ORIGINAL ARTICLE

Readily-dissolved edible herbal film for supression of bad breath

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ABSTRACT

Bad breath (Halitosis) is a health problem occasionally encountered among adults and children. A readily-dissolved edible herbal film was developed. The film contained lyophilized powder of the 80% ethanolic extract of guava leaves (*Psidium guajava* Linn.), Kaffir lime oil (*Citrus hystrix* DC.) and other ingredients. The film obtained was of good flexibility, resilient, non-hygroscopic and non-sticky. Sensory evaluation test was carried out, using 9-point Hedonic Scale method. The average score for overall preference was 6.3 ("like slightly" to "like moderately"). Overall appearance, flavor, and texture were evaluated as well. Suppression test was conducted to determine the capability of the film to mask of the odor of the garlic extracts *in vitro*. It was found that after adding the herbal film to the garlic suspension, all the panelists were not able to detect the garlic odor from the suspension with the corresponding minimum detection concentration of each panelist.

Keywords: *Psidium guajava*, *Citrus hystrix*, edible film, halitosis

แผ่นฟิล์มละลายเร็วชนิดรับประทานได้จากสมุนไพรเพื่อระงับกลิ่นปาก

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บทคัดย่อ

กลิ่นปากเป็นหนึ่งในปัญหาสุขภาพที่พบได้เป็นครั้งคราวทั้งในเด็กและผู้ใหญ่ ทำการพัฒนาแผ่นฟิล์มละลายเร็วชนิดรับประทานได้ แผ่นฟิล์มประกอบด้วยผงแห้งจากสารสกัด 80%เอทานอลของใบฝรั่ง (*Psidium guajava* Linn.) น้ำมันมะกรูด (*Citrus hystrix* DC.) และสารประกอบอื่น แผ่นฟิล์มที่พัฒนาได้มีคุณสมบัติยืดหยุ่นดี เหนียว ไม่ดูดความชื้นง่าย และไม่ติดมือ จากการประเมินทางประสาทสัมผัสโดยวิธี 9-point Hedonic Scale พบว่า คะแนนความชอบโดยรวมจากแผ่นฟิล์มสมุนไพร คือ 6.3 (“ชอบเล็กน้อย” ถึง “ชอบปานกลาง”) นอกจากนี้ทำการประเมินในส่วนของ ลักษณะที่ปรากฏโดยรวม รสชาติโดยรวม และเนื้อสัมผัสโดยรวม สำหรับการทดสอบการระงับกลิ่น ทำโดยการละลายแผ่นฟิล์มลงในหลอดทดลองที่มีสารแขวนลอยของผงกระเทียมอยู่ พบว่าหลังการผสม ผู้ประเมินไม่สามารถบ่งบอกถึงกลิ่นกระเทียมในความเข้มข้นน้อยที่สุดที่เคยบ่งบอกได้

INTRODUCTION

Bad breath (halitosis) is found occasionally, chronically or regularly in adults and many children at specific times of the day. In the U.S.A., public awareness and concern for this phenomenon were evidenced by an $ 850 million mouthwash industry in the United States in 1992 (Anonymous, 1992). Research reports on the etiologies of breath malodor agreed that the vast majority of halitosis originate with the anaerobic bacterial degradation of sulfur containing amino acids within the oral cavity resulting in the emission of hydrogen sulfide (H_2S), methyl mercaptan (CH_3SH), and dimethyl sulfide (CH_3SCH_3), that are collectively referred to as volatile sulfur compounds (Tonzetich, 1977; Preti *et al*, 1992; Rosenberg and MaCulloch, 1992; Yagaki and Sanada, 1992; Persson *et al*, 1990). On the other hand, bad breath has been reported to be caused by dental caries. Dental caries are caused by demineralization of the crown or root of a tooth (Lewis, 1995). Normally, the three factors involved are the causative cariogenic bacteria, *Streptococcus mutans*, the digestible carbohydrate e.g. sucrose, and the appropriate time for the bacterial fermentation. The bacteria produce insoluble, sticky glucan on the surface of the enamel from sucrose by way of an extracellular enzyme, glucosyltransferase. The water-insoluble glucan facilitates the accumulation of the bacteria on smooth surfaces (formation of dental plaque) (Hara, 1999). The accumulated bacteria produce lactic acid from available sucrose and caused demineralization. When demineralization exceeds remineralization, a loss of enamel occurs and eventually progresses into a cavity in the root (Dawes, 1989; Rolla and Saxgaard, 1990; Lewis and Ismail, 1995). When dental caries have progressed into the dental pulp and further down to the supporting bone; dental infections usually follow. Consuming strong aromatic foods, e.g. garlic, contributes to bad breath as well. Substances which represent those that cause bad breath include methyl mercaptan, allyl sulfide (garlic odor) or trimethylamine (fishy odor) (Hara, 1999).

