Effect of Coating Materials on the Characteristics of Microencapsulated Tomato Powder

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Abstract

In the food processing field, microencapsulation technique has been widely used to protect food ingredients (i.e., flavors, essential oils, lipids, oleoresins and colorants) against deterioration, volatile losses or interaction with other ingredients. The protective mechanism therein is to form a membrane (wall system) around droplets or particles of the encapsulation material (core).The encapsulation process involves coating or entrapment of a material, usually a liquid but can be a solid or gas, or a mixture into another material. This material is also known as the core material. The coating material can also be called the capsule, wall material, membrane, carrier or shell. The objective of this research was to prepare the encapsulated tomato powder for food processing and to determine the effect of the amount of coating material. Optimum processing conditions to develop encapsulated tomato powder were determined based on product color and solubility. The acceptability of the product was tested through chemical analysis, appearances and solubility for food processing as a natural colour.

Keywords: microencapsulation, coating material

Introduction

Tomato *(Lycopersiconesculentum* L.) is the most consumed vegetables in the world which belongs to the family Solanaceae. Tomato is an important fleshy vegetable in daily dietary. It is a rich source of minerals, vitamins, organic acid and dietary fibre. The principal coloring matter responsible for the characteristic deep-red color of ripe tomato fruit and tomato product is lycopene. It is important not only because of the color it imparts but also because of its recognized health benefits associated with its presence (Bulgarin Journal of Agricultural Science, 17 (No.6) 2011).

Food industries from all over the world have great interest for natural colorant and flavor elicited characteristics of authentic food. 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. The main purpose of this study was to prepare the encapsulated tomato powder by using encapsulation technology to overcome instability problem of unstable functional pigments extracted from natural sources and also to focus on determining the physico-chemical properties and solubility of finished product for food processing.

Materials and Methods

Matrix (Coating) and Core Materials

Starch, pectin and gelatin collected from local market were used as the matrix (coating materials) for microencapsulation. Fresh, mature and ripe tomato *(Lycopersiconesculentum* L.) was collected from plantation which is located in Thone Taung Ywa, Pyin Oo Lwin Township, Mandalay Region. Tween 80 (Polysorbate 80) (commercial grade) was used as an emulsifier for the stabilization of the emulsions.

Phytochemical Investigation of the Raw Tomato Powder (*Lycopersiconesculentum* 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 Tomatoes are shown in Table 1.

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Preparation of Encapsulated Powder

Fresh mature tomatoes were washed thoroughly with water and cut into about 15 mm length and seeds were removed. Tomato juice was extracted by using blender and the various amount of different coating materials such as pectin , gelatin and starch were dissolved in the portion of aqueous extract solution individually, followed by adding aqueous extract solution into it to reach (100) ml. 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 60ºC. Finally, the dried matter was ground and sieving with 160-mesh by using sieved 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 starch on yield percent of encapsulated tomato powders were shown in Tables 2, 3, 4 and Figures (1.a, b, c).

Evaluation of the Physico-chemical Characteristics of Encapsulated Tomato Powder

Prepared encapsulated tomato powder samples were determined by physico-chemical analysis such as moisture content, total fibre content, ash content, protein content, Vitamin-C Content, Total Soluble Solid (° Brix), pH and the results are shown in Table 6.

Determination of Elements in Encapsulated Tomato Powder by X-ray Fluorescence Spectrometry (XRF)

The analysis of major and trace elements in encapsulated tomato powder were measured by using X-ray Fluorescence Spectrometry (XRF). The data are shown in Table 7.

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.

In this manner, the solubility of the encapsulated powder with other coating materials (starch and gelatin) was determined and the results are shown in Table 8.

Determination of Color Reaction Test

The reactions of the encapsulated powder were studied with various reagents. About 15 drops of each of various reagents such as 1% sodium hydroxide solution, concentrated hydrochloric acid and concentrated sulphuric acid were placed in test tubes respectively and the encapsulated powder (0.01g) was added to each of the reagents. The tubes were placed and the color reactions were noted at room temperature. The results are shown in Table 9.

Identification of Carotenoids in Encapsulated Tomato Powder by Ultraviolet Spectroscopy (UV)

The carotenoid content of encapsulated tomato powder in ethanol was determined by UV Spectrophotometer from 400 to 600 nm. The result is shown in Figure 2.

Results and Discussion

Tomatoes, which are actually fruit and not vegetable, are loaded with all kinds of health benefits for the body. One of the most well-known tomatoes eating benefit is its lycopene content. Lycopene is important not only because of the color it imparts, but also because of its recognized health benefits. However, the presence of unsaturated bonds in its molecular structure, lycopene is susceptible to oxidants, light and heat.

