Evaluation on the Quality of Freeze-Dried Vegetable Juice Products

Swe Swe Hlaing[1],Wai Phyo Mon[2],Nwe Nwe Aung[3]

Abstract

Commercialization of dried vegetables has gained importance worldly due to the search of consumers for practicability and products of great nutritional value. The application of the freeze-drying technique in vegetables conservation is the key to their success for commercialization. Freeze-drying is a technique that preserves the flavor, color and nutrients in the final product.

The emphasis of this research was the dehydration of tomato and carrot juices in powder forms by freeze drying method (-50ºC, between 0.1 to 2.0 torr) in order to maintain the prolonged shelf-life. The phytochemical investigations (such as alkaloids, tannins, protein, phenol, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds) and physico-chemical characteristics (such as moisture, total fibre, ash, protein, vitamin C, total soluble solid and pH)of freeze-dried products were determined for the assessment of their quality. It was found that some physico- chemical characteristics of freeze products were lower than that of literature values except pH, ash and protein content. The UVspectrum of carotenoids in raw tomato and freeze-dried tomato juice powder exhibit very high distinctive coefficients between 400 and 600 nm. Similarly, UV spectrum of carotenoids in raw carrot and freeze-dried carrot juice powder were scanned from 400 to 600 nm. These were in good agreement with the standard wavelength of α-carotene (428,451,480nm) and that of β-carotene is 448 nm. The aim of this research is to produce value added products of tropical vegetables by advanced technology.

Key words: dehydration, phytochemical , flavonoids, saponins, physico- chemical characteristics

Introduction

Fruits and vegetables provide an abundant and inexpensive source of energy, body-building nutrients, vitamins and minerals. Consumption of some fruits and vegetable is strongly linked with several health benefits due to their high nutritional value and medicinal properties (Ames et al., 1993).Chemical and enzymes spoilage occurs especially when vegetables and fruits are damaged by falling or breaking. Such damage can release enzymes that cause chemical reactions. Tomatoes become soft, for example, and apples and other types of fruit turn brown. Enzymes can be deactivated by heating the fruits or vegetables.

Drying is the unique method for producing powder forms of fruits and vegetables. The main benefits of powder forms, as compared with fresh vegetables, are the potential for long storage at ambient temperature, and a significant reduction in the costs for transportation and storage. Furthermore, the most important factor is that powder forms are very convenient food ingredients for use as flavors and colorings in food products, including juices and dairy products.

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At present, there are many drying techniques used for producing powder forms in the food industry; therefore, a suitable drying method for a particular food should be carefully selected. Many factors, such as the characteristics of the food material to be dried, the quality of the desired final product, and processing costs, that is, energy and space requirements, must be considered. Freeze-drying has been used to eliminate water from a frozen material at low temperature under vacuum condition. It is a dehydration process of frozen solvent, which normally refers to water in foodstuff, at very low temperature which sublimed directly from a solid phase into a vapor phase. The targets of freeze-drying are to produce a highly dried product where the main constituents are preserved compared to other methods of food drying due to a low temperature processing (Marques *et al.*, 2007). The main objective of the present study was to appraise the effect of freeze-drying on the selected antioxidant compound (ascorbic acid) and physico-chemical properties of tomato and carrot which are important vegetables in daily dietary. They contain not only the nutritional and antioxidants such as vitamin A, B, and C, but also a great quantity of non-nutritional antioxidants, such as beta-carotene, carotenoid, flavonoids, flavones, and phenolic compound.

Materials and Methods

Materials

Fresh, mature and ripe tomato *(Lycopersiconesculentum* L.) and fresh, mature carrot (*Daucuscarota*L.) were collected from plantation which is located in Thone Taung Village, Pyin Oo Lwin Township, MandalayRegion.

Methods

Preparation of Raw Tomato and Carrot Powders for Phytochemical Investigation

Fresh, mature and ripe tomatoes *(Lycopersiconesculentum* L.) were washed thoroughly with water. Then they were chopped into about 15 mm length, sun dried (25-30^{o}C) for 7 hours and ground. After that fine powder form of tomato was obtained. Fresh, mature carrots (*Daucuscarota* L.) were also washed thoroughly to remove the dirt and grit. Then, carrots were scrubbed and chopped into about 1 cm length and sun dried (25-30^{o}C) as tomatoes for 7 hours, followed by grinding. Then the powder forms were stored individually in bottles until use for the analysis, respectively.