Commercially available products for dental caries or suppression of bad breath include fluoride-containing products such as drinks, tablets, toothpastes, dental gel, mouthwash. These products are able to reduce dental caries by 20 - 50% (Lewis and Ismail, 1995). Other products contain chlorhexidine and thymol as antimicrobial varnish or mouthwash. Most of these products are inconvenient as carry-along products. Edible films, more convenient as carry-along products and containing antiseptic chemicals or green tea, are available commercially as antiseptics/antibacterial or for suppression of bad breath. They were either imported and/or expensive.

In Thailand, there are reports of some medicinal plants with suppression activity of bad breath or antibacterial activities. The leaves of Guava (*Psidium guajava* Linn., Myrtaceae) have been used, according to Thai Traditional Textbooks, for masking of the alcohol breath odor (Medicinal Plant Trade Association, 1983; Panjaphan, 1981; Phongboonrod, 1976; Piyajarn, n.d.; Anonymous, 1979; Phra-athikan Ratintaro, n.d.); other activities included uses for treatment of diarrhea (Aajsalee, 1981; Aajsalee, 1979; Iamsomboon, 1975; Medical Science Department, 1983; Medicinal Plant Trade Association, 1983; Panjaphan, 1981; Panjaphan 1979; Phongboonrod, 1976; Silpa-acha, n.d.) and dysentery (Aajsalee, 1979; Boonyachol, 1972; Iamsomboon, 1975; Medicinal Plant Trade Association, 1983; Paethong, n.d.; Phongboonrod, 1976; Pongphamorn, 1979; Pragusalo, n.d.) and in the treatment of inflammation (Aajsalee, 1981). It has been used as pus and lymph absorber (Kitikajorn, 1983; Pongphamorn, 1979; Sujamnong, 1981; Uthokapaak, 1981) and as a deodorant (Chewakakomarapach, 1974; Kaewtanang, 1977; Panjaphan, 1947; Pratepwimolmolee, 1981; Sujamnong, 1981).

The chemical constituents found in the leaves of Guava are alpha-caryophyllene, beta-caryophyllene (Tip-pyang, 1901), cineole (Fonseca, 1960), condensed tannins (Pande and Kumar, 1920), and essential oil (Bhati, 1953), etc. The essential oil of the leaves contains aromadendrene, beta-bisabolene, caryophyllene, caryopheyllene oxide, longicyclene, nerolidiol, selin-11-en-4alpha-ol, beta-selinene (Smith and Siwatibau, 1975). A 1:40 saline extract of guava leaves have been reported to show antibacterial activity against *Staphylococcus aureus*, but no activity against *Escherichia coli* (Collier and Van de Piji, 1949). The water extract of dried leaves also possessed the antibacterial activities against *S. aureus*, *Sarcina lutea*, and *Mycobacterium phei* (Malcom and Sofowora, 1969). Moreover, the water extract of guava leaves showed antibacterial activity against *Shigella dysenteriae* as well (Praserdsook and Sukchotiratana, 1986).