Encapsulation is defined as a technology of packaging solids, liquids or gaseous materials in matrices that can release their contents of controlled rates under specific conditions. In food industry, diverse encapsulation techniques have been applied to protect unstable compounds such as flavors, pigments, vitamins, enzymes and microorganisms.

Encapsulated tomato powder is intended for use as a food color. It provides the similar color shades, ranging from yellow to red. Encapsulation of tomato powder is used as a food/dietary supplement in products where the presence of lycopene provides a specific value. The product may also be used as an antioxidant in food supplements. The purpose of this study was to find the appropriate conditions for the preparation of encapsulated tomato powder.

In this study, it was obvious that the effect of the amount of coating material on the yield percent of encapsulated tomato powder, appearance of 5% encapsulated powder solution and solubility (cold water/hot water). Pectin, gelatin and starch were used as coating materials and Tween-80 was used as emulsifier for this study.

Phytochemical investigation of mature and ripe tomato were carried out. The solubility of encapsulated powder with different reagents was also determined. The physico-chemical characteristics of encapsulated powder with pectin were also analyzed.

According to the phytochemical investigation of mature and ripe tomato, it was observed that alkaloids, tannins, protein, phenols, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds were present.

The three different types of coating materials such as pectin, gelatin and starch by using various amounts were used for natural color encapsulation. According to Tables 2, 3, 4 and Figures (1.a,b,c), it was observed that the increased amount of coating materials (pectin, gelatin, starch) could increase the yield percent of encapsulated tomato powder but the strength of color encapsulated powders was gradually decreased from brightness to lightness except starch. It was noted that the more cloudiness was appeared when starch was used as coating material.

It was observed that the amount of pectin (2) g with the amount of emulsifier (Tween-80) (1.5) g, the stirring time (30 min) and the drying temperature (60°C) were suitable condition for encapsulated tomato powder by using a pectin as a coating material from the point of view of appearance and solubility.

While gelatin was used as a coating material, the amount of gelatin (1) g, the amount of emulsifier (1) g, the stirring time (45 min) and the drying temperature (60°C) were appropriate conditions for encapsulated tomato powder because of 5% encapsulated powder solution. According to Table (4) and Figure (1.c) the amount of starch (2) g, the amount of emulsifier (1.5) g, the stirring time (45 min) and the drying temperature (60°C) were suitable condition for encapsulated tomato power.

On comparing the solubility of encapsulated powders using pectin, gelatin and starch as coating materials, the encapsulated powder by using pectin was slightly soluble in acetone, fairly soluble in acetic acid and precipitate was formed and very soluble in petroleum ether. Encapsulated powder by using gelatin was insoluble in vegetable oil, slightly soluble in water, acetone, formaldehyde, soluble in ethyl alcohol, very soluble in petroleum ether and acetic acid. Encapsulated powder by using starch was insoluble in vegetable oil, slightly soluble in water, formaldehyde, fairly soluble in ethyl alcohol, acetone, very soluble in acetic acid and petroleum ether, shown in Table 8.

From Table (6), it was observed that the chemical compositions of encapsulated tomato powder with pectin were quite different with that of fresh tomato because of the effect of coating material, emulsifier and drying temperature.

Although the chemical composition of encapsulated tomato powder was quite different with that of fresh tomato, the objectives of this study were to find out the effect of encapsulation on natural color of tomato using different coating materials (pectin, gelatin and starch), emulsifier (Tween-80) for utilization of food products such as jam, jelly, candy and juice.

Table 9 showed that the color reactions of encapsulated powder using different coating materials with different reagents. According to this table, it was noted that the stability of color depends on the nature of food.

The UV spectrum of carotenoids in raw tomato and encapsulated tomato powder [Figure 2] exhibit very high extinction coefficients between 400 and 600 nm. This was in good agreement with standard wavelength of carotenoids (400-500 nm) in literature values (Mohan, J. 2000).

It was concluded that pectin was suitable coating material for encapsulated tomatoes powder because it gave the attractive colour and easily soluble of encapsulated tomato powder.

