PROCESSING AND PRESERVATION OF MIXED VEGETABLE JUICE (Tomato, Cucumber & Pumpkin)

A THESIS

BY

AYESHA SIDDIKA

Student No. 1105036

Session: 2011-2012
Semester: January- June, 2012

MASTER OF SCIENCE

IN

FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE, 2012

PROCESSING AND PRESERVATION OF MIXED VEGETABLE JUICE (Tomato, Cucumber & pumpkin)

A THESIS

BY

AYESHA SIDDIKA

Student No. 1105036

Session: 2011-2012

Semester: January-June, 2012

Submitted to the Department of Food Engineering and Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur

In partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE (MS)
IN
FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE, 2012

PROCESSING AND PRESERVATION OF MIXED VEGETABLE JUICE (Tomato, Cucumber & pumpkin)

A THESIS

BY

AYESHA SIDDIKA

Student No. 1105036

Session: 2011-2012

Semester: January-June, 2012

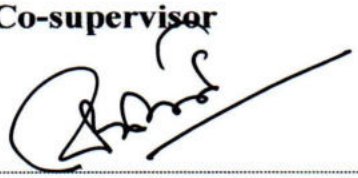
Approved as to the style and content by

(Prof. Dr. Md. Kamal Uddin Sarker)

Supervisor

(Md. Aslam Ali)

Co-supervisor



(Prof. Dr. Md. Kamal Uddin Sarker)

Chairman of the Examination Committee

and

Chairman

DEPARTMENT OF THE FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJPUR

JUNE, 2012

DEDICATED TO

MY

BELOVED PARENTS

ACKNOWLEDGEMENT

All admiration and praises are solely due to Almighty Allah, the creator of the universe and source of all knowledge who enabled me to pursue MS degree in Food Engineering and Technology. I express my deepest sense of appreciation, heartiest gratitude and indebtedness to my respected supervisor Professor, Dr. Md. Kamal Uddin Sarker, Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his tremendous help, co-operation, advice and constructive criticism throughout the period of research work as well as in the preparation of the thesis manuscript.

I would like to extend my gratitude and appreciation to my Co-supervisor Assistant Professor Md. Aslam Ali of Food Processing and Preservation Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for his sincere co-operation and suggestions for carrying out the research work and improving the thesis.

I wish to record my sincerest appreciation and profound regard to my teachers, Professor Md. Ruhul Amin, Department of Agricultural and Industrial Engineering and honourable Vice Chancellor Hajee Mohammad Danesh Science and Technology University, Dinajpur, Professor, Dr. Md. Shiddiqur Rahman, Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and Technology University , Dinajpur, and all other teachers of the faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur, for their kind co-operation and constructive advices during the study period.

Profound thanks and appreciation are due to my intimate friends and juniors for their contribution in panel test and for their support, friendly co-operation and constant encouragement in preparing the manuscript. I also extend my thanks to the senior lab technician Md. Milon, Lab Assistant Md. Kabir and the staff-members of the faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur for their help during the experiment.

Lastly, I would like to acknowledge my heartfelt indebtedness to my beloved parents, sisters and brother for their continuous inspiration, sacrifices and blessings that opened the gate and paved the way for my higher studies.

The Author

ABSTRACT

Vegetable juice is a drink made primarily of blended vegetables. Juice is an easy way to add more vegetables to any diet. Vegetables are perishable, so we can preserve these vegetables by making juice. Vegetables are equally nutritious eaten raw or processed. Vegetable juice was processed in three types differing in the ingredients. The shelf life of vegetable juices was studied for 60 days storage period. Chemical analyses were carried out during the 60 days at the interval of 15 days. Sensory evaluation, by serving the vegetable juice to the panelists, was done and the secured scores were analyzed with ANOVA and DMRT at the significance level of $P < 0.05$. At this level taste, color, flavor, texture, and overall acceptability were found significant with LSD values of 0.5734, 0.8047, 0.5646, 0.5457 and 0.3047 respectively. There were three treatments of vegetable juices. Treatment 1(vegetable juice with vinegar, and spice) was best for color and flavor. Treatment 2(vegetable juice without vinegar, spice and citric acid) was best for texture. Treatment 3 (vegetable juice with vinegar and citric acid) was best for color, flavor, taste and overall acceptability. The keeping quality, shelf life and consumer's acceptability of the products were investigated. The products were analyzed for their TSS, acidity and vitamin - C. It was found that TSS was increased slightly and Vitamin-C was decreased gradually during the storage periods. Fading of color was found at the end of storage periods. The sedimentation was minimized by using CMC as thickening agent. The prepared mixed juices were tasted by a taste – testing panel for different sensory attributes using 9 point hedonic scale. The panelists tasted the products and assigned marks for taste, color, flavor, texture and overall acceptability. The mean score for taste, color, flavor, texture and overall acceptability showed secured score within the acceptable limit. Storage studies were carried out up to two months at refrigeration temperature (4° C). The shelf life of juices from the first day to thirty days found that, color of juices were slightly changed and flavor was natural. Then after thirty days fade color and off flavor was found and all the juices were sedimented. But, at room temperature (28-30°C) juices were spoiled after three days.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Vegetable juices are becoming an important part of modern-day diet in many cities of the world. Vegetable juice is a drink made primarily of blended vegetables. The nutritive value of vegetables is generally recognized, particularly as regard to minerals and vitamins. Juice is an easy way to add more vegetables to any diet. Vegetable juice is not practiced in Bangladesh.