Kaffir lime (*Citrus hystrix* DC.) has been used as a common ingredient in Thai dishes. Kaffir lime fruit is in pear-shape, dark green in color, with wrinkled outer skin. It is believed that the essential oil contributes to the suppression of bad breath. The fruit rind of Kaffir lime (*Citrus hystrix* DC.) contained 4.4% essential oil (Boonyaratavej *et al*., 1981). The major constituents include beta-pinene, limonene, and sabinene;

other compounds included alpha-pinene, camphene, myrcene, 1,8 cineol, gamma-terpinene, para-cymene, terpinolene, trans-sabinene hydrate, citronellal, copaene, linalool, beta-cubebene, terpinen-4-ol and beta-elemene, cryophyllene, citronellyl acetate, alpha-terpineol, geranial, geranyl acetate and citronellol, delta-cardinene, geraniol, nerolidol, and elemol (Lawrence *et al*., 1971; Boonyaratavej *et al*., 1981). The alcoholic extract of the rind of Kaffir lime exhibited antibacterial activity against *Staphylococcus aureus* and *Bacillus subtilis* (Temsiririrkkul *et al*., 1994).

A previous study had shown that readily-dissolved edible film could be developed from tacca starch. The developed film still lacked the non-hygroscopic property and had short shelf-life (Srisukh *et al*., 2000). The purpose of this study was to develop a readily-dissolved edible film with non-hygroscopic property, containing dried extract of guava leaves and Kaffir lime oil to be used for the suppression of bad breath.

MATERIALS AND METHODS

Preparation of dried powder from guava extract

Guava leaves (*Psidium guajava* Linn., Myrtaceae) were obtained from Faculty of Pharmacy's Siriruckhachati Medicinal Plant Garden, Mahidol University, Salaya campus, Nakorn Pathom, Thailand. The leaves were cut into small pieces and macerated in 80% ethyl alcohol, at the ratio of 1:10 (g:ml). The guava leaves in 80% ethyl alcohol were then mixed, and blended in a blender for 1 minute. The blended mixture was then filtered through a Whatman # 4 filter paper. The extract was concentrated using a vacuum evaporator. The concentrated extract was lyophilized. The dried powder obtained was stored in dry place for further use.

Preparation of Kaffir lime oil

Kaffir lime oil was purchased from Thai China Flavors and Fragrance. It was prepared by steam distillation from the outer rind of Kaffir lime fruits.

Preparation of base film

Tacca starch (Tong Chan, Thailand) suspensions at 5, 10, 15, and 20%w/w were prepared. The starch suspensions were then gelatinized at 70 - 75 ^{O}C with constant stirring until a translucent paste was obtained. Pre-weighed gelatinized paste was poured into a 0.02 inch thin-layer spreader onto a preheated non-stick metal surface at 40 - 45 ^{O}C. The paste was spread into a long rectangular shape. The dried film which separated itself from the surface was then removed. The film was then determined for average thickness from 3 measurements using a micrometer (Mitutoyo, Japan) with a measuring range of 0 - 25 mm. The starch suspension which provided the best attributes was selected for further development.

The selected concentration of tacca starch was replaced in part or totally by carrageenan (Italy, through Union Chemical 1986, Thailand) at 0, 2.5, 5.0, 7.5, 10.0, 12.5, and 15.0 %w/w. The suspensions, paste, and film were prepared as previously described. The combination which provided the best attributes of the film was selected for further development.

Preparation of herbal film

Determination of the optimal herbal concentration

The dried guava powder was incorporated into the selected formula of tacca starch and carrageenan suspension at 1, 3, and 5% w/w. It was then gelatinized, and prepared into films as previously described. The dried guava powder concentration which provided the best attributes was selected for further development. Kaffir lime oil, at 0.1, 0.3, and 0.5%w/w was separately incorporated into the prepared paste. The film was then prepared as previously described. The Kaffir lime oil concentration which provided the best attributes was selected for further development.

