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Effect of the Encapsulating Matrix on the Dehydration of Papaya Fruit (*Carica Papaya.* L)

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Abstract

The objective of this research is to prepare the encapsulated papaya powder as food colorants and to determine the optimum operating condition of encapsulation. The effect of the type and amount of encapsulating matrix (coating material) on the dehydration of papaya fruit was determined based on the product color and solubility. The acceptability of the product was tested through chemical analysis such as moisture content, total fibre content, ash content, protein content, Vitamin-C content, total soluble solid (°Brix), pH, water absorption Index, water solubility index, loose bulk density (g/ml) and packed bulk density (g/ml), element content, appearance and solubility of the encapsulated papaya powder.

Key words: encapsulation, encapsulating matrix (core material) coating material

Introduction

Color is one of the most important visual attributes of food materials. Food colorants are usually classified as either natural (or nature-identical) or synthetic. Natural colorants are generally more sensitive to light, temperature, pH and redox agents. One of the most consumed carotenoid groups of pigments are responsible for the yellow, orange and red color of many foods, continue to be intensely investigated mainly because of their health-promoting effect.

Carica papaya (family: Caricaceae) belongs to the fruits and vegetable class. Practically, every part of the plant is of economic value and its use ranges from nutritional to medicinal. The fruits are popularly used as desert or processed into jam, puree or wine, while the green fruits are cooked as vegetable. The seeds are medicinally important in the treatment of sickle cell diseases, poisoning related disorder. The leaf tea or extract has a reputation as a tumor destroying agent.

Carica papaya (pawpaw) is a source of carotenoids, Vitamin C, thiamine, riboflavin, niacin, Vitamin B-6 and Vitamin K. The carotenoids are responsible for the flesh color of the fruit mesocarp (fruit pulp). The red-fleshed papaya (pawpaw) contains five beta carotene: beta-crytonanthin, beta carotene -5-6-epoxide, lycopene and zetacarotene while the yellow fleshed contains only beta carotene, beta-cryptoxantain and zetacarotene.

Microencapsulation has numerous applications in chemical processing and in the food industry for coating aroma compounds and oleoresins, vitamins, colorants and enzymes. Encapsulated colors are easier to handle and offer improved stability.

In this study, pectin, maltodextrin and gelatin were used as coating materials. The main purpose of this study was to prepare the encapsulated papaya powder and to focus on determining the effect of encapsulating matrix, the physico-chemical properties and solubility of the encapsulated papaya powder.

Materials and Methods

Fresh, mature and ripe papaya fruit (*Carica papaya* L.) was collected from Pyin Oo Lwin Township,Mandalay Region. Pectin, gelatin and maltodextrin were used as the matrix (coating materials) for microencapsulation. Tween 80 (Polysorbate 80) (commercial grade) was used as an emulsifier for the stabilization of the emulsions.

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Phytochemical Investigation of the Fresh, Mature and Ripe Papaya (*Carica papaya* L.)

Phytochemical investigation was carried out according to the following standard procedures.Test for alkaloids, tannins, protein, phenol, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds were carried out and results of phytochemical investigations of Papaya are shown in Table (1).

Preparation of Encapsulated Powder

Fresh mature and ripe papaya fruit were thoroughly washed with water, peeled and cut into about 1 cm length and seeds were removed. Papaya juice was extracted by using blender and the extraction of natural color from papaya juice 100 g was done by mixing 100 g of papaya with pectin 2 g and then 0.5 g of Tween-80 was added to the mixture as emulsifying agent. Then, the mixture was stirred, using a magnetic stirrer for 30 minutes. The mixture was dried in a hot air oven at 60^{o}C for about 9 hours. Finally, the dried matter was ground and sieved with 160 mesh by using sieve shaker. Then, the powder obtained was collected in air-tight bags and stored in the desiccator for analysis. Effect of amount of different coating material such as pectin, gelatin and maltodextrin on yield percent of encapsulated papaya powder were shown in Tables (2),(3) and (4).