Fruit and vegetable juices have become important in recent years due to overall increase in natural juice consumption as an alternative to the traditional caffeine containing beverages such as coffee, tea, or carbonated soft drinks. Consuming fruits and vegetables promotes health, energy and quality of life. Juices are obtained from a single fruit or from different kinds of fruits and vegetables (Tombak, 2000).

A diet that is rich in fruits and vegetables has been associated with protection against cardiovascular disease (Bazzano *et al.,* 2002) and several common cancers (Van't Veer *et al.,* 2000).

Fruit and vegetable juices have significantly improved blood lipid profile in people affected by hyper-cholesterolemia as well as promote detoxification of human body (Deanna and Jeffrey, 2007).

Vegetable juice is a drink produced mainly from vegetables, however here the combination of vegetables is tomato, cucumber and pumpkin. Tomato (*Lycopersicon esculentum*) is one of the most popular and demanding vegetables grown in Bangladesh. Ripe red tomatoes are rich in beta-carotene and the anti-oxidant lycopene. Many studies have shown tomatoes inhibit cancer cells, and are effective against a wide range of cancers, help to blood purifying, prevent dangerous blood clots, cleans liver, and help to fight gallstones, reduce cholesterol, protect the skin from sunburn, and premature aging (Moreno *et al.*, 2006).

Cucumbers (*Cucumis sativus* L.) are extremely beneficial to health especially during the summers as it mostly contains water and many important nutrients that are essential for human body. In central Asia, people drink cucumber juice on warm days to help cool their body. Cucumber juice in the diet is one of the best favorable juices to improve and maintain healthy skin, nails and hair, weight loss, high blood pressure, acne, eczema, to dissolve kidney stone etc. Calbom (1992) writes, "Drinking a glass of cucumber juice before each meal can help curb our appetite." Cucumbers are very high in water content and satisfy the appetite.

Pumpkin (*Benincasa hispida)* is a member of the family Cucurbitaceae. Pumpkin has a good shelf-life and it contains carotene, watersoluble vitamins and amino acids. Pumpkins are relatively low in total solids, usually ranging between 7% and 10% (Alibas, 2007). Its unique constituents, rich in antioxidants and vitamins, allow the pumpkin to have an important health-protecting effect. Raw pumpkin juice is a good source of alpha-carotene, beta-carotene, fiber, vitamins C, B1, B2, B6, and E, potassium, magnesium, iron, and fatty acids. Beta-carotene is an antioxidant precursor to vitamin A in the human body (Weinstein, Vogt, & Gerrior, 2004).

Raw pumpkin juice is good for digestive system. It can help constipation and loose stools. Pumpkin juice reduces the risk of high blood pressure and heart disease. It is rich in pectin that helps lower cholesterol. Raw pumpkin juice is a good source of vitamin C and minerals that boost the immunity. Being rich in Vitamin E and beta-carotene, fresh pumpkin juice promotes healthy and beautiful skin (Saha, 2004).

Vegetable juice is important for health to supply vitamins and minerals. Raw vegetable juice cannot be kept for long time for storage, this are rotten quickly. Farmers cannot get suitable price at the time of harvest. It is not easy and cost worthy to preserve vegetable in row from in frozen condition. Vegetable juice can be made attractive to people as a drink rather than only vegetable. Children love juice than raw vegetable. So, in a juice form it can be supplied to kids. The value of agricultural produce can be increased and preserved in processed form for long time.

Fruits and vegetables are major contributors of key nutrients; consumption of vegetables and fruits is associated with reduced risk of many chronic diseases, including cardiovascular disease, certain types of cancer and type 2 diabetes; and most vegetables and fruits, when prepared without added fats or sugars, are relatively high in dietary fiber and low in calories (Mazur, et al. 2003).

In Bangladesh, a huge amount of vegetables (18-34 %) are spoiled due to lack of suitable post harvest facility. If vegetables converted into lucrative food product (e.g. juice) then they could be preserved for longer time. Also many people and children are not interested to eat vegetables but they will take vegetable juice interestingly. The vegetables in a juice form will increase the value of agricultural products become easily consumable nutrient element and farmers will get good value for their products. With the above considerations in mind, the current research has been conducted with following objectives:

- To formulate mixed vegetable juice.
- To assess the overall acceptability of the formulated juice.
- To study on the shelf life of the juice.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Vegetable juices are becoming popular in comparison to synthetic beverages evidently because of their taste, flavor and nutritive value. Mixed juices have a good demand in this sub continent as well as many other foreign countries. A number of research workers in different countries investigated the formulations of different vegetable based soft drink, squash, non carbonated vegetable juice drink containing sugar, water, citric acid, sometimes gums, artificial color and flavor.

Fruits and vegetables form an essential part of a balanced diet. They are important part of the world agricultural food production, even though their production volumes are small when compared with grains. Fruits and vegetables are important sources of digestible carbohydrates, minerals and vitamins, particularly vitamins A and C. In addition, they provide roughage (indigestible carbohydrates) which is needed for normal healthy digestion (Salunkhe and Kadam, 1995).