Preparation of herbal film with maltodextrin

The selected formula of tacca starch-carrageenan-dried guava powder suspension was prepared into a paste. In separate containers, Kaffir lime oil, at selected concentrations, was added onto maltodextrin (DE=10-12, Staley, U.S.A.) (at 0.5-2%w/w). The paste was then added to the Kaffir lime oil-maltodextrin container. The film was prepared as previously described. The proportion that provided the optimal attributes was selected for further development.

Preparation of herbal film with gelatin, pectin, and maltodextrin

Tacca starch, carrageenan, gelatin (160 Bloom, BP, Union Chemical 1986, Thailand) (at 1, 2, and 3%w/w), pectin (Union Chemical 1986, Thailand)(at 1, 2, and 3%w/w), and dried guava powder were prepared into a paste. Selected proportion of maltodextrin-Kaffir lime oil was prepared in a separate container. The paste was then added to the maltodextrin-Kaffir lime oil mixture and thoroughly mixed. It was then prepared into film. The proportion which provided the best attributes was selected for further development.

Preparation of herbal film with flavorants

Tacca starch, gelatin, guava powder, and aspartame (Nutrasweet, Thailand) (at 1-5%w/w) were prepared into pastes. In a separate container, maltodextrin, Kaffir lime oil, and peppermint oil (Union Chemical 1986, Thailand) (at 0.1-0.5%w/w) were mixed. The paste was then added to the mixture and prepared into film. The proportion that provided the best attributes was selected as the final formula of the suspension for herbal film. The thickness of the film was measured using a micrometer, the average thickness of 3 measurements was recorded. The film was then cut into 2.2 x 1.6 cm^2 pieces and stored at room temperature in a dry place. The herbal film pieces were evaluated for the hygroscopic property (lack of smoothness, waviness of the surface, stickiness to touch), brittleness (broken after slight bending), resilience (flexibility after slight bending) at the time of preparation, 1, 2, 3, and 4 weeks.

Sensory evaluation of the herbal film

Ten panelists were recruited for the sensory evaluation test, using 9-point Hedonic Scale method. Each panelist was provided with a 2.2 x 1.6 cm^2 piece of the herbal film and asked

to evaluate the attributes as follows:

-Overall appearance (color, intensity of color, smoothness)

-Overall flavor (sweetness, saltiness, coolness)

-Overall texture (dissolution, thickness, residue, moisture)

-Overall preference

The panelists were asked to record the time to dissolve the film. The average scores and the average time were determined. The sensory test was carried out in 2 separate sessions among 10 panelists.

Test for suppression of bad breath

Determination of saliva produced in 1 minute

Five recruited volunteers were asked to put a pre-weighed guaze piece in the mouth for 1 minute. The soaked gauze pieces were individually weighed. The average weight of the saliva produced in 1 minute was determined. The density of the saliva was determined by weighing 1 ml of the saliva. The volume (V) of the saliva produced in 1 minute was determined.

Selection of panelists

In a screw-capped test tube, a suspension of dried garlic powder in water at 0.001% w/v was prepared. The total volume was equal to V ml, as previously determined. In a separate test tube, V ml of water was added. Panelists were asked to differentiate between the two tubes. Ten panelists who passed the screening test were recruited for the subsequent duplicate determinations.

Determination of the minimum detection concentration of the individual panelist

All the panelists were asked to sniff 6 tubes of garlic suspensions; the concentration of the garlic powder in the suspension was 0.0005, 0.001, 0.005, 0.01, 0.05, and 0.1%w/v. The minimum concentration which each panelist was able to detect was recorded.

Determination of the suppression of garlic odor

The minimum detection of each panelist was selected for the suspension test. A piece of the herbal film, 2.2x1.6 cm^2, was added to screw-capped test tube of V ml of the selected concentration of garlic suspension. Test tubes with higher concentration of garlic powder were prepared as described. The test tubes were then incubated in a water bath at 37 ^{o}C with constant stirring until the film was dissolved. Panelists were asked to detect the garlic odor, starting from the tube with minimum detection concentration. Test tubes with higher concentrations were presented in ascending order. The two consecutive concentrations of the garlic suspension which the panelists were able to detect were recorded.