Determination of Solubility Test

About (15) drops of each various solvents such as water, vegetable oil, ethyl alcohol, acetic acid, acetone, formaldehyde and petroleum ether were placed in test tubes and about (0.01 g) of the encapsulated powder with pectin was added to each of the solvents. The tubes were shaken vigorously for 5 minutes and its solubility was noted at room temperature.

Determination of Elements in Encapsulated Papaya Powder by X-ray Fluorescencs Spectrometry (XRF)

The analysis of major and trace elements in encapsulated Papaya powder were measured by using X-ray Fluorescence Spectrometry (XRF). The data are shown in Table (9).

Evaluation of the Physico-chemical Characteristics of Encapsulated Papaya Powder

Physico-chemical analysis of prepared encapsulated papaya powder sample with pectin such as moisture content, total fibre content, ash content, protein content, Vitamin-C content, total soluble solid (°Brix), pH, water absorption Index, water solubility index, loose bulk density (g/ml) and packed bulk density (g/ml) were determined and the results are shown in Table (8).

Results and Discussion

Papaya (*Carica papaya* L.) is well known for its expectional, nutrional and medicinal properties throughout the world. The whole papaya plant including its leaves, seeds, ripe and unripe fruits and their juice is used as a traditional medicine. It is a rich source of three powerful antioxidant Vitamin C, Vitamin A and Vitamin E; the minerals, magnesium and potassium; the B Vitamin pantothenic acid and folate and fiber.

The aim of the present research is to prepare a natural orange color from papaya as a food color by using encapsulation technique. The effect of ratio of core to coating material (encapsulating matrix) on the dehydration of papaya fruit was determined based on product color and solubility was analyzed for the optimization study.

The phytochemical investigation, chemical analysis of fresh papaya and the solubility of product with different reagents were also determined. The phytochemical analysis of papaya revealed the presence of alkaloids, tannins, proteins, phenols, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds. The presence of tannin contributes towards antioxidant activity of food. According to the literature, main papayas nutrution's are phenolic compounds, carotenoids, soluble dry matter, β carotene, sugars and others.

Compounds found in the papaya influence the flavor of the papaya include the sugar (glucose, fructose, sucrose) which contribute to sweetness and phenolic compounds which impart bitterness (Table 1).

For the preparation of encapsulated papaya powder, coating materials (pectin, gelatin and maltodextrin) were used for the encapsulated papaya powder .From Table (2), the suitable amount of coating material(pectin) 2 g and the amount of emulsifier (Tween-80) 0.5 g, the stirring time 30 min, the drying temperature 60^{o}C and drying time 9 hours were the suitable conditions for the preparation of encapsulated papaya powder because pectin 2 g gave the orange color solution and the encapsulated powder was soluble in cold water although the yield percent was increased.

According to Table (3),the amount of coating material (gelatin) 2 g, the amount of emulsifier (Tween-80) 0.5 g, the drying temperature 60^{o}C and drying time 9 hours were the appropriate conditions for the preparation of encapsulated papaya powder while gelatin was used as coating materials from the point of view of appearance, yield percent and solubility.

From Table (4), it was noted the increased amount of coating material (maltodextrin) influenced the color and appearance of encapsulated powder. The amount of coating material (maltodextrin) 1 g was suitable for papaya juice 10 g.

On comparing the solubility of encapsulated powders derived from pectin, gelatin and maltodextrin, the encapsulated powder with gelatin was insoluble in formaldehyde, petroleum ether, slightly soluble in vegetable oil, soluble in ethyl alcohol, fairly soluble in water, acetic acid and precipitate was formed in acetone. Encapsulated powder with pectin was slightly soluble in acetone, soluble in vegetable oil, ethyl alcohol, very soluble in water, acetic acid, formaldehyde and petroleum ether. The encapsulated powder with maltodextrin was insoluble in petroleum ether, slightly soluble in water, ethyl alcohol, acetic acid, acetone, and formaldehyde, shown in Table (6).