Phytochemical Investigation of Raw Tomato and Carrot Powders

The analysis of raw tomato and carrot powders includes phytochemical investigations such as alkaloids, tannins, protein, phenol, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds and results of phytochemical investigations are shown in Tables (1) and (2).

Preparation of Freeze – dried Tomato and Carrot Juice Powders

Fresh mature and ripe tomatoes were washed thoroughly with water and cut into about 15mm length and homogenized by a juice extractor to obtain the homogeneous juice without seeds. The juice was poured into each 300ml bottle and freeze-dried by using a freeze dryer (**Operon** Ultra-Low Temperature Freezer -86°C, Korea) with total pressure and temperature inside a vacuum chamber (between 0.1 to 2.0 torr) and -50°C, respectively. Average freeze-drying time was approximately 72 hours and after stage of drying, freeze -

dried juice powder was obtained. The freeze-dried powder was stored in desiccators at room temperature until further analysis.

Carrot powder was also prepared in the same manner without the step for removal of seeds. Freeze- dried processing of tomato and carrot powders and their prepared samples are shown in Figures (1) and (2) respectively.

Evaluation of the Physico- chemical Characteristics of Freeze-dried Juice Powders

Prepared freeze –dried juice powered 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 Tables (3) and (4). Physico-chemical analysis of freeze-dried tomato and carrot juice powders are shown in Figures (3) and (4).

Determination of Elements Content of Freeze-dried Juice Powders by X-ray Fluorescence Spectrometry (XRF)

The analysis of major and trace elements in freeze- dried tomato and carrot juice powder were determined by using X-ray Fluorescence Spectrometry (XRF).The relevant data are shown in Tables (5) and (6).

Elements content (w/w %) of freeze-dried tomato and carrot juice powder are shown in Figures (5) and (6).

Identification of Carotenoids in Raw and Freeze- dried Tomato and Carrot Juice Powder by Ultraviolet Spectroscopy (UV)

The carotenoid of raw and freeze-dried tomato juice powder was evaluated by UV Spectrophotometer from 400 to 600 nm. Ethanol was used as solvent. The results are shown in Figures (7) and (8) respectively. Similarly, the carotenoids of raw and freeze-dried carrot juice powder are shown in Figures (9) and (10) respectively.

Results and Discussion

The importance of freeze-drying process in vegetables preservation and the high quality of dried products must be offered to the consumers. Freeze-drying was performed under controlled drying conditions, regulating pressure during drying (-50ºC, between 0.1 to 2.0 torr).The drying times required for freeze- drying are substantially long when compared to the conventional drying methods which may change depending on temperature, air velocity and humidity. During freeze-drying process, the total time was determined to be 72 hours.

According to the phytochemical investigation of mature and ripe raw tomato, it was observed that alkaloids, tannins, protein, phenols, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds were presented (Table 1). Similarly, the phytochemical analysis of carrot revealed the presence of alkaloids, tannins, protein, phenols, glycosides, flavonoids, saponins, reducing sugar, carbohydrates and phenolic compounds. The presence of tannin contributes towards antioxidant activity of foods. According to the literature, main carrots nutrition’s are phenolic compounds, carotenoids, soluble dry matter, sugars and others. Compounds found in the carrot influence the flavor of the carrot include the sugar (glucose, fructose, sucrose) which contribute to sweetness and phenolic compounds which impart bitterness (Table 2).

The physico- chemical composition of tomato and carrot juice powder prepared by freeze- drying were presented in Table (3),(4) and Figures (3) and (4).The low moisture content of freeze-dried powders would enhance their storage stability. It was also noted that the freeze- drying condition could noticeably affect the composition of some other components of tomato and carrot. The freeze- drying increased the ash content and the protein ratio in the both freeze-dried tomato and carrot powder. However total soluble solid of both freeze-dried powder were lower than that of fresh juices, the vitamin C content is significant lower in only freeze –dried tomato juice powder.

According to literature, the content and ratio of nutrients differ in different parts of plant, the variation are particularly great between plant species. The ratios between plant nutrients have a significant effect on the chemical composition of plant. It can be observed that the elements content of tomato and carrot were quite different with those of literature values [Tables (5) and (6) and Figures (5) and (6)].

