very poor. Spray dried extract without carrier (F1) had "passable" flowability. F2 and F5 formula revealed "fair" flowability. F3 and F4 showed "good" flowability, and F6 showed "excellent" flowability. It mean that spray drying carrier improve powder flowability [4,5]. Bulk density and tapped density (or bulk volume and tapped volume) were used to calculate compressibility index and Hausner ratio. Bulk density and tapped density of spray dried extract powder had 0.36-0.53 g/cm^3 and 0.52-0.73 g/cm^3, respectively.

Compressibility index and Hausner ratio had 7 levels of tabletability. F2 and F4 had "poor" tabletability. F1, F3, and F5 formulas were "very poor" and F6 was "very, very poor" tabletability. The less value of compressibility index and Hausner ratio means high probable of powder compression into tablets or filled into capsules, such as F6 showed high flowability but low tabletability. The moisture content showed that F1 and F2 formula had high moisture content, 7.00% and 6.25%, respectively. This result revealed that colloidal silicon dioxide with concentration of 0.5% and 1.0% (F3 and F4) suitable used for spray drying of anti-FMS extract than 0.1% (F2). Higher concentration of spray drying carrier showed lower in moisture content of spray dried powder. Some publication use colloidal silicon dioxide up to 10% [6]. F3-F6 had moisture content less than 5%, especially F4 had moisture content less than 3%. Moreover, colloidal silicon dioxide had better drying performance than maltodextrin [7].

Table 3 Physical properties of spray dried anti-FMS herbal extract.

Physical properties	F1	F2	F3	F4	F5	F6
Angle of repose (°)	41±4.02	38±2.24	35±3.30	34±1.53	39±3.56	27±2.04
Bulk density (g/cm^3)	0.39±0.02	0.37±0.01	0.41±0.02	0.53±0.01	0.36±0.01	0.36±0.02
Tapped density (g/cm^3)	0.58±0.02	0.52±0.04	0.64±0.04	0.73±0.03	0.55±0.02	0.62±0.02
Compressibility index (%)	32±1.92	31±1.45	33±1.57	29±2.54	35±0.74	41±1.76
Hausner ratio	1.48±0.04	1.41±0.09	1.56±0.06	1.42±0.05	1.53±0.02	1.70±0.05
Moisture content (%)	7.00±0.18	6.25±0.22	3.73±0.05	2.95±0.16	4.14±0.26	4.12±0.10

Data represent as average±SD

CONCLUSION

Spray drying carriers play an important role for spray drying of anti-FMS extract. Both colloidal silicon dioxide and maltodextrin were used as spray drying carriers. Colloidal silicon dioxide with concentration of 0.5% and 1.0%, and maltodextrin with concentration of 10.0% and 20.0% were suitable for anti-FMS spray drying process.

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