Table 1 Phytochemical Investigation of Tomato

No.	Test	Extract	Reagent	Observation	Result
1.	Alkaloids	5% HCl	Wagner's reagent, Dragendroff's reagent,	Reddish Brown ppt	+
2.	Carbohydrates	H_2O	10% α- naphthol& H_2SO_4	Red color ring	+
3.	Glycosides	H_2O	10% NaOH solution	Yellow color	+
4.	Reducing sugars	H_2SO_4	Benedict's solution	Brown color	_
5.	Tannins	H_2O	Gelatin & 1% $FeCl_3$	Pale Yellow	+
6.	Saponins	H_2O	Distilled water	Frothing	+
7.	Flavonoids	EtOH	Mg ribbon & conc. HCl	Pale Yellow color	+
8	Phenols	H_2O	10% aqueous $FeCl_3$	Brown color	+
9.	Protein	H_2O	10% NaOH solution & 3% $CuSO_4$ solution	Green Brown solution	+

(+) Present (-) Absent

Table 2 Effect of Amount of Pectin on Yield Percent of Encapsulated Powder

Sr. No	Pectin (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water (20-25ºC)	Hot water (100ºC)
1	1	8.09	reddish colour, after one night colour was stable	soluble, a few amount of ppt was formed after one night	soluble
2	*2	9.00	bright reddish colour, after one night colour was stable	soluble, a few amount of ppt was formed after one night	soluble
3	3	9.50	reddish colour, after one night colour was stable	soluble, a few amount of ppt was formed after one night	soluble
4	4	9.85	pale reddish colour, after one night colour was unstable	soluble, a few amount of ppt was formed after one night	soluble
5	5	10.10	pale reddish colour, after one night colour was unstable	soluble, a few amount of ppt was formed after one night	soluble

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

Amount of Emulsifier (Tween-80) = 1 g

* Most Suitable Amount of Pectin Note: ppt = precipitate

Table 3 Effect of Amount of Gelatin on Yield Percent of Encapsulated Powder

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

Sr. No	Gelatin (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water(20-25ºC)	Hot water (100ºC)
1	0.5	6.45	reddish colour	fairly soluble, a few amount of ppt was formed after one night	soluble
2	* 1.0	7.00	bright reddish colour	fairly soluble, a few amount of ppt was formed after one night	soluble
3	1.5	7.55	pale reddish colour	fairly soluble, a large amount of ppt was formed after one night	soluble
4	2.0	7.75	pale reddish colour	fairly soluble, a large amount of ppt was formed after one night	soluble
5	2.5	7.95	pale reddish colour	fairly soluble, a large amount of ppt was formed after one night	soluble

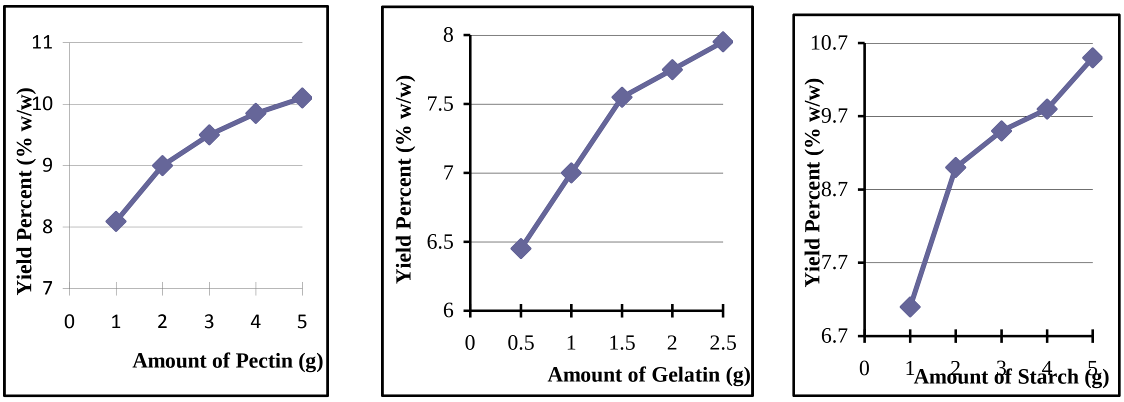
* Most Suitable Amount of GelatinNote: ppt = precipitate

Table 4 Effect of Amount of Starch on Yield Percent of Encapsulated Powder

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

Sr.No	Starch (g)	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder solution	Solubility	
				Cold water(20-25ºC)	Hot water (100ºC)
1	1	7.10	pale reddish colour	slightly soluble in water, low cloudy after one night	slightly soluble
2	*2	9.15	bright reddish colour	slightly soluble in water, low cloudy after one night	slightly soluble
3	3	9.50	reddish colour	slightly soluble in water, more cloudy after one night	slightly soluble
4	4	9.80	reddish colour	slightly soluble in water, more cloudy after one night	slightly soluble
5	5	10.50	deep reddish colour	slightly soluble in water, more cloudy after one night	slightly soluble

* Most Suitable Amount of StarchNote: ppt = precipitate



(a) (b) (c)

