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Development of a Suitable Process for Inhibition of Browning in Some Fruit Purees

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Abstract

In this research, the first part was focused on finding techniques for efficient processing methods for inhibition of enzymatic browning in banana purees. In the second part, the focus was to study some suitable approaches for the control of nonenzymatic browning in tomato purees. Improvement of color in processed banana and tomato purees has been made by using familiar processes such as vacuum treatment and addition of browning inhibitors such as ascorbic acid, citric acid and malic acid. The degree of browning of the fruit products was determined by measuring the increase in absorbance at 420 nm in PD - 303 S Digital Spectrophotometer and TRSP-722 Grating Spectrophotometer. In order to control the quality of the processed foods, other physicochemical properties such as pH, acidity, ºBrix, moisture and ash contents as well as bacteriological examination were investigated. It was found that different processing methods for minimizing brown color formation affected the degree of browning and shelf-life of the products. Although 0.1% w/w ascorbic acid was suitable for the inhibition of enzymatic browning in banana puree, the method using 0.05%w/w ascorbic acid in conjunction with 0.05% w/w citric acid was more effective than ascorbic acid alone as the treated samples gave good color, flavor and texture. In heat preservation of banana puree, pasteurization at 70ºC for 10 minutes was found to be adequate for the control of browning. In processing of tomato puree, it was observed that immersion of tomatoes in 0.1%w/w ascorbic acid solution for 1 hour was effective in retaining the natural red color of tomatoes. Besides immersion, further addition of 0.1% w/w citric acid or malic acid to puree gave better color preservation and longer shelf-life of over one year. In open pan method, concentration temperature of 70-75°C for 5 hours was found to be suitable in order to meet the standard specification of ºBrix for tomato puree and to maintain the natural red color.

Key words: absorbance, enzymatic browning, vacuum treatment

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Introduction

Color, flavor, texture and nutritional value are four attributes considered by consumers when making food choices. During preparation, processing and storage of foods, browning can be observed by both enzymatic and nonenzymatic reactions (Marshall et al., 2000).

Enzymatic browning is one of the most predominant reactions in fruits which contain phenolic compounds. These phenolic compounds are oxidized into brown color pigments by the action of enzyme polyphenoloxidase (PPO). In various fruits and products which can turn brown, browning of banana and its products is more obvious than others. During processing of tomato purees, nonenzymatic browning reaction produces undesirable effects.

Statement of the Problem

In Myanmar, banana grows in abundance in almost every part of the country all year round. However, many economic losses are encountered due to browning of bananas before reaching into the consumers. In addition, they turn brown rapidly during handling, peeling, processing and even in storage. This browning decreases the quality of banana, decreases the nutritional value and reduces its marketability. Therefore, the inhibition of browning during processing and storage of banana products is very critical. The undesirable effects produced in processed foods due to Maillard reaction also occur during processing and storage of tomato products. Therefore, control of Maillard browning without using artificial dyes is now very important.

Objectives of the Study

The overall objective of this study was to gain an efficient process which can solve browning problems encountered during handling, processing and storage of fruits and fruit products.

The specific objectives of this study were to:

- investigate a suitable approach for the control of browning in some tropical fruit-products such as banana and tomato purees
- preserve natural color of foods without using artificial colors and synthetic dyes
- reduce losses of nutritional and economic value due to browning in foods

Significance of the Study

The results and findings from this research work will be used to solve other browning problems encountered in food processors. If tomato processing industries in Myanmar can expand their product's range and improve their product quality, especially maintaining the natural color of tomatoes, their brands will be competitive with tomato products imported from other countries.

Materials and Methods

Materials

- Pheegyan banana (*Musa saba*) from Kyon Pyaw Township, Ayeyawady Region.
- Tomato (*Lycopersicon esculentum*) from Khin Mon Village, Chaung Oo Township, Sagaing Region.