The UV spectrum of carotenoids in fresh tomato and freeze-dried tomato juice powder [Figures (7) and (8)] and that of fresh carrot and freeze-dried carrot juice powder [Figures (9) and (10)] exhibit very high extinction coefficients between 400 and 600 nm. These were in good agreement with the standard wavelength of α-carotene (428,451,480nm) and β-carotene (448 nm) (Mohan, J. 2000).

The results confirm that, concerning the considered quality attributes, freeze-dried samples are much superior to the convective dried ones because of their better appearance, flavor, color and nutritional properties.

Conclusion

Fruit and vegetable juice powders have many benefits and economic potentials over their liquid counterparts such as reduced volume or weight, reduced packaging, easier handling and transportation, and much longer shelf life. The quality of freeze-dried foods is quite dependent on the operating parameters. Thus variation of factors affecting the product properties should be required for the process optimization, in order to obtain products with better sensory and nutritional characteristics and better process yield. The most notable advantages of freeze-drying are the preservation of the intrinsic micro scale structure or the formation of high porosity, minimization of thermal and chemical degradation, retention of volatile or aromatic components, etc. Thus freeze drying is generally accepted as the best method to dehydrate high quality and heat sensitive products such as quality foods, pharmaceuticals and biochemical products.

(a) **(b)** **(c)**

Figure (1) (a) (b) Freeze-dried Processing of Tomato Juice Powder and (c) Prepared Tomato Juice Powder Sample

(a) (b) (c)

Figure (2) (a) (b) Freeze-dried Processing of Carrot Juice Powder and (c) Prepared Carrot Juice Powder Sample

Table (1) Phytochemical Investigation of Raw Tomato Powder

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

(+) Present (-) Absent ppt = precipitate

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

Table (2) Phytochemical Investigation of Raw Carrot Powder

Sr.No.	Test	Solvent	Reagent	Observation	Result
1	Alkaloids	1% HCl	Wagner's reagent, Dragendroff's reagents	Blue Bluish black color solution	+
2	Tannins	H_2O	Gelatin and 1% $FeCl_3$	Pale yellow color solution	+
3	Protein	H_2O	10% NaOH solution and 3% $CuSO_4$solution	Reddish brown color solution	+
4	Phenols	H_2O	10%aqueous $FeCl_3$	Greenish yellow colour solution	+
5	Glycosides	H_2O	10% NaOH solution	Pale yellow ppt	+
6	Flavonoids	EtOH	conc. HCl& Mg ribbon	Pale green colour solution	+
7	Saponins	H_2O	Distilled water	Frothing	+
8	Reducing sugar	H_2SO_4	5 N NaOH solution & Benedict's solution	Pale brown colour solution	+
9	Carbohydrate s	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 (3) Physico-chemical Analysis of Freeze-dried Tomato Juice Powder

Sr. No.	Characteristics	Freeze-dried juice powder	Literature Values of Fresh Juice*
1	**Moisture (%)	24	92.43
2	**Total Fibre(%)	0.26	1.0
3	**Ash (%)	4.08	0.51
4	**Protein (%)	12.88	0.6
5	**Vitamin-C(mg/100g)	0.35	19.25
	***TotalSoluble Solid(°Brix)	4	4.9
7	***pH	4.57	3.68

*Sources

1. Adubofluor, J.et al(2010),
2. Nutritient Analysis of Fruits and Vegetables, U K, (2013).
3. Tiziani,Stefano, (2006)
4. USDA Fruits and Vegetable analysis, (2012).