Vegetables are good sources of carbohydrates, vitamins and minerals and are considered a staple source of stew and soup ingredient in Nigeria. The quality good shelf-life of vegetables is related to some biochemical processes that take place after harvest. Physiological actions such as respiration involves heat emission of heat resulting in temperature increase, and this accelerates metabolic processes and decay phenomena (Sánchez-mata *et al.,* 2003).

Vegetables are an important part of the human diet and a major source of biologically active substances such as vitamins, dietary fiber, antioxidants, and cholesterol-lowering compounds. phytochemicals have been linked to many positive effects on human health, including coronary heart diseases, diabetes, high blood pressure, cataracs, degenerative diseases, and obesity (Liu and others 2000; Djouss´e and others 2004).

The links between fruit and vegetable consumption and protection against cancers of stomach, esophagus, lung, pharynx, endometrium, pancreas, and colon have also been extensively reported (Temple and Gladwin 2003; Hung and others 2004).

Consumption of fresh fruit and vegetable juices are on the increase as people from all ages and income groups consume the juice throughout the year for its nutritional value and health reasons. In the same vain, commercial ice used by this food vendors should be safe to consume and be of the same quality as drinking water because it is ingested directly when added to juices and soft drinks or indirectly when used to refrigerate food items (Falcão *et al.,* 2002).

Pathogenic micro-organisms can have access into the fruit and vegetable juice through damage surfaces, such as punctures and cuts that occur during growing and harvesting. Contamination from raw materials and equipments, improper handling, prevalence of unhygienic conditions contributes substantially to the entry of pathogenic micro-organisms into the juice (Titarmare *et al.,* 2009).

In order to extend the shelf-life of vegetables, several authors have recommended the storage of these products at 4- 10^0 C (Wills *et al.* 1999). Modified or controlled atmosphere storage is also a useful technique for extending shelf-life of vegetables, especially for those that deteriorate quickly (Sanchez-mata *et al.* 2003).

Ranganna & Bajaj (1966) reported that sulphur-dioxide is widely used throughout the world principally for treating food of plant origin. It is used in the preservation of vegetable juices, pulps, beverages and concentrates. Concentration used may vary from 350 to 2000 ppm. Soluble sulphite salts (e.g. K.M.S) are usually used in treating vegetable products. The activity is higher at pH below 4.0.

Martin glicksman (1969) reported that CMC was used as a bodying agent in beverages containing sodium cyclohexyl sulphate made instead of sugar. In this application the CMC bodying agent is necessary to impart the syrupy texture normally supplied by the high sugar concentration.

Processing and cooking can change the nutrient quality of foods. Fat-soluble compounds such as lycopene can be stabilized or enhanced through cooking. Water-soluble vitamins such as vitamin C and folate can be lost at high rates when cooking water is discarded (Lee, 2000).

Mahale *et al.*, (2008) suggested that unpasteurized juice sold by street vendors and hawkers are preferred by consumers because of the "flesh flavour" attributes.

Regular consumption of lycopene has been linked to decreased incidence of prostate cancer, lung cancer, digestive tract cancer and cardiovascular disease. It has been shown to induce cell-to-cell communication, modulate hormones and immune systems and affect other metabolic pathways (Kuti, 2005).

Anonymous (1984) reported that vegetable juice is normally an acid food and does not support the growth of pathogens. He specified pasteurization time and temperature for these foods which are as follows:

For these foods, i.e. at low pH foods

- Pasteurization was done for 80^0 C for 30 sec.
- For cloudy juice pasteurization will be performed at 90 to 95^0 C for 30 sec.

The second specification may be applied for all types of fruit juice for more conformation.

In food industry vegetable juice is defined as the liquid expressed by manual or mechanical means from the edible of the vegetable. Frequently the juice may be turbid, contain cellular components in colloidal suspension with variable amounts of finely divided tissue. It sometimes may contain oily or waxy material and carotenoid pigments (Hulme, 1971).

Hulme (1971) stated that all juices are inherently unstable. Microorganisms already present on the vegetable or graining access to the product during processing rapidly attack them; they are also subject to enzymatic and non enzymatic changes. It is thus essential to destroy the microorganisms at an early stage or to prevent their development. At the same time inactivating the enzyme activity will restrict the chemical change by heating or refrigeration.

Health-benefiting properties of fruits and vegetables

The world health organization acknowledges that the global intake of vegetables is less than 20-50% of the recommended amount. In developed countries, the significantly low vegetable intake is due to the consumer's preferences for convenience foods and not the scarcity of the vegetables. In the US more processed vegetables are consumed than fresh vegetables (Rickman *et al.,* 2007).

Green vegetables have high respiration rate which limits their shelf-life after harvest to 1-4 weeks maximum. This is partly attributed to the high metabolic activity of the leaves and in some cases the seeds inside some of the fruits (Wills *et al.* 1999).

In order to extend the shelf-life of vegetables, several authors have recommended the storage of these products at 4-10°C (Wills *et al.* 1999).

Modified or controlled atmosphere storage is also a useful technique for extending shelf-life of vegetables, especially for those that deteriorate quickly (Sánchez-Mata *et al.* 2003).