RESULTS

Preparation of dried guava powder

The dried guava powder obtained from guava leaf extract was green in color, free-flowing, light, but hygroscopic. The yield of the powder from the guava leaves was 6.87%w/w.

Preparation of base film formula

Optimal concentration of tacca starch

The tacca starch suspension at 5, 10, 15, and 20%w/w provided pastes and films as shown in Table 1. The concentration that provided the best attributes of paste and film was 15%w/w.

Optimal concentration of carrageenan

When carrageenan was used to replace tacca starch partially or totally, the results of the pastes and films were as shown in Table 2. It was found that the combinations that provided the best attributes were tacca starch:carrageenan at 15.0:0, 12.5:2.5, and 10.0:5.0.

Preparation of herbal film

Optimal concentration of dried guava powder

Dried guava powder was incorporated at 1, 3, and 5%w/w into the selected formula of tacca starch and carrageenan suspension. The attributes of the paste and film were as shown in Table 3. The combination which provided the best attributes of paste and film were tacca starch:carrageenan :dried guava powder at 12.5:2.5:1, 12.5:2.5:3, 10.0:5:1, 10.0:5:3.

Optimal concentration of Kaffir lime oil

Kaffir lime oil was incorporated into the 3 selected formulae of tacca starch:carrageenan at 0.1, 0.3, and 0.5%w/w. The results were shown in Table 4. The combination which provided the best attributes were tacca starch:carrageenan:Kaffir lime oil at 10.0:5.0:0.1 and 10.0:5.0:0.3.

Optimal concentration of maltodextrin

Maltodextrin was incorporated in the selected formula. Higher concentration of Kaffir lime oil and maltodextrin formula was prepared as well. The results were as shown in Table 5. The combination which provided the best attributes was tacca starch:carrageenan:Kaffir lime oil:maltodextrin:dried guava powder at 10.0:5.0: 0.3:1.0:1.0

Optimal concentration of gelatin and pectin

Gelatin at 1, 2, and 3%w/w was incorporated into the formulation. It was found that gelatin at 2%w/w and pectin at 1%w/w provided the best attributes to the film produced.

Optimal concentration of flavorants

Peppermint oil at 0.1 - 0.5%w/w and Aspartame at 1 - 5%w/w were incorporated into the formula. It was found that Peppermint oil and Aspartame, both at 0.1%w/w provided the best attributes to the film. The final formula was as shown in Table 6.

Property of the herbal film

The average thickness of the herbal film was 0.3 mm. The film was smooth, non-hygroscopic (not wavy, non-sticky to touch), not brittle (not broken when bended slightly), and resilient (flexible when bended slightly) at the time of preparation, and at 1, 2, 3, and 4 weeks as well.

Table 1 Attributes of pastes and films prepared from tacca starch at various concentrations

Tacca starch concentration (%w/w)	Paste attributes				Film attributes				
	Color and Clarity/opacity	Viscosity	Air bubble	Spreadability	Peeling	Smoothness	Resilience/ brittleness	Thickness (mm)	Dissolving time (sec)
5	Clear	+	None	Not spreadable	No film formed				
10	Clear	+	None	Not spreadable	No film formed				
15	Clear	++	+	Continuous	Readily	Smooth	Not brittle	0.030	3
20	Clear	+++	++	Continuous	Readily	Smooth	Not brittle	0.030	6

+ = low, ++ = medium, +++ = high

Table 2 Attributes of pastes and films from various combinations of tacca starch: carrageenan

Tacca starch: carrageenan (%w/w)	Paste attributes				Film attributes				
	Color and Clarity/opacity	Viscosity	Air bubble	Spreadability	Peeling	Smoothness	Resilience/ brittleness	Thickness (mm)	Dissolving time (sec)
15.0:0	Clear	++	+	Continuous	Readily	Smooth	Not brittle	0.030	3
12.5:2.5	Clear	++	++	Continuous	Readily	Smooth	Not brittle	0.035	5
10.0:5.0	Clear	++	++	Continuous	With force applied	Smooth	Not brittle /resilient	0.035	8
7.5:7.5	Yellow, opaque	+++	++	Not continuous	Difficult	Smooth	Not brittle /resilient	0.050	20
5.0:10.0	Yellow, opaque	++++	None	Not spreadable	No film formed				
2.5:12.5	Yellow, opaque	++++	None	Not spreadable	No film formed				
0:15.0	No paste formed				No film formed				