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

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

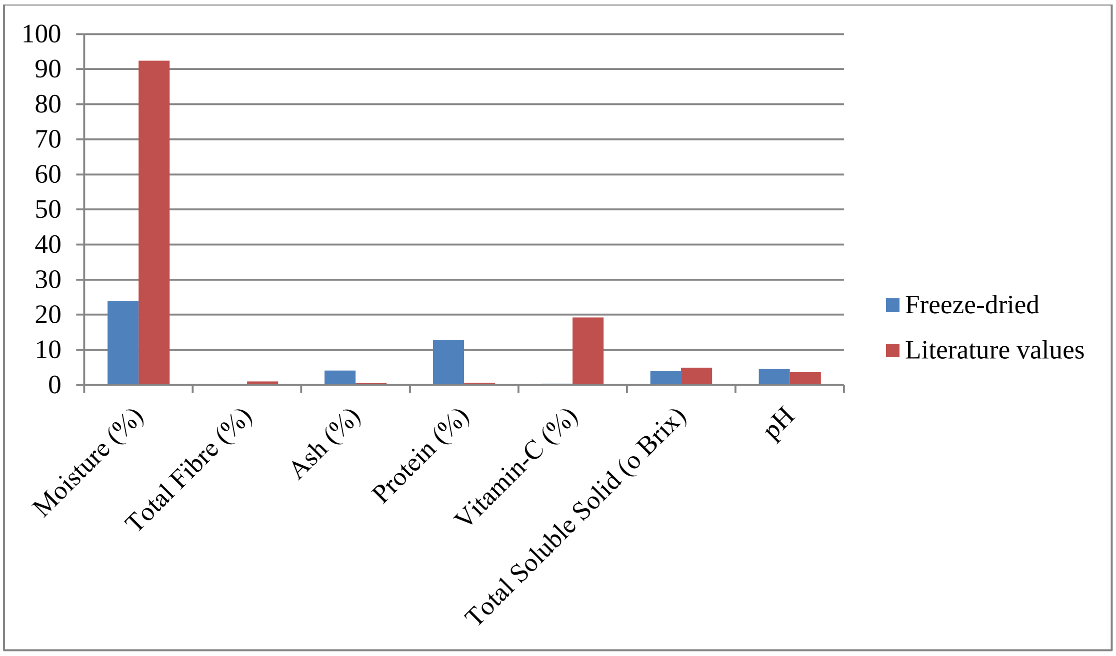

Figure (3) Physico-chemical Characteristics of Freeze-dried Tomato Juice Powder

Table (4) Physico- chemical Characteristics of Freeze-dried Carrot Juice Powder

Sr.No	Characteristics	Freeze-dried Juice Powder	Literature Values of Fresh Juice*
1	**Moisture (%)	23.40	89.68
2	**Total Fibre(%)	0.31	0.81
3	**Ash (%)	6.44	0.88
4	**Protein (%)	14.69	0.93
5	**Vitamin-C (mg/100g)	21.00	20.10
6	***Total Soluble Solid(°Brix)	1.50	4.00
7	***pH	6.38	6.00

*Sources

1. Adubofluor, J.et al(2010),
2. Nutritive Value of Indian Foods, National Institute of Nitrition, Indian Council of Medical Research, Hyderabad. India 1984.
3. USDA Fruits and Vegetable analysis, (2012).

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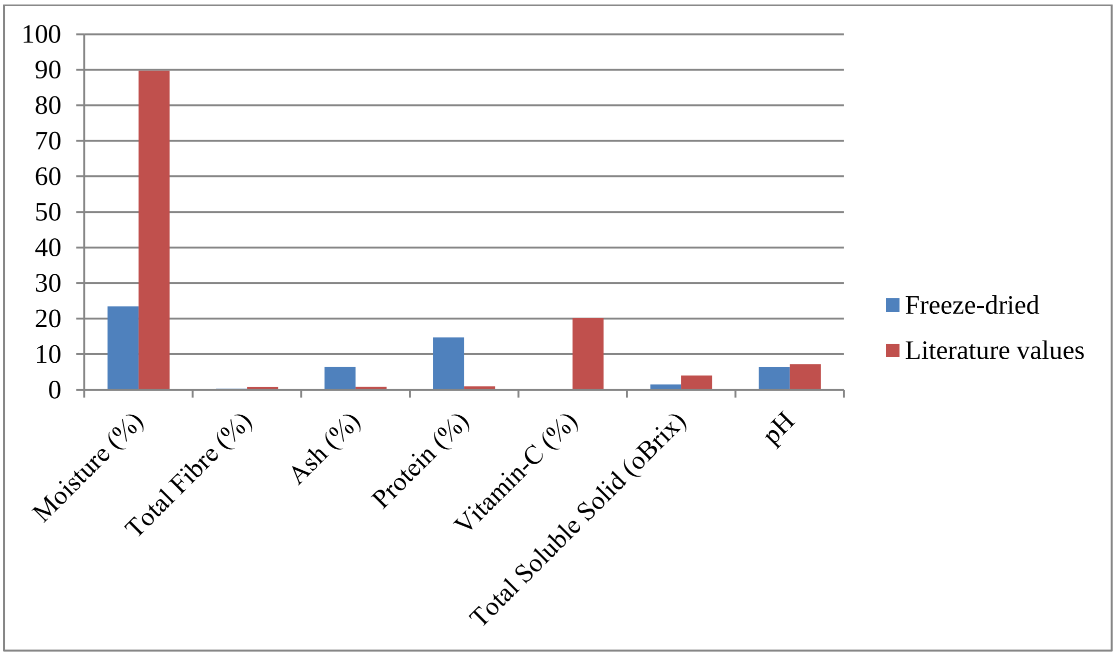