Fruits and vegetables usually have considerable amounts of vitamins and minerals and generally they contain little protein or fat and have low calorie content (Pamplona-Roger, 2003).

Fruits and vegetables have high fiber content and they also contain natural colour pigments and as such are used as food colourants in food preparation to improve the sensory quality of foods (Tombak, 2000).

Phytochemicals such as flavonoids, limonoids (prominent in orange) and lycopene (prominent in tomatoes), which are powerful antioxidants and also prominent in most fruits and vegetables (Negri, 1991), help in the prevention of arteriosclerosis, cardiovascular diseases and prostate cancer (Trout, 1991).

Nutritional Value: The nutritional value of raw tomato per 100 gm is shown in table 2.1 and that of tomato juice is shown in table 2.2.

Table 2.1: Nutritional Value of Raw Tomato

Nutrient	Value per 100 gm
Energy	18 Kcal
Carbohydrates	3.9 g
Sugars	2.6 g
Dietary fiber	1.2 g
Fat	0.2 g
Protein	0.9 g
Water	94.5 g
Vitamin-C	14 mg
Vitamin-E	0.54 mg
Calcium	10 mg
Iron	0.3 mg
Magnesium	11 mg
Zinc	0.17 mg
Lycopene	2573 ug

(Source: USDA National Nutrient Data Base 2009)

Table 2.2 Nutritional Value of Tomato Juice per 100 gm

Tomato juice, canned, salt added	
Nutritional value per 100 gm	
Energy	17 Kcal
Carbohydrates	4.24 g
Sugars	3.56 g
Dietary fiber	0.4 g
Fat	0.05 g
Protein	0.76 g
Vitamin-C	18.3 mg
Water	93.90 g

(Source: USDA Nutrient Database 2011)

Table 2.3 Nutritional Analysis of Mixed Vegetable (tomato, cucumber and pumpkin) Juice per 100 gm

Energy	47.17cal
Protein	2.36g
Total fat	0.36g
Saturated fat	0.01g
Carbohydrates	7.16g
Total sugars	6.96g
Fibers	2.96g
Sodium	501.25mg
Cholesterol	0mg
Potassium	382.54mg

(Source: USDA Nutrient Database 2010)

Nutritional Analysis: The nutritional analysis of raw cucumber per 100 gm is shown in table 2.4 and that of raw pumpkin is shown in table 2.5.

Table 2.4: Nutritional Analysis of Cucumber

Nutrient	Value per 100 gm
Energy	65kcal
Carbohydrates	3.63 g
Sugars	1.67 g
Dietary fiber	0.5 g
Fat	0.11 g
Protein	0.65 g
Water	95.23 g
Vitamin-C	2.8 mg
Vitamin-E	0.03 mg
Calcium	16 mg
Iron	0.28 mg
Magnesium	13 mg
Potassium	147 mg
Zinc	0.2 mg

(Source: USDA Nutrient Database 2011)

Table 2.5: Nutritional Analysis of Pumpkin

Nutrient	Value per 100 gm
Energy	26 Kcal
Carbohydrates	6.5 g
Sugars	1.36 g
Dietary fiber	0.5 g
Fat	0.1 g
Protein	1.0 g
Vitamin-C	9 mg
Vitamin-E	1.06 mg
Calcium	21 mg
Iron	0.8 mg
Magnesium	12 mg
Potassium	340 mg
Sodium	1 mg
Zinc	0.32 mg

(Source: USDA Nutrient Database 2012)

CHAPTER III

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter explains the methods and materials required for the preparation, processing and preservation of mixed vegetable juice of tomato, cucumber and pumpkin.

The experiment was conducted in the laboratory of the department of Food Engineering and Technology under the faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.1 Materials and Apparatus Required

Materials Required

Fresh vegetables (tomato, cucumber and pumpkin) and other raw materials were collected from local market. The glass bottles and other chemicals such as citric acid, carboxy methylcellulose (CMC), potassium metabisulphite (KMS), vinegar, sugar, salt and other materials were used from the laboratory stock and also collected from local market. The glass bottles were used in the bottling of juice.

Apparatus & Equipment Used

i. Blender
ii. Desiccator
iii. Oven
iv. Measuring flask
v. Electrical balance
vi. Saucepan
vii. pH meter
viii. Conical flask
ix. Muffle furnace
x. Measuring cylinder
xi. Refractometer
xii. Bottle sealing machine
xiii. Heater
xiv. Crucible

3.2 Vegetable Juice Processing

Raw materials (tomato, cucumber and pumpkin – all are deshi varieties) were received and washed with water for cleaning. Then cucumber and pumpkin were peeled. The seeds of cucumber and pumpkin were removed. The peel and seeds of tomato was removed by the strainer. The raw materials were chopped by the slicer and put them in the blender and blend with sufficient amount of water. After suitable blending the juice was filtered using strainer. Then the juice was cooked on low heat for 10-15 minutes. Cooking was done because raw vegetable juices are not suitable for direct consumption, because of its strong flavor and acidity. The raw juice may be viscous due to the presence of soluble pectin. Heat treatment or refrigeration of juices can restrict the growth of microorganisms. Then the vegetable juice was allowed to cool slightly and collected in sterilized bottles. Salt, sugar and other ingredients were used to increase the taste of juice. Then the juices were put into refrigerator for further consumption. Formulations of mixed vegetable juice for different treatments are shown in table 3.1.