From the analysis of solubility and color reaction of encapsulated papaya powder using different coating materials with different reagents, pectin was the suitable coating material for the preparation of encapsulated powder, shown in Table (5), and (7). According to Table (7), it was noted that the solubility of color depends on the nature of food products (alkali/acid media).

According to Table (8) protein content of encapsulated powder was higher than that of fresh papaya and pH value of encapsulated powder was lowered than that of fresh papaya.

From the literature review, bulk density depends on water content and particle size and it is important for packaging and shipping considerations. Particle size distribution plays a major role in processing, handling and shelf life and the microstructure is related to powder's functionality, stability and flowability. The water absorption index, water solubility index, loose bulk density (g/ml) and packed bulk density (g/ml) of encapsulated papaya powder were 1.83, 50.78, 0.38, and 0.53, respectively (Table 8).

It was also noted that the potassium content and calcium content of encapsulated papaya powder were higher than that of fresh papaya and the iron content of encapsulated papaya powder was lower than that of fresh papaya (Table 9).

Comparison of shelf-life on encapsulated papaya powder using different coating materials (pectin, gelatin, maltodextrin) are shown in Table (10) and Encapsulated papaya powder could be used as a natural color for the preparation of food such as Jelly, shown in Figure (1) (d) . For the preparation of encapsulated papaya powder, pectin was the suitable encapsulating matrix (core material) from the point of view of solubility, color appearance and shelf-life.

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Table (1) Phytochemical Investigation of Raw Papaya Powder

No.	Text	Solvent	Reagent	Observation	Result
1.	Alkaloids	1% HCl	Wagner's reagent, Dragendroff's reagents	Blue and bluish black	+
2.	Tannins	H_2O	Gelatin and 1% $FeCl_3$	Pale Yellow	+
3.	Protein	H_2O	10% NaOH solution and 3% $CuSO_4$ solution	Reddish brown	+
4.	Phenols	H_2O	10% aqueous $FeCl_3$	Greenish yellow color	+
5.	Glycosides	H_2O	10% NaOH solution	Pale yellow ppt.	+
6.	Flavonoids	EtOH	Conc: HCl & Mg ribbon	Pale green color	+
7.	Saponins	H_2O	Distilled Water	Frothing	+
8.	Reducing Sugar	H_2SO_4	5 N NaOH solution & Benedict's solution	Pale brown color	+
9.	Carbohydrates	H_2O	10% α-naphthol and H_2SO_4	Purple ring	+
10.	Phenolic Compounds	H_2O	Benedict's solution	Brown ppt.	+

(+) Present (-) Absent ppt. = precipitate

These experiments were carried out at Laboratory of Industrial Chemistry Department, Yadanabon University

Table (2) Effect of Amount of Pectin on Yield Percent of Encapsulated Papaya Powder

Papaya Juice =100 g Stirring Time =30 min Drying Temperature=60ºC

Amount of Emulsifier (Tween-80) =1 g

Sr.No	Pectin (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water (20-25ºC)	Hot water (100ºC)
1	0.5	5.12	pale orange, cloudy solution	soluble in water, a large amount of ppt. was formed after one night.	soluble
2	1.0	6.55	pale orange, cloudy solution	soluble in water, a large amount of ppt. was formed after one night.	soluble
3	1.5	7.51	orange, cloudy solution	soluble in water, a large amount of ppt. was formed after one night.	soluble
4	*2.0	9.01	Bright orange, clear solution	soluble in water, a fair amount of ppt. was formed after one night.	soluble
5	2.5	10.03	yellow, cloudy solution	soluble in water, a large amount of ppt. was formed after one night.	soluble

* Most Suitable Amount of Pectin Note: ppt = precipitate

Table (3) Effect of Amount of Gelatin on Yield Percent of Encapsulated Papaya Powder

Papaya Juice =100 g Stirring Time =30 min Drying Temperature=60ºC
Amount of Emulsifier (Tween-80) =1 g