Methods

Inhibition of Browning Reactions

Enzymatic Browning

- Control by inactivating enzymes with the use of reducing agent such as ascorbic acid
- Prevent by eliminating oxygen with vacuum treatment
- Slow down enzyme action by decreasing pH with the use of acidulants such as ascorbic acid and citric acid

Maillard Browning

- By decreasing pH of the food product
- By lowering processing and storage temperature

Preparation of Banana Puree

Banana purees were prepared at the Department of Industrial Chemistry, University of Yangon. The preparation process includes washing, peeling, coring, acidification, homogenizing, deaerating, pasteurization and packaging of the products. Firstly, the ripe, mature bananas were weighed and washed thoroughly with water. Then, bananas were peeled and cored. The resultant banana pulps were weighed and ascorbic acid (0.05 - 0.25 %w/w on the basis of pulp) alone or in combination with citric acid (0.05 - 0.2%w/w) was added to the banana pulp to control enzymatic browning of banana puree. After that, the puree was homogenized, pasteurized, filled into sterilized bottles and the bottles were sealed and inverted for about 5 minutes. The prepared purees were stored at room temperature in order to determine the shelf-life and physicochemical properties of the samples.

In this research work, enzymatic browning was controlled by using enzyme inhibitors such as ascorbic acid, citric acid and vacuum treatment.

Investigation of Physicochemical Characteristics of Banana Puree

Brown Color Absorbance (A_{420}) - Brown color absorbance of banana puree was measured by using TRSP-722 Grating Spectrophotometer against distilled water at 420nm. Banana purees (initial Brix levels of 20º - 25º) were mixed with distilled water to 10ºBrix. Vacuum filtration was used to obtain clear filtrate. The clear filtrate was placed in a cuvette and measured by selecting the absorbance (ABS) mode.

Soluble Solids Content - The soluble solids content of banana puree was measured with a refractometer (ATAGO Hand Refractometer).

pH, acidity, moisture content, protein content and ash content were determined by using the methods stated in the Chemical Analysis of Foods (Pearson, D., 1970).

Processing of Tomato Puree

The processing of tomato puree was carried out at the Shwe Thandar International Co. Ltd., South Dagon Industrial Zone. The ripe, sound tomatoes were washed, crushed and pulped by passing through a pulping machine fitted with a fine mesh sieve to separate juice from the seeds and the skins. The juice obtained was concentrated by open pan or using Makeshift vacuum evaporator (Figure 1) until soluble solids content of 10 – 12 ºBrix was reached. Then, the hot puree was filled into sterilized bottles by means of filling machine, sealed immediately and pasteurized at 80ºC for about 10 minutes and then cooled. The crushing and pulping machine, open pan cooker and filling machine are shown in Figures (2), (3) and (4), respectively.

Investigation of Physicochemical Characteristics of Tomato Puree

Brown Color Absorbance (A_{420}) - About 10 g of processed tomato puree (ºBrix 10 – 12) was first placed in a 50 ml beaker. Next, 10 ml of distilled water was added into the beaker and thoroughly agitated. Then, the clear supernatant solution was obtained by filtering the sample with a filter paper. The ºBrix levels of all the filtrates were adjusted to 5ºBrix which is the original ºBrix of the raw tomato juice. After that, the brown color absorbance of the filtrate was determined at 420 nm with a PD-303S spectrophotometer.

Soluble Solids Content – The soluble solids content of tomato puree was measured by using a refractometer (ATAGO Hand Refractometer).

pH, acidity, moisture content, protein content and ash content were determined by using the methods stated in the Chemical Analysis of Foods (Pearson, D., 1970).

Equipment Used for Vacuum Treatment

Makeshift Vacuum Evaporator

This makeshift vacuum evaporator was designed by the researcher and fabricated at the Scientific Equipment Workshop, Department of Higher Education (Lower Myanmar), Ministry of Education. The reaction vessel was made of aluminium- steel alloy. This apparatus was a modification of a pressure-cooker. The apparatus is shown in Figure (1).