Table 3.1: Formulations of mixed vegetable juice for different treatments

Ingredients (based on 100 gm finished product)	Formulations (%)		
	S1	S2	S3
Tomato	5%	9%	7%
Cucumber	9%	7%	5%
Pumpkin	7%	5%	9%
Sugar	12%	15%	13%
Vinegar	1%	-	1%
Citric acid	-	-	0.2%
KMS	0.001%	0.001%	0.001%
CMC	0.2%	0.2%	0.2%
Spice	0.01%	-	-
Water	65%	63%	64%
Tamarind	0.3%	0.3%	-
Salt	0.5%	0.5%	0.5%

Juice processing technology is shown below in the flow chart:

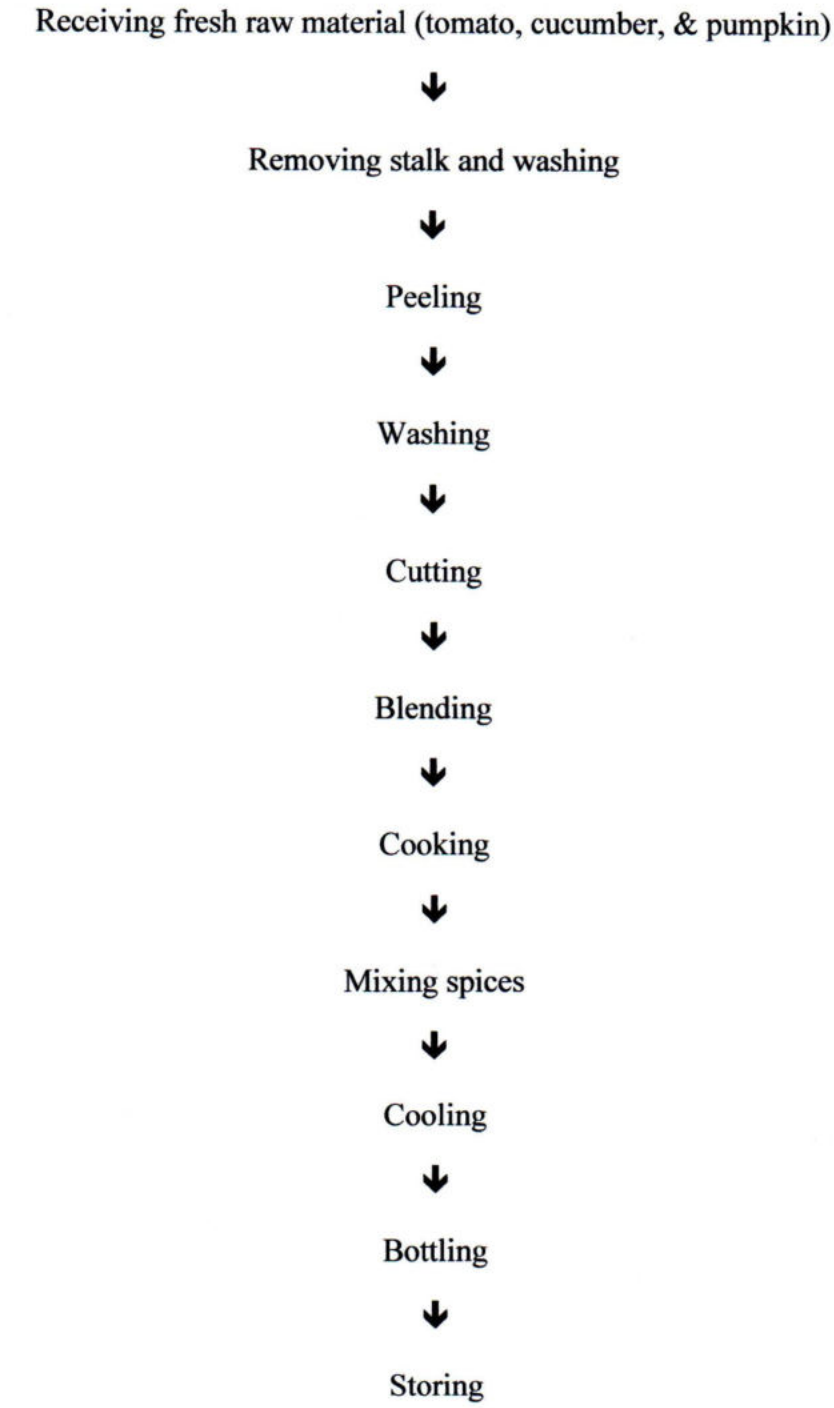


Figure 3.1: Flow diagram of mixed vegetable juice processing

Fig: 3.2 Ripe tomato

Fig: 3.3 Sliced pumpkin

Fig: 3.4 Peeled cucumber

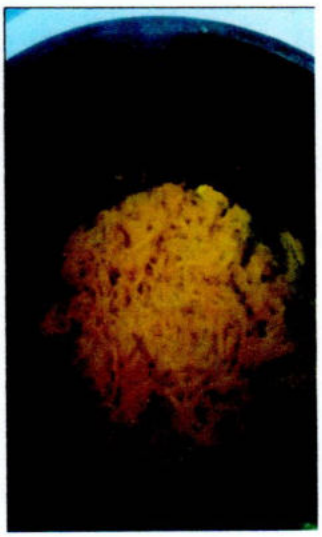


Fig: 3.5 Chopped pumpkin

Fig: 3.6Chopped cucumber

Fig: 3.7 Blended vegetables

3.3 Chemical Analysis

The processed vegetable juices were analyzed for their vitamin-C, total soluble solid and acidity.