Sr. No	Pectin (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water (20-25ºC)	Hot water (100ºC)
1	1	7.12	orange, cloudy solution	soluble in water, a large amount of ppt was formed after one night	soluble
2	*2	8.33	bright orange, clear solution	soluble in water, a fair amount of ppt was formed after one night	soluble
3	3	9.58	yellow, cloudy solution	soluble, a large amount of ppt was formed after one night	soluble
4	4	10.96	yellow, cloudy solution	incompletely soluble, a large amount of ppt was formed after one night	soluble
5	5	11.01	pale orange, cloudy solution	incompletely soluble, a large amount of ppt was formed after one night	soluble

* Most Suitable Amount of Pectin Note: ppt = precipitate

Table (4) Effect of Amount of Maltodextrin on Yield Percent of Encapsulated Papaya Powder

Papaya Juice =100 g Stirring Time =30 min Drying Temperature=60ºC
Amount of Emulsifier (Tween-80) =1 g

Sr.No	Pectin (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water (20-25ºC)	Hot water (100ºC)
1	0.5	8.42	orange, clear solution	soluble in water, a few amount of ppt was formed after one night	soluble
2	*1.0	10.86	bright orange, clear solution	soluble in water, a fair amount of ppt was formed after one night	soluble
3	1.5	10.09	orange, clear solution	soluble, a few amount of ppt was formed after one night	soluble
4	2.0	10.52	orange, cloudy solution	soluble, a large amount of ppt was formed after one night	soluble
5	2.5	11.89	orange, cloudy solution	soluble, a large amount of ppt was formed after one night	soluble

* Most Suitable Amount of Pectin Note: ppt = precipitate

Table (5) Comparison of Coating Materials on the Characteristics of Encapsulated Papaya Powder

Papaya Juice=100 g   Amount of Emulsifier (Tween-80)=0.5 g

Stirring Time= 30 min   Drying Temperature=60^{o}C

No.	Types of Coating Mater-ials	Yield Percent (% w/v)	Appearance of 5% Encapsulated Powder Solution	Color				Solubility	
				Violet	Blue	Green	Red	Cold Water (20-25^{o}C)	Hot Water (100^{o}C)
1.	*Pectin	9.01	Bright orange, clear solution	0.96	0.81	0.16	0.08	Soluble in water, a few amount of ppt. was formed after one night.	Very soluble
2.	Gelatin	8.33	Bright orange, clear solution	0.55	0.46	0.12	0.05	Soluble in water, a few amount of ppt. was formed after one night.	Soluble
3.	Maltodextrin	10.86	Bright orange, clear solution	0.90	0.76	0.17	0.09	Soluble in water, a few amount of ppt. was formed after one night.	Soluble

Note: ppt. = precipitate   * Soluble Coating Material

Table (6) Comparison of Solubility on Encapsulated Papaya Powder Using Different Coating Materials
(Pectin, Gelatin, and Maltodextrin) in Different Solvents

Amount of Encapsulated Papaya Powder = 0.01 g

Volume of Solvent = 15 drops

No.	Coating Mateirals	Solubility						
		Water	Ve-getable Oil	Ethyl Alcohol	Acetic Acid	Acetone	Formald-ehyde	Pet-Ether
1.	*Pectin	Very Soluble	Soluble	Soluble	Very Soluble	Slightly Soluble	Very Soluble	Very Soluble
2.	Gelatin	Fairly Soluble	Slightly Soluble	Soluble	Fairly Soluble	Fairly Soluble, ppt was formed	Insoluble	Insoluble
3.	Maltodext-rin	Slight Soluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Insoluble

Note: ppt. = precipitate

Table (7) Color Reactions of Encapsulated Papaya Powder Using Different Coating Materials with Different Reagents

Amount of Encapsulated Papaya Powder =0.01 g

Volume of Reagent =15 drops

No.	Samples	Different Reagents		
		(% w/v) Sodium Hydroxide Solution	Hydrochloric Acid (Conc:)	Sulphuric Acid (Conc:)
1.	Encapsulated powder with pectin	bright orange	yellow	yellow
2.	Encapsulated powder with gelatin	dark brown	orange	yellow
3.	Encapsulated powder with maltodextrin	orange	orange	pale yellow