The operating conditions used in the reactor were as follows:

Vacuum deaeration of banana puree	:	260mmHg at ambient temperature for 30 minutes.
Vacuum concentration of tomato puree	:	210 mmHg at 70°C for 3 hours

Figure (1) Makeshift Vacuum Evaporator

Figure (2) Crushing and Pulping Machine

Figure (3) Open Pan Cooker

Figure (4) Filling Machine

Results and Discussion

In Table (1), it was found that the initial values of brown color absorbance of banana purees decreased in accordance with the increase in proportion of ascorbic acid from 0.05 to 0.25% w/w. However, in two months of storage, the brown color absorbance of the samples processed with 0.2%w/w and 0.25%w/w ascorbic acid were higher than those of other samples prepared with 0.05%w/w, 0.1%w/w and 0.l5%w/w ascorbic acid. During three month storage, samples inhibited browning with 0.2%w/w and 0.25%w/w ascorbic acid gave fermented smell although no browning was observed in all processed banana purees. It was found that these results were in accordance with the following statement: Potter (1973) stated that food containing acid may be in a state of preservation, but oxygen is available and surface mold grow and then further ferment the acid. When this reaction happens, the preservative action of the acid against other microorganisms is lost.

In addition, the combined effect of ascorbic acid and citric acid was studied and the results are indicated in Table (2). From these resultant values, it was seen that the samples prepared by 0.1%w/w ascorbic acid combined with 0.15%w/w or 0.2%w/w citric acid inhibited browning but gave fermented smell after four months of storage. The banana puree using 0.1%w/w ascorbic acid in conjunction with 0.1%w/w citric acid resulted not only browning with absorbance value of 1.109 in one month storage after pasteurization at 90ºC for 10 minutes but also gave out fermented smell after four months of storage. Among the processed purees in Table (2), the sample using browning inhibitors of 0.05%w/w ascorbic acid combined with 0.05%w/w citric acid was more suitable as indicated by better color, flavor and texture than the others and the appearances of the samples are shown in Figure(6).

Ascorbic acid combined with vacuum treatment was more effective than using ascorbic acid alone. The results are presented in Figure (5). Moreover, the percentage of ascorbic acid could be reduced when used in conjunction with other enzyme inhibitors such as citric acid. This finding is confirmed by the fact that citric acid is a stabilizer for ascorbic acid (Woodroof and Luh,1973). Moreover, Dauthy (1995) stated that citric acid is used in conjunction with antioxidants such as ascorbic acid to inhibit color and flavor deterioration caused by metal-catalysed enzymatic oxidation.

From the results of Table (3), it can be seen that the values of pH, acidity, soluble solids content, moisture, protein and ash content are comparable to those of literature value.

Table (1) Effect of Ascorbic Acid on Changes in Brown Color Absorbance of Banana Purees during Storage at Room Temperature

Sr. No.	AA (% w/w)	PS (%w/w)	SMBS (% w/w)	Brown Color Absorbance			Observation
				Initial time	Storage time		
					2 months	3 months	
1	0.05	0.05	0.05	0.451	0.495	0.739	No browning
2	0.1*	0.05	0.05	0.388	0.456	0.602	No browning
3	0.15	0.05	0.05	0.300	0.342	0.692	No browning
4	0.2	0.05	0.05	0.290	0.515	0.318	Fermented smell
5	0.25	0.05	0.05	0.285	0.528	0.155	Fermented smell

Note: AA – Ascorbic Acid, PS – Potassium Sorbate, SMBS – Sodium Metabisulfite: %w/w are based on banana pulp weight.
* Optimum
Brown Color Absorbance was measured at the Department of Industrial Chemistry, University of Yangon.

Table (2) Combined Effect of Ascorbic Acid and Citric Acid on Changes in Brown Color Absorbance and Transmittance of Banana Purees during Storage at Room Temperature

Sr. No.	AA (% w/w)	CA (% w/w)	PS (%w/w)	SMBS (% w/w)	Storage Time						Observation
					1 month		2 months		4 months		
					ABS	T (%)	ABS	T (%)	ABS	T (%)	
1*	0.05	0.05	0.05	0.05	0.290	51.0	0.315	48.0	0.425	37.8	No browning
2	0.1	0.05	0.05	0.05	0.314	48.5	0.412	47.1	0.509	31.5	No browning
3	0.1	0.1	0.05	0.05	1.109	7.8	1.371	4.3	0.215	60.6	Browning & fermented smell
4	0.1	0.15	0.05	0.05	0.310	49.2	0.181	66.2	0.094	80.5	Fermented smell
5	0.1	0.2	0.05	0.05	0.308	49.5	0.080	82.7	0.105	78.0	Fermented smell

Note: AA – Ascorbic Acid, CA – Citric Acid, PS – Potassium Sorbate, SMBS – Sodium Metabisulfite: %w/w are based on banana pulp weight.
ABS – Brown Color Absorbance, T – Transmittance
Sample (3) was pasteurized at 90ºC for 10 minutes.
*Optimum
ABS and T (%) were measured at the Department of Industrial Chemistry, University of Yangon.