3.3.1 Determination of vitamin-C

Ascorbic acid was determined following the method of Rangana (1977).

The reagents used for the estimation of vitamin C were as follows:

i) Metaphosphoric acid (3%)

ii) Standard ascorbic acid solution

iii) Dye solution

For estimation of ascorbic acid, the following steps were followed:

Standardization of Dye Solution

5ml standard ascorbic acid solution was taken in a conical flask and 5 ml Metaphosphoric acid (HPO_3) was added to it and then shaken. A micro-burette was filled with Dye solution and the mixed solution was titrated with Dye using phenolphthalene as indicator. Dye factor was calculated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of Sample

20gm of sample was blended and homogenized in a blender with 3% mataphosphoric acid solution. The homogenized liquid was transferred to a 250ml volumetric flask and made to volume with metaphosphoric acid solution. Content of flask was then thoroughly mixed and filtered.

Titration:

5ml of the aliquot was taken in a flask and titrated with standard dye solution, using phenolphthalein indicator. The ascorbic acid content of the sample was calculated using the following formula:

$$\text{Mg of vitamin C per 100g sample} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre

D = Dye factor

V_1 = Volume made up

V_2 = Aliquot of extract taken for estimation

W = Weight of sample taken for estimation

3.3.2 Total Soluble Solids (TSS)

Two drops of prepared pulp was taken in a refractometer plate and the total soluble solids of juice were read directly from the hand refractometer (%).

3.3.3 Determination of Acidity

Reagents:

a. 0.1 N NaOH

b. 1% phenolphthalein indicator

c. Procedure:

Acidity was determined following the methods of Jacob (1959) and Rangana (1977). Known volumes of the vegetable juices were measured in graduated cylinders and then they were transferred to beakers. The juices were then cooled and poured back to the same graduated measuring cylinder and made up to the lost volume with distilled water.

Titration:

10 ml pulp was taken in a 100 ml conical flask. A few drops of 1% phenolphthalein solution (indicator) was added to the flask and titrated with 0.1N NaOH solution from a burette until a light pink color appeared and persist for 15 seconds. The titration was done for several times for accuracy. Percent titrable acidity was calculated using the following formula:

$$\% \text{ Titrable acidity} = \frac{T \times N \times V_1 \times E}{V_2 \times W \times 1000} \times 100$$

Where,

T= Titre

N= Normality

V_1=Volume made up

E= Equivalent weight of acid

V_2=Volume of sample taken for estimation

W= Weight of sample

3.4 Microbiological Examination

For total viable count of microorganism present in mixed vegetable juice, standard plate count method was done for three times and followed according to the method described in "Recommended method for the microbiological examination of food in "American Public Health Association (1967).

Preparation of media:

In this study dextrose tryptone Agar (DTA) from Difco laboratories Detriot, USA was employed.

Ingredients	Amount (gm.)
Tryptophene (peptone)	5
Dextrose (glucose)	1
Yeast extract	2.5
Agar	14
Total	22.5

22.5 gm of DTA was dissolved in 1000 ml cold distilled water and heated to boiling to dissolve the ingredients completely. Then media was filled into different screw cap bottles and sterilized at 121^0C for 15 minute in an autoclave. After sterilization the media was kept in water bath at 45^0C until used.

Preparation of dilution blanks:

Dilution blanks were prepared by buffered distilled water. The buffered-distilled water was filled into screw cap bottles of 100 ml each bottles were sterilized at 121^0C for 15 minutes. After sterilization each bottles contained 99ml buffered distilled water.

Procedure of plating:

Ten (10) gm juice was taken into 100 ml of buffered distilled water. 1gm well blended juice was transferred into 99 ml buffered distilled water and the sample shaken up and down movement for 25 times at a height about 30 cm (1ft) at a time interval not exceeding 7 seconds. The solution was made in 1:10, 1:100, 1:1000, 1:10000 dilutions in the Sterilized buffer distilled water. One ml and 1/10 ml from each dilution were placed into sterilized petridishes. Then the mouth of the agar bottle was flamed and 10-15 ml poured into each petridish, rotating and tilting gently and allowed them sometime for solidification.

Incubation and colony count:

After solidification petridishes were placed in the incubator at 37^0C for 48 hours, the overloaded petridishes were avoided and the petridishes containing countable colony was selected. Colonies were counted with the aid of a magnifying glass and multiplied by dilution number.

3.5 Sensory Evaluation

The consumer's acceptability of developed vegetable juice was evaluated by a taste tasting panel. The hedonic rating test was used to determine this acceptability. The panelists were selected from the teachers, students and lab attendants of the faculty of Agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Samples were served to the panelists and were asked to assign appropriate score for characteristics taste, color, texture and overall acceptability of processed vegetable juice.