Figure (4) Physico- chemical Analysis of Freeze-dried Carrot Juice Powder

Table (5) Elements Content of Freeze-dried Tomato by X-ray Fluorescence Spectrometry (XRF)

Sr.No	Elements	*Freeze-dried (% by weight)	Literature values (% by weight)
1	Calcium (Ca)	8.29	7**
2	Magnesium (Mg)	0.910	5***
3	Iron (Fe)	0. 218	0.4**
4	Zinc (Zn)	0.121	1***

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

**Swaminathan, M.,1995.

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

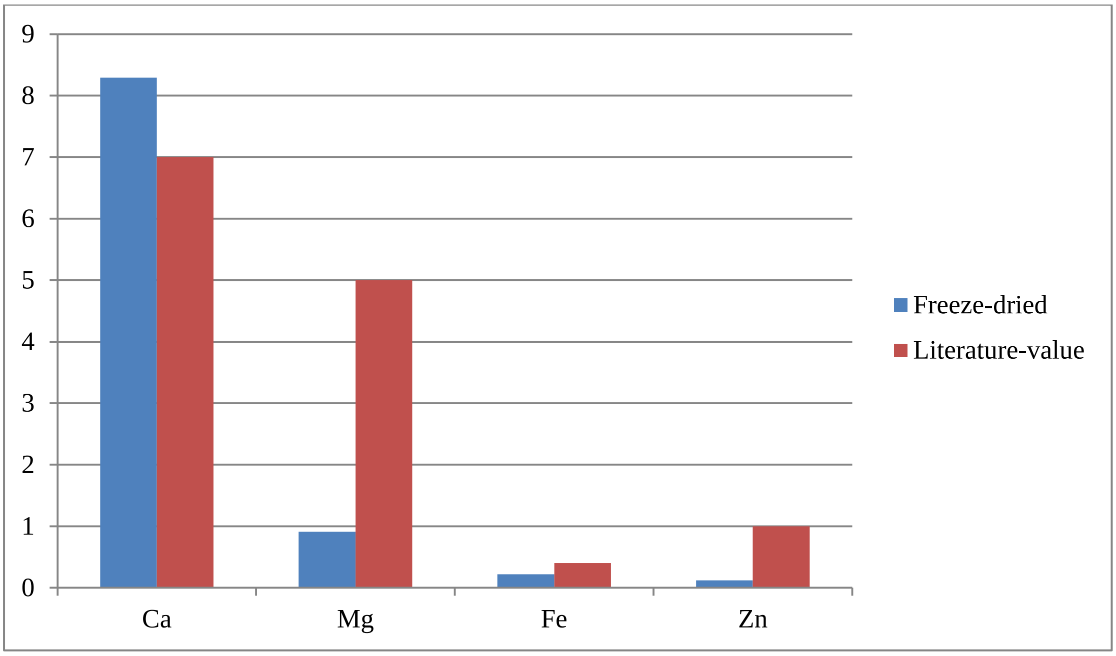


Figure (5) Elements Content (w/w %) of Freeze-dried Tomato Juice Powder by X-ray Fluorescence Spectrometry (XRF)

Table (6) Elements Content of Freeze-dried Carrot by X-ray Fluorescence Spectrometry (XRF)

Sr.No	Elements	*Freeze-dried (% by weight)	Literature values (% by weight)
1	Calcium (Ca)	11.86	3
2	Magnesium(Mg)	1.30	3
3	Iron (Fe)	0.29	2
4	Phosphorus(P)	1.03	5
5	Chlorine (Cl)	4.84	2
6	Sulphur (S)	1.14	1