Figure 1 Effect of Amount of Different Coating Materials on Yield Percent of Encapsulated Powder (a) Pectin (b) Gelatin (c) Starch

Table 5 Comparison of Coating Materials on the Characteristics of Encapsulated Tomato Powder

Sr. No	Types of coating material	Yield Percent (% w/w)	Appearance of 5% Encapsulated Powder Solution	Solubility	
				Cold water (20-25ºC)	Hot water 100 ºC
1	*Pectin	9.30	bright reddish colour, after one night colour was stable	soluble, a few amount of ppt was formed after one night	soluble
2	Gelatin	7.20	reddish colour	fairly soluble, a few amount of ppt was formed after one night	soluble
3	Starch	10.22	reddish colour	slightly soluble, low cloudy after one night	soluble

*Suitable Coating Material = PectinNote: ppt = precipitate

Table 6 Chemical Composition of Encapsulated Tomato Powder by using Pectin as Coating Material

Sr. No	Characteristics	Experimental Values of Encapsulated Tomato Powder (per 100 g)
1	Moisture (%)	19.0
2	*Total Fibre (%)	4.77
3	*Ash (%)	17.74
4	*Protein (%)	7.69
5	**Vitamin-C (%)	1.93
6	***Total Soluble Solid (°Brix)	2.0
7	***pH	6.1

*These values were measured at Food Industries Development Supporting Laboratory, UMFCCI Tower, Yangon Myanmar

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

***These experiments were carried out at the Laboratory of Industrial ChemistryDepartment,Yadanabon University

Table (7) Determination of Elements in Encapsulated Tomato Powder by X-ray Fluorescence Spectrometry (XRF)

Sr. No	Elements	*Experimental values (% by weight)
1	Calcium (Ca)	1.758
2	Potassium (K)	26.23
3	Iron (Fe)	0.168
4	Zinc (Zn)	0.678
5	Magnesium (Mg)	0.1901

*These data were measured at Department of Geology, Mandalay University.

Table (8) Comparison of Solubility on Encapsulated Tomato Powder Derived from Different Coating Materials as Pectin, Gelatin and Starch in Different Solvents

Volume of Solvent = 15 drops,

Amount of Encapsulated Tomato Powder = 0.01 g

Sr. No	Coating Materials	Different Solvents						
		Water	Vegetable Oil	Ethyl Alcohol	Acetic Acid	Acetone	Formal-dehyde	Pet Ether
1.	Pectin	soluble	fairly soluble	fairly soluble	fairly soluble ppt was formed	slightly soluble	fairly soluble	very soluble
2.	Gelatin	slightly soluble	insoluble	soluble	very soluble	slightly soluble	slightly soluble	very soluble
3.	Starch	slightly soluble	insoluble	fairly soluble	very soluble	fairly soluble	slightly soluble	very soluble