Hedonic scale used; Like extremely=9, Like very much=8, Like moderately=7, Like slightly=6, Neither like nor dislike=5, Dislike slightly=4, Dislike moderately=3, Dislike very much=2, Dislike extremely=1

3.6 Storage Studies

Three samples of mixed vegetable juices were stored at room temperature (28-30° C) and at low temperature (4°C) in refrigerator. At the room temperature juices were good at 3 days but at refrigeration temperature juices were good at 30 days. The color, flavor, turbidity, TSS, acidity and microbial load (Standard plate count) in the mixed vegetable juices were observed at the storage period of 60 days. The addition of citric acid and potassium metabisulphite were improved the transparency of mixed vegetable juice. No gas formation occurred up to 30 days was observed in the mixed vegetable juice, which indicated that the heat processing was adequate. Color was no change at the day of preparation and then color was slightly changed after 30 days. Flavor was no change up to 30 days then after 30 days flavor was changed. The taste of mixed vegetable juices was good up to 30 days. But after 30 days all juice samples were spoiled.

3.7 Analysis of Mixed Vegetable Juice

The prepared juices were analyzed for acidity, TSS, vitamin-C and microbial plate count. The prepared mixed vegetable juices were analyzed for acidity, TSS, vitamin-C and microbial plate count. Sensory evaluation was carried out by ten well trained panelists from Food Engineering and Technology Department, Faculty of agro-Industrial and Food Process Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

Statistical Analysis:

Results were statistically analyzed using SPSS statistical package (Version 9.05) according to Rattanathanalerk *et al.*, (2005), analysis of variance (ANOVA), Duncan's multiple range test and least significant difference (LSD) was chosen to determine any significant difference among three samples of mixed vegetable juice.

CHAPTER IV

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the effective means of processing and preservation of mixed vegetable juice from tomato, cucumber and pumpkin. Vegetable juice was studied for their acceptability and shelf life at room temperature (28-30 ^{0}C) and at low temperature (4 ^{0}C). The acceptability and shelf life were evaluated through preservation observation along with chemical and microbiological analysis.

The prepared juices were tested for chemical composition, microbial plate count and preservation observation after every fifteen days interval during the 60 days storage period. For chemical composition TSS, Acidity and Vitamin C content were analyzed and the following result sheet was found given as Table 4.1.

From Table 4.1 we can see that Total soluble solids (T.S.S) slightly decreased with the increase of storage period. This result may be due to fermentation of sugar present in the juice. Acidity also decreased slightly with the increasing of storage period for vegetable juices from three varieties. For Sample 1 the TSS was 13.7% at the day of preparation and 13.5% at the 60th day. For Sample 2 and Sample 3 the TSS was 13.5% and 13.9% at the first day and 13.4% and 13.7% at the last day of storage period.

In case of acidity it was found that for Sample 1 the acidity was 0.37% at the day of preparation and 0.32% at the 60th day. For Sample 2 and Sample 3 the acidity was 0.35% and 0.33% at the first day and 0.32% and 0.30% at the last day of storage period.

From Table 4.1 it shows that vitamin C lost reasonably during the storage period. Table show, Sample 1 contained vitamin C (18.292 mg / 100 gm) on the day of preparation and 8.744 mg /100 gm after 60 days.

Table 4.1 Chemical composition of mixed vegetable juice

Sample No.	Constituents	Day 1	Day 15	Day 30	Day 45	Day 60
Sample 1	TSS (%)	13.7	13.7	13.7	13.4	13.5
	Acidity (%)	0.37	0.37	0.35	0.34	0.32
	Vitamin C (mg/100gm)	18.292	15.123	11.325	9.187	8.774
Sample 2	TSS (%)	13.5	13.5	13.5	13.4	13.4
	Acidity (%)	0.35	0.35	0.35	0.32	0.33
	Vitamin C (mg/100gm)	23.481	19.134	15.987	11.987	9.321
Sample 3	TSS (%)	13.9	13.9	13.9	13.6	13.7
	Acidity (%)	0.32	0.32	0.31	0.29	0.26
	Vitamin C (mg/100 gm)	17.716	14.212	11.123	9.329	8.011