+ = low, ++ = medium, +++ = high, ++++ = very high

Table 3 Attributes of paste and film prepared from various combinations of tacca starch: carrageenan:dried guava powder

Tacca starch: Carrageenan: dried guava powder (%w/w)	Paste attributes				Film attributes				
	Color and Clarity/opacity	Viscosity	Air bubble	Spreadability	Peeling	Smoothness	Resilience/ brittleness	Thickness (mm)	Dissolving time (sec)
15.0:0:1	Green, clear	++	None	Continuous	Readily	Not smooth	Brittle	0.048	6
15.0:0:3	Green, opaque	++	None	Continuous	Readily	Not smooth	Brittle	0.035	6
15.0:0:5	Green, opaque	+++	None	Continuous	Readily	Not smooth	Very brittle	0.060	14
12.5:2.5:1	Green, opaque	++	+	Continuous	Readily	Smooth	Sticky	0.030	5
12.5:2.5:3	Green, opaque	++	+	Continuous	Readily	Smooth	Sticky	0.030	4
12.5:2.5:5	Green, opaque	+++	+	Continuous	Readily	Smooth	Sticky	0.032	4
10.0:5.0:1	Green, opaque	++	+	Continuous	Readily	Smooth	Sticky	0.035	5
10.0:5.0:3	Green, opaque	++	+	Continuous	Readily	Smooth	Sticky	0.033	6
10.0:5.0:5	Green, opaque	+++	+	Continuous	Readily	Smooth	Sticky	0.035	6

+ = low, ++ = medium, +++ = high

Table 4 Attributes of paste and film prepared from various combinations of tacca starch: carrageenan:Kaffir lime oil

Tacca starch: Carrageenan :Kaffir lime oil (%w/w)	Paste attributes				Film attributes				
	Color and Clarity/ opacity	Viscosity	Air bubble	Spreadability	Peeling	Smoothness	Resilience/ brittleness	Thickness (mm)	Dissolving time (sec)
15.0:0:0.1	Clear	++	None	Not spreadable	No film formed				
15.0:0:0.3	Clear	++	None	Not spreadable	No film formed				
15.0:0:0.5	Clear	++	None	Not spreadable	No film formed				
12.5:2.5:0.1	Clear	++	None	Not spreadable	No film formed				
12.5:2.5:0.3	Clear	++	+	Not spreadable	No film formed				
12.5:2.5:0.5	Clear	++	+	Not spreadable	No film formed				
10.0:5.0:0.1	Clear	++	None	Porous	With force applied	Smooth	Slightly brittle	0.030	5
10.0:5.0:0.3	Clear	++	+	Porous	With force applied	Smooth	Slightly brittle	0.030	5
10.0:5.0:0.5	Clear	++	+	Not spreadable	No film formed				

+ = low, ++ = medium

Table 5 Attributes of paste and film prepared from 2 combinations of tacca starch: carrageenan: Kaffir lime oil:maltodextrin:dried guava powder

Tacca starch: Carrageenan: Kaffir lime oil maltodextrin:dried: guava powder (%w/w)	Paste attributes				Film attributes				
	Color and Clarity/ opacity	Viscosity	Air bubble	Spreadability	Peeling	Smooth ness	Resilience/ brittleness	Thickness (mm)	Dissolving time (sec)
10.0:5.0:0.3:1.0:1.0	Clear	++	+	Continuous	With force applied	Smooth	Slightly brittle	0.03	5
10.0:5.0:0.5:1.67:1.0	Clear	++	+	Slightly porous	With force applied	Smooth	Slightly brittle	0.03	13