Table (3) Physicochemical Characteristics of Banana Puree

Characteristics	**Banana Puree	Literature Value	
		*** Banana	Banana puree
pH	4.2 – 4.3	4.0 – 4.6	#4.2 – 4.5
Acidity (% w/v)	0.1 – 0.3	-	*0.45 maximum
Soluble solids (ºBrix)	21- 26	20	*20 minimum
Moisture (%w/w)	69 – 74	70.1	-
Protein (%w/w)	1.1-1.2	1.1-1.2	#1
Ash (% w/w)	0.8 – 0.95	0.8	-
Total Plate Count	6×10^3	-	*5000/g

Note: ** Acidity, ºBrix, moisture, ash & pH were determined at the Department of Industrial Chemistry, University of Yangon.
Protein (%) was measured at the Laboratory of Development Centre for Food Technology (DCFT), Ministry of Industry (I).

Ref: ***Srilakshmi B.,2007, Food Science. #http://www.nw.naturals.com, *http://www.fruitpulps.com/products.html, 2000, Safal India Inc.

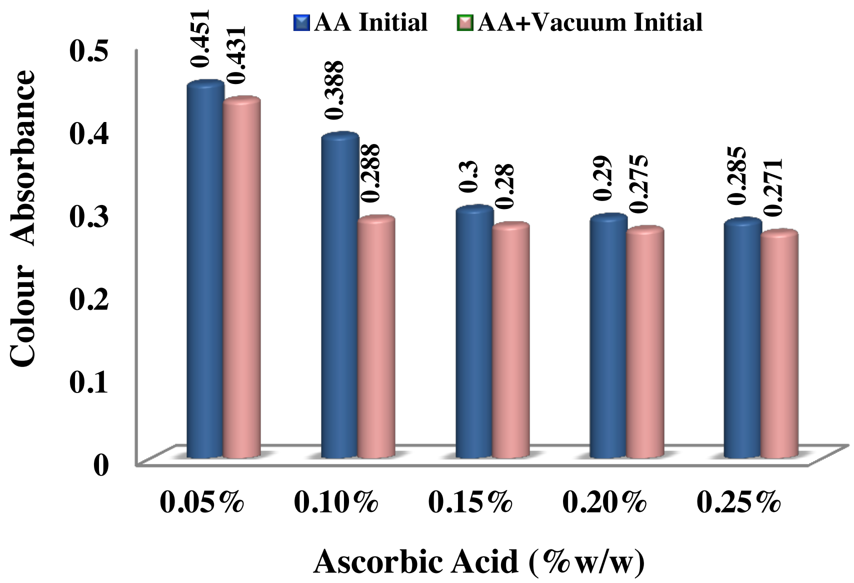

Figure (5) Combined Effect of Ascorbic Acid and Vacuum Deaeration on Changes in Brown Color Absorbance of Banana Purees

For the effect of processing condition, Table (4) shows that vacuum concentration of tomato puree achieved shorter concentration time, better color stability and higher yield percent.

In Table (5), it was found that the immersion-treated samples processed with the addition of 0.1% w/w citric acid or malic acid to tomato puree were more favorable than others: the shelf-life was found to be above one year and no browning was observed for these samples. The appearances of the fresh tomato puree samples are compared with those of the samples stored for six months and for one year, and these pictures are illustrated in Figure (7).

The results of Table (6) show the characteristics of tomato purees. It was found that the resultant values were comparable with those of literature values.

Table (4) Comparison of the Parameters and Characteristics of Tomato Purees Prepared by Vacuum Concentration Method and Open Pan Concentration Method

Parameters and Characteristics	Vacuum Concentration Method	Open Pan Concentration Method
Pressure (mmHg)	200-210	760
Cooking Temp: (ºC)	70	70
Cooking Time (hr)	3	5
ºBrix (Initial)	5	5
ºBrix (Final)	10	10
Abs (Initial)	0.245	0.245
Abs (Final)	0.431	0.623
Yield (%)	58	51.25

Note : Abs – Brown Color Absorbance

Brown Color Absorbance was measured at the Department of Industrial Chemistry, University of Yangon.