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

**http:www.en.wikipedia.org/wiki/Carrot

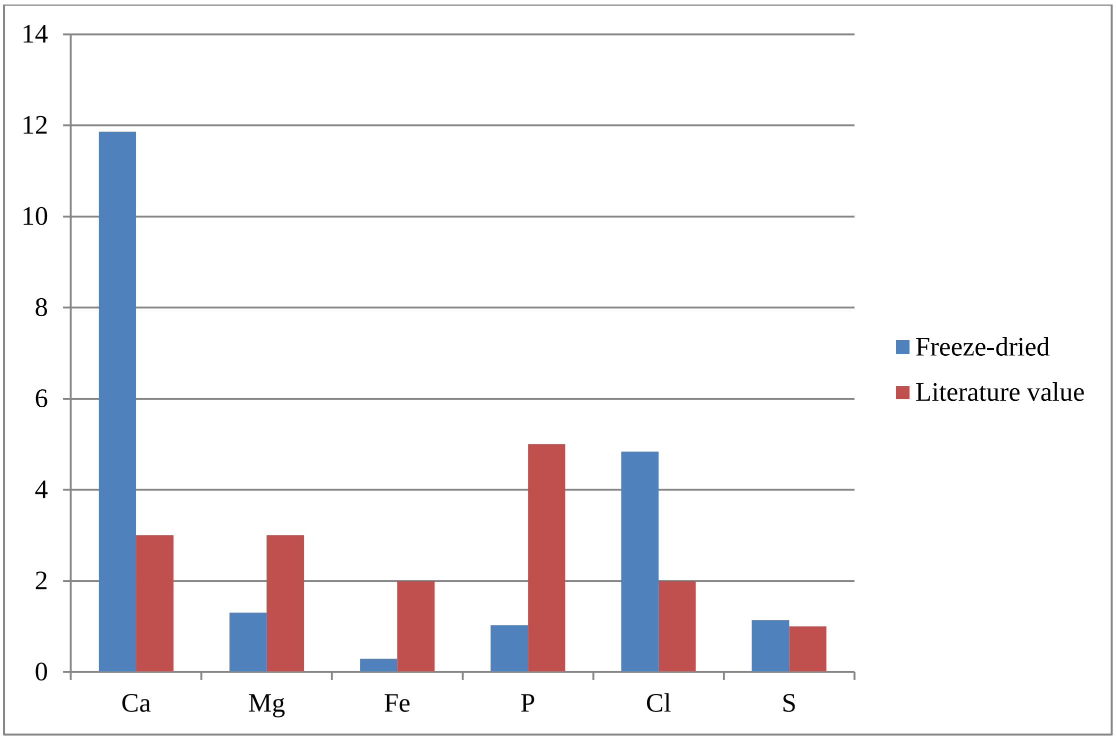
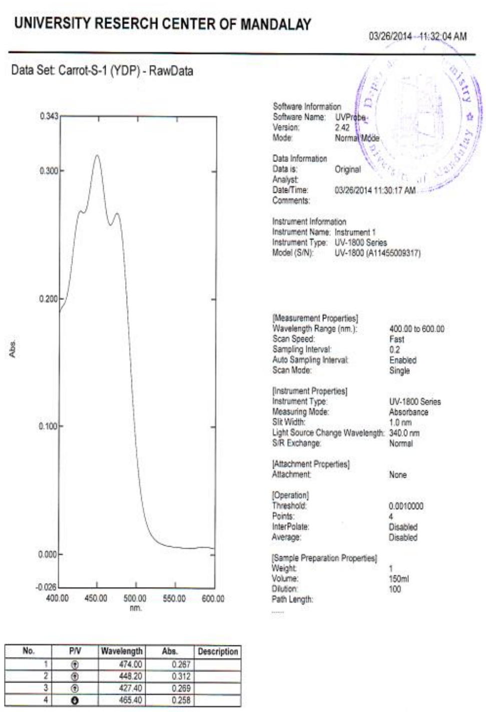
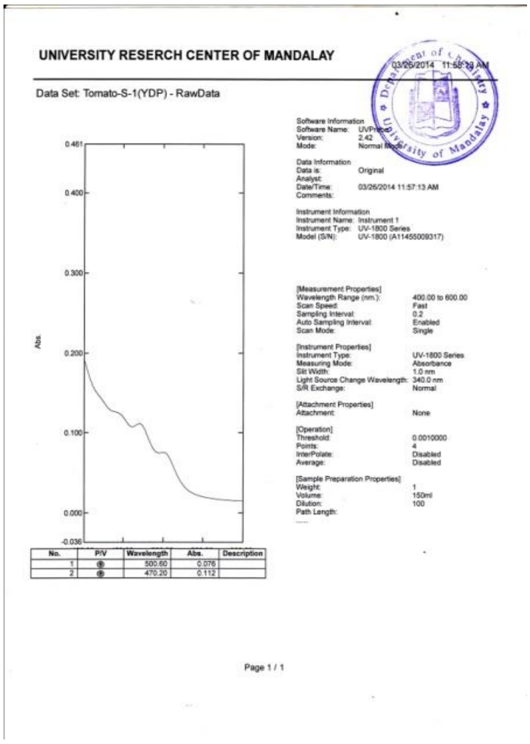