+ = low, ++ = medium

Table 6 Ingredients of the suspension formula for herbal film

Ingredients	Amounts (w/w)
Tacca starch	10.0
Carrageenan	5.0
Dried guava powder	1.0
Kaffir lime oil	0.3
Maltodextrin	1.0
Gelatin	2.0
Pectin	1.0
Aspartame	0.1
Peppermint oil	0.1
Water q.s.	100.0

Table 7 Odor suppression test of the herbal film

Panelist	Minimum detection concentration of garlic suspension (%w/v)	
	Without herbal film	With herbal film
1	0.0005	0.005
2	0.0005	0.005
3	0.0005	0.005
4	0.0005	0.005
5	0.0010	0.005
6	0.0010	0.010
7	0.0010	0.005
8	0.0010	0.010
9	0.0010	0.005
10	0.0050	0.050

Sensory evaluation test of the herbal film

Sensory evaluation test of the herbal film was carried out , using 9-point Hedonic Scale method. The average score for overall appearance (color, intensity of color, smoothness) was 5.6 ("neither like nor dislike" to "like slightly") whereas the average scores for overall flavor (sweetness, saltiness, coolness) and the overall texture (dissolution, thickness, residue, moisture) were 6.15 and 6.85 ("like slightly" to "like moderately"), respectively. The average score for overall preference of the film was 6.3 ("like slightly" to "like moderately"). The average dissolving time of the film was 16 seconds.

Suppression of odor

Of the ten panelists recruited for the odor suppression test, it was found that the minimum detection concentration of the panelists were 0.0005%w/v (4 panelists), 0.001%w/v (5 panelists) and 0.005% (1 panelist). When the herbal film was dissolved in the garlic suspension (volume V = 0.48 ml), all of the panelists were unable to detect the garlic odor at the corresponding minimum detection concentrations as performed previously. The results were as shown in Table 7

DISCUSSION

Base film formula

In the determination of the concentration of tacca starch in the formula which provided the best attributes, it was shown that the tacca starch concentration of 15%w/w provided paste with optimal viscosity, and spreadability. The film obtained had good attributes. It was self-peeling, smooth, not brittle and readily-dissolved. The tacca starch concentration of 5 and 10%w/w provided paste with low viscosity and unspreadable whereas the 20%w/w suspension provided paste with high viscosity and unspreadable. Since the film from the tacca starch suspension still lacked flexibility, carrageenan was incorporated to increase the flexibility. Although it was found that carrageenan at 2.5 and 5%w/w provided good attributes to the film obtained, the tacca starch suspension without carrageenan provided film with good attributes as well (as recorded immediately after the preparation). At higher concentration of carrageenan the paste became too viscous, difficult to spread, and took longer time to dissolve.

Preparation of herbal film

At 5%w/w of dried guava powder, the film obtained was brittle, not smooth since the concentration of the guava powder was too high. The bitter flavor of the film was also distinct for the formula with guava powder at the concentration higher than 3%w/w. So the optimal concentration of dried guava powder was 1%w/w. Since Kaffir lime oil was immiscible with the paste which was water base, maltodextrin was used to adsorb Kaffir lime oil to facilitate the mixing of the oil with the paste. At 0.5%w/w of Kaffir lime oil, the paste was unspreadable; the oil tended to interfere with the spreading process. With the high concentration of maltodextrin, the film was stiff, inflexible, thus 0.3%w/w Kaffir lime oil was the highest concentration of the oil which could be

incorporated into the paste. Since the film still showed slight brittleness, it was further developed.

Gelatin and pectin, at 2, and 1%w/w, respectively, increased the flexibility of the herbal film. On the other hand, guava powder precipitated slightly and subsequently caused lumpy paste when gelatinized.

Aspartame was included to provide sweetness at low concentration. Peppermint oil aroma was compatible with Kaffir lime oil and refreshing the breath.