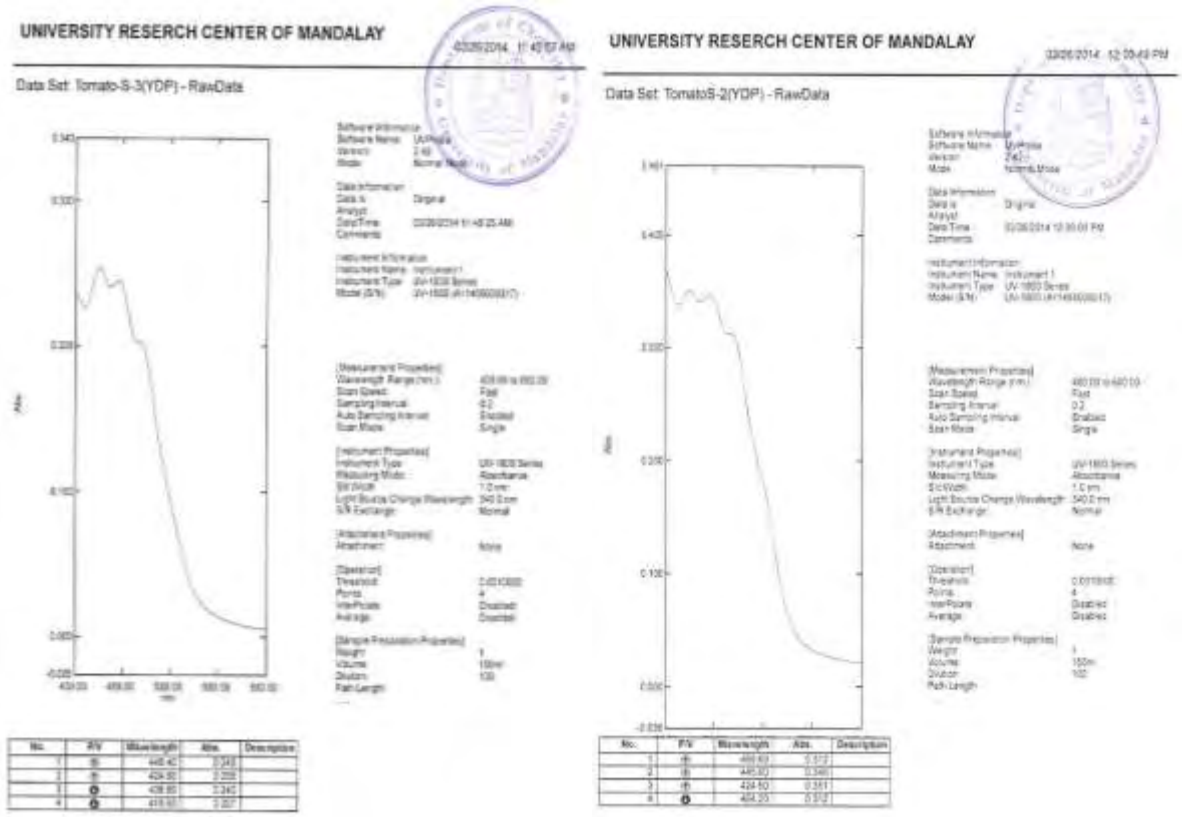
Note: ppt = precipitate

Table (9) Colour Reactions of Encapsulated Powder using Different Coating Materials with Different Reagents

Volume of Solvent = 15 drops,
Amount of Encapsulated Tomato Powder = 0.01 g

Sr. No	Samples	Different Reagents		
		(1% w/v) Sodium Hydroxide Solution	Hydrochloric Acid (Conc.)	Sulphuric Acid (Conc.)
1	Encapsulated powder with pectin	pale red	reddish brown	golden brown
2	Encapsulated powder with gelatin	bright red	red-ppt was formed	black
3	Encapsulated powder with starch	green	colourless	black

Note: ppt = precipitate



(a) (b)

Figure (2) Identification of Carotenoids in Raw and Encapsulated Tomato Powder by Ultraviolet Spectroscopy (UV) (a) Raw Tomato (b) EncapsulatedTomato Powder

Conclusion

In this study, pectin, gelatin and starch were used as coating materials for encapsulation of tomato. Four variables (amount of coating material, the amount of emulsifier, stirring time anddrying temperature) were found to exert significant effect on encapsulation efficiency.

Among different experiments, it was noted that the suitable parameters for the encapsulation of tomato powder with pectin were the amount of coating material (2 g), the amount of emulsifier (1.5 g), the stirring time (30 min) and drying temperature(60ºC). It was concluded that pectin was suitable coating material for encapsulated tomato powder because it gave the better appearance and solubility. The present findings, especially on the encapsulation of tomato powder would provide an opportunity to improve and stabilize the shelf life of active ingredient of tomato as a natural color for food processing.

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References

"**Bulgarian Journal of Agricultural Science**", 17 (No.6)2011

Lees, R., (1975), **Food Analysis: Analytical and Quality Control Methods for Food Manufacture andBuyer**, Leonard Hill Books, Landon.

Mohan, J. (2000), **Organic Spectroscopy: Principles and Applications**. Narisa Publishing House, New Delhi.

Pearson, D., (1976), **The Chemical Analysis of Food**, 7th Edition, Churchill Livingstone.

Pearson, D., (1984), **The Chemical Analysis of Food**, 8th Edition, Churchill Livingstone.

Potter, N.N, (1994), **Food Science**, 4th Edition, AVI Publishing Company Inc.

Srilakshmi. B. (1991), **Nutritive value of Indian Foods, National Institute of Nutrition**, ICMR, Ityderabad.Gopalan, C, Rama Sustri B. V. and Balasubramanian.

Website

http://www.fruit-and-vegetable-ucdavis.edu/files/123842.html

http://www.en.wikipedia.org/wiki/Tomato

http://www.fitday.com/fitness-articles//5healthbenefitsoftomatoes.html

http://www.en.wikipedia.org/wiki/food-coating

http://www.gelatin-coza/gltin.1.html

http://wisegeek.org/what-is-gelatin

http://www.wisegeek.org/what-is-pectin.html

http://www.en.wikipedia.org/wiki/starch

http://amazon.com/Tomatopowder-24-Jar-Each/dp/BOORHTOB6