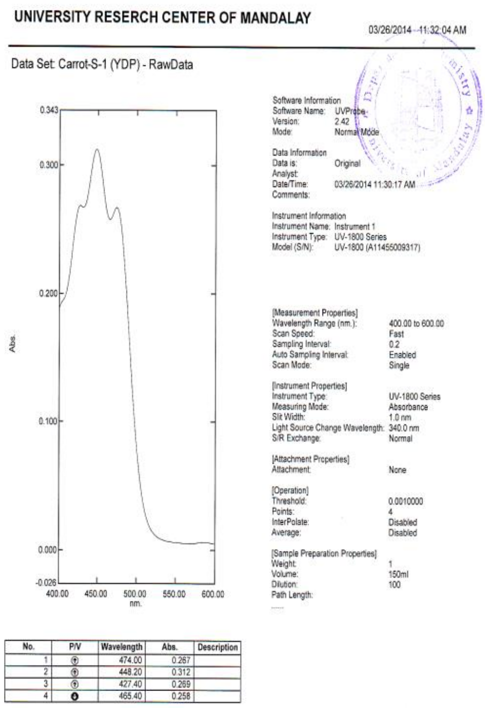
Figure (6) Elements Content (w/w %) of Freeze-dried Carrot Juice Powder by X-ray Fluorescence Spectrometry (XRF)

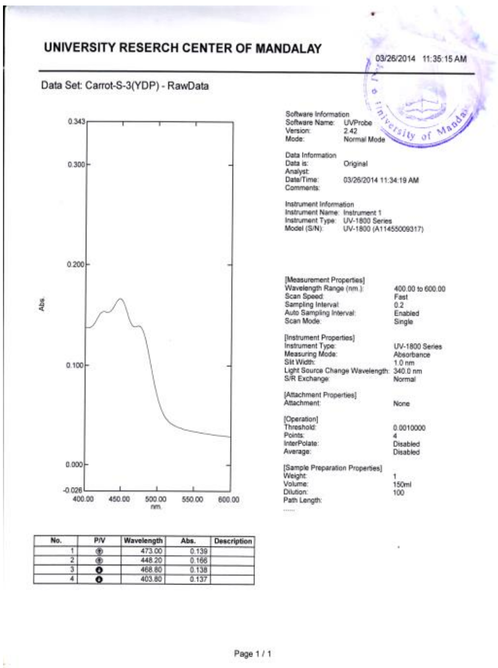




(a) (b)

Figure (7) Identification of Carotenoids in (a) Raw Tomato Powder and (b)Freeze- dried Tomato Powder by Ultraviolet Spectroscopy





(a) (b)

Figure (7) Identification of Carotenoids in (a) RawCarrot Powder and (b)Freeze- dried Carrot Powder by Ultraviolet Spectroscopy

Acknowledgements

The authors would like to appreciate Dr. Aye Kyaw, Rector and Dr. Aung Aung Min, Pro-rector of Yadanabon University, for their permission to submit this article and Dr. Khin Maung Oo, Rector, Magway University (Former Rector, Yadanabon University) for his permission to carry out this research. We are grateful to Professor Dr. Yi Yi Myint Part-time Professor, (Retd., Head of Industrial Chemistry Department) for her valuable suggestions and editing this project paper. We would also like to express our sincere gratitude to Dr. Khin Hnin Aye, Associate Professor, Head, Department of Industrial Chemistry, Yadanabon University, for her kind permission and help in various ways. We also express our thanks to master students for their help to conduct this research.

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