Property of the herbal film from the final formula. Normally, among the edible starch films, the linear starch polymer amylose produces a hydrophilic film with low oxygen permeability. Hydroxylated amylose also yields film with very low oxygen permeability (Nisperos-Carriedo, 1994). Since the films, both in the previous study and in this study, contained tacca starch, hydrophilic films with low oxygen permeability would be expected. One drawback of most edible films was the moisture sensitivity (Miller and Krochta, 1997). According to the previous study of the herbal film using tacca starch as the main film base ingredient (Srisukh *et al*., 2000), the film produced turned hygroscopic after only a short period of storage (< 1 month). The stored film in the previous study lost its smoothness and transformed into a wavy film which was sticky when touched. It became more brittle, easily broken when it was slightly bended. In this study, the herbal film showed better attributes. The inclusion of carrageenan improved the flexibility while pectin and higher concentration of gelatin (2%w/w against 1.25%w/w in the formula from the previous study) decreased the brittleness of the film, thus providing the film with more resilience. Better resilience enhanced subsequent film handlings, providing the film which was more practical to consume. The film obtained in this study was non-hygroscopic, retained its smoothness, flexibility and resilience throughout one-month storage at room temperature. It retained its property, similar to the property at the time of preparation. Further study on the property during longer storage of the herbal film should be carried out.

Sensory evaluation of the herbal film

Overall appearance. When the panelists were asked to evaluate the color, the intensity of color and the smoothness of the herbal film, the average score obtained was 5.6 ("neither like nor dislike" to "like slightly"). Since no colorants was added to the formula, the film's color was faint natural green contributed by dried guava powder. The faint color might be the undesirable attribute contributing to the low score obtained for the overall appearance. The film was moderately smooth.

Overall flavor. Sweetness, saltiness, and coolness were the attributes contributing to the overall flavor of the herbal film. The average score obtained was 6.15 ("like slightly" to "like moderately"). Aspartame and carrageenan contributes the sweet and salty taste to the film, respectively. Peppermint oil contributes the coolness and refreshing taste to the film. The concentration of peppermint oil was limited due to its immiscibility with the paste.

Overall texture. After the panelists evaluate the dissolution, thickness, residue on the tongue and the moisture of the film, the average score obtained was 6.85 ("like slightly" to "like moderately"). The herbal film readily dissolved at 16 seconds which was longer than the dissolving time of the film from the previous study (10 seconds) (Srisukh et al, 2000). Carrageenan, while improving the flexibility of the film, was believed to be responsible for the undesirable increase in the dissolving time. A slight residue was found on the tongue. The film was not sticky when touched, a desirable quality of the film and an improvement to the film from the previous study. Further development was suggested to reduce the dissolving time and the residue.

Overall preference. Three attributes were evaluated, i.e. overall appearance, flavor, and texture. The average score was 6.3 ("like slightly" to "like moderately"). The herbal film should be developed further in order to obtain a higher score in overall preference.

Suppression of bad breath

For the test on suppression of bad breath, the garlic odor suppression test was carried out to evaluate the suppression property of the herbal film. Dried garlic powder at the concentration of 0.0005, 0.001, 0.005, 0.01, 0.05, and 0.1%w/v were included in the test. The herbal film was dissolved in the garlic suspension as described. The panelists detection concentrations were higher when the suspension included the herbal films. The herbal film was capable of increasing the minimum detection concentration 10 times in seven of the panelists (70%) and 5 times in three of the panelists (30%).

CONCLUSION

In this study, a readily-dissolved edible herbal film was developed from a formula with the drawbacks of hygroscopic property and brittleness during storage in a previous study. The herbal film contained Kaffir lime oil and guava powder in a tacca starch-based formula. Carrageenan was introduced into the formula; it improved the flexibility of the film. Gelatin and pectin contents were adjusted and they jointly reduced the brittleness of the film. Although the dissolving time increased slightly from the previous study, the produced film in this study retained its original non-hygroscopic property, flexibility, and resilience during a one-month storage at room temperature. In the suppression test, the herbal film increased the minimum detection concentrations of garlic odor among all of the panelists.

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