Table (8) Chemical Characteristics of Encapsulated Papaya Powder by Using Pectin as Coating Material

No.	Characteristics	Experimental Values (per 100 g)	Literature Value for Fresh Papaya (per 100 g)
1.	*** Moisture (%)	7.10	85.7
2.	** Crude Fiber (%)	0.065	1.7
3.	** Ash (%)	4.42	5.8
4.	** Protein (%)	50.31	3.74-8.26
5.	** Vitamin-C (%)	0.215	-
6.	*** Total Soluble Solid (^{o}Brix)	6.0	12.94
7.	*** pH	4.5	5.2
8.	WAI**	1.83	-
9.	WSI*	50.78	-
10.	Loose Bulk Density (g/ml)	0.38	-
11.	Packed Bulk Density (g/ml)	0.53	-

** These values were measured at Myanmar Pharmaceutical Factory (Sagaing), Ministry of Industry

*** These values were measured at Laboratory of Industrial Chemistry Department, Yadanabon University

WSI*= Water Solubility Index WAI**= Water Absorption Index

Table (9) Determination of Elements in Encapsulated Papaya Powder by Using Pectin X-ray Fluorescence Spectrometry (XRF)

No.	Elements	Experimental Values*(% by weight)	Literature Value**(% by weight)
1.	Potassium (K)	5.38	5.0
2.	Calcium (Ca)	3.34	2.5
3.	Iron (Fe)	0.37	1.0

*These values were measured at University Research Centre, Yangon.

**http://www.en.wiki.pedia.org/wiki/papaya.

Table (10) Comparison of Shelf-life on Encapsulated Papaya Powder Using Different Coating Materials (Pectin, Gelatin, Maltodextrin)

No.	Samples	Shelf-life (months)
1.	Encapsulated Papaya Powder with Pectin	6
2.	Encapsulated Papaya Powder with Gelatin	4
3.	Encapsulated Papaya Powder with Maltodextrin	5

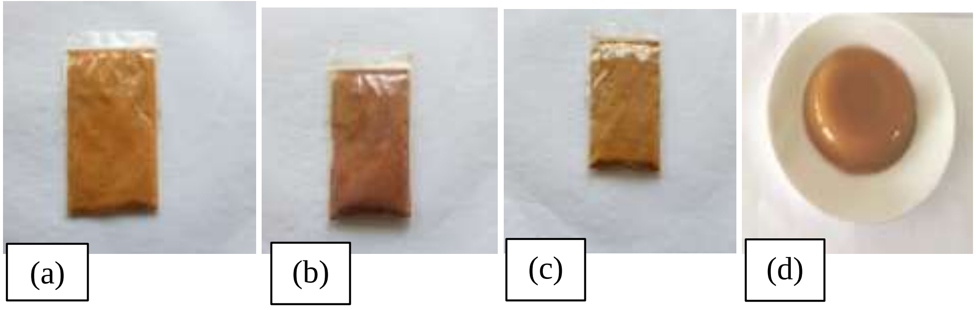

Figure (1) (a) Encapsulated Papaya Powder with Pectin
(b) Encapsulated Papaya Powder with Gelatin
(c) Encapsulated Papaya Powder with Maltodextrin
(d) Preparation of Apple Jelly Using Encapsulated Papaya Powder with Pectin

Conclusion

In this research, preparation of encapsulated powders was carried out by using papaya juice with coating material (pectin, gelatin, and maltodextrin) and emulsifier, by stirring, drying, grinding and then packaging. The prepared encapsulated pigments would be ultilized in coloring some food products included jam, jelly, candy, and juice.Among different encapsulating matrix (coating material), it was observed that 2g of coating material pectin gave the good result with 0.5g of emulsifier, stirring time for 30 min, and drying temperature $60^{o}C$ due to solubility and appearance (color stability) of encapsulated papaya powder.

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