Table (5) Combined Effect of Immersion in 0.1%w/w Ascorbic Acid Solution for 1Hour and Food Additives on Brown Color Absorbance of Tomato purees during Storage at Room Temperature

Initial ºBrix = 5 Final ºBrix = 10
Concentration time = 5hr, Concentration Temp: = 70 – 75ºC, Yield (% w/w) = 51.25

Sr. No.	AA (%w/w)	CA (%w/w)	MA (%w/w)	PS (%w/w)	SMBS (%w/w)	Brown Color Absorbance (A_{420})						Shelf-life	Observation
						Initial time	Storage time (week)						
							1	2	3	4	5		
1	0	0	0	0.05	0.05	0.302	0.336	0.354	0.379	0.392	0.406	8months	Browning
2	0.05	0	0	0.05	0.05	0.332	0.365	0.419	0.452	0.490	0.762	6months	Browning
3*	0	0.1	0	0.05	0.05	0.308	0.309	0.309	0.310	0.325	0.346	Above 1year	No browning
4	0	0	0.1	0.05	0.05	0.295	0.315	0.324	0.398	0.401	0.412	Above 1year	No browning
5	0.05	0	0.1	0.05	0.05	0.315	0.322	0.324	0.333	0.354	0.373	6months	Browning

Note: AA- Ascorbic Acid, CA- Citric Acid, MA- Malic Acid, PS- Potassium Sorbate, SMBS- Sodium Metabisulfite: %w/w are based on tomato puree weight.
*Optimum - Tomato puree was prepared at the Food Factory Shwe Thandar International Co.Ltd., South Dagon Industrial Zone, Yangon.
Brown Color Absorbance was measured at the Department of Industrial Chemistry, University of Yangon and East Yangon

Table (6) Characteristics of Tomato Purees Prepared by Open Pan Concentration Method

Characteristics	Experimental Value		Literature Value	
	Tomato	Tomato Puree	Tomato	Tomato Puree
pH	4.3	4.0 – 4.3	-	< 4.4
Acidity (% w/v)	0.2	0.2 – 0.3	0.2 – 0.6	0.4 – 0.55
Soluble Solids (ºBrix)	4 – 5	10	4 – 6	8 – 12
Moisture (% w/w)	94.5 – 94.7	87 – 88	94.5	-
Protein (%w/w)	0.9	0.9	0.8-1.2	-
Ash (% w/w)	1.42	1.468	-	-
Standard Plate Count	-	11×10^3	-	-
Yield (% w/w)	-	51.25	-	-

Note: Acidity, ºBrix, moisture, ash (%) & pH were determined at the Department of Industrial Chemistry, University of Yangon.

Ref : Swaminathan, 2009 . Handbook of Food and Nutrition, 5th Ed., The Bangalore Printing & Publishing Co. Ltd. HCP Live Healthcare Newes, HCP Live com. (online)

Figure (6) Banana Puree Processed with Ascorbic Acid and Citric Acid

Figure (7) Tomato Puree Processed with Immersion in Ascorbic Acid Solution and Citric Acid as Addition

Conclusion

Most of the food manufacturers encountered browning problems during processing, storage and before transporting the products to the market. In order to understand the problem of browning of foods, including enzymatic and non-enzymatic, a systematic approach becomes necessary.

The present research work is mainly concerned with control of enzymatic browning in banana puree as well as reduction of non-enzymatic browning during processing and storage of tomato puree. Inhibitors of browning which do not affect product flavor, texture and color are also under investigated.

It can be concluded that only a limited amount of browning inhibitors are considered acceptable with respect to consumer safety and / or cost when they are used as food additives. Furthermore, when ascorbic acid was used as anti-browning agent, its oxidative degradation was reduced as much as possible because ascorbic acid browning was also a problem involved in browning of fruit and vegetable products. Therefore, ascorbic acid in conjunction with vacuum treatment was favorable in controlling browning problems in tomato puree making.

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