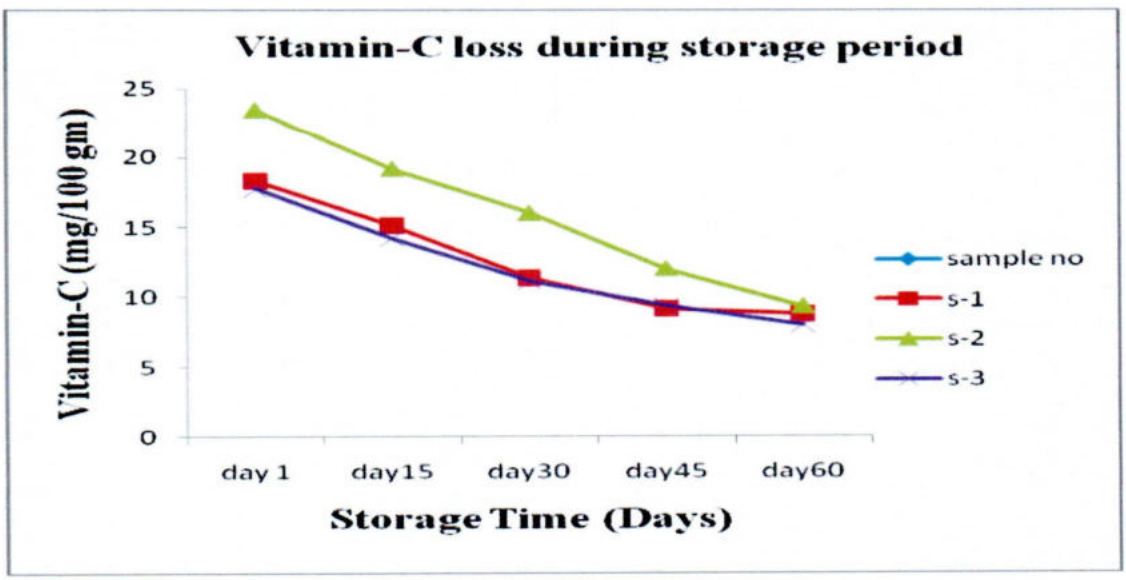


Figure 4.1: Changes of vitamin-C in different samples of vegetable juice with time (28-30° C)

Similarly, vitamin C content of Sample 2 and Sample 3 was 23.481mg /100gm and 17.716mg /100gm on the day of preparation. After 60 days vitamin C content had reduced to 9.321 mg /100gm and 8.011mg /100gm in Sample 2 and Sample 3 respectively.

In the Figure 4.1, it is shown that the loss of vitamin C increased with the increase of storage period. Vitamin C is light and heat sensitive, the concentration of vitamin C follows first order kinetics and thus storage time affects vitamin C content (Heldman, 1981). However, Vitamin C is highly oxidized and may be oxidized with the increase of storage period.

4.1 Microbiological load calculation

Microbiological activity, its multiplication and load were calculated during 60 days storage period for the juices from three samples.

4.1.1 Bacterial growth

This study was performed by Colony count method. After 48 hours incubation, colonies developed were counted. The total viable bacteria present in vegetable juice were not uniform. The total number of viable bacteria per ml. of vegetable juice was obtained by multiplying the number of colony forming units (CFU) on the plate with respective dilution factor and then was converted into logarithmic form. The total numbers of viable bacteria count in juices from different varieties have been shown in Table 4.2. The result showed that among the varieties sample 1 contained least viable bacteria (4.14 log. cfu / ml) after seven days and sample 3 contained highest viable bacteria (4.83 log. cfu / ml) after thirty days at refrigeration temperature (4^{o} C).

From the above results, it is clear that the total viable bacteria count increased with the increase of storage period. The samples which were kept in room temperature after three days those samples were spoiled.

Table 4.2: Growth of bacteria in vegetable juice from three samples at refrigeration temperature. (4° C)

Storage condition	Storage Period	Sample no	Total count (log. cfu/ml)
Refrigeration temperature (4° C)	7 day	Sample - 1	3.53
		Sample -2	3.19
		Sample -3	3.31
	15 day	Sample - 1	3.73
		Sample -2	3.56
		Sample -3	3.49
	30 day	Sample - 1	4.63
		Sample -2	4.42
		Sample -3	4.89

4.2 Sensory evaluation

The processed vegetable juice was evaluated for its color, flavor, taste, texture and overall acceptability through a taste testing panel. The panelists were asked to score the sample in ascending order of 1-9 points showing their degree of preference in respect of color, flavor, texture, taste and overall acceptability of the juice sample. The responses were tabulated in table 4.3.

Table 4.3 Mean score for taste, color, flavor, texture and overall acceptability of mixed vegetable juice is given below

Sample code	Sensory attributes				
	Taste	color	flavor	Texture	overall acceptability
S-1	6.4^{b}	5.7^{b}	6.2^{b}	6.4^{b}	6.1^{b}
S-2	5.6^{c}	6.2^{b}	5.3^{c}	5.2^{c}	5.1^{c}
S-3	7.4^{a}	7.1^{a}	7.0^{a}	7.4^{a}	7.1^{a}
LSD ($P< 0.05$)	0.5734	0.8047	0.5646	0.5457	0.3047

A two way analysis of variance (ANOVA) was carried out for color preference and overall acceptability of processed vegetable juices and the result showed that there were no significant differences among the three samples.

In case of flavor a two way analysis of variance (ANOVA) was carried out and the results showed that there were significant differences in flavor acceptance among the juices from different sample as the tabulated F value (6.013) was less than the calculated F value (18.96), (Table 3.2 of appendix III).

As shown in Table 4.4 sample S3 was the most acceptable in flavor preference among the samples securing the highest score (7) and ranked as "like moderately". This was followed by sample S1 and S2 securing 6.2 and 5.3 respectively and was equally acceptable. However, samples S1 and S2 can be ranked as "like slightly". In case of texture of products there were significant differences among the samples at 5% level of significance as calculated F (6.013) value was less than tabulated value of F (34.12), (Table 4.2 of appendix IV).

4.3 Preservation observation

Preservation observation of vegetable juices from three samples during storage period at room temperature (RMT) and refrigeration temperature (RFT) were judged on basis of color. flavor, and sedimentation. The observations have been shown in Table 4.4.

Table 4.4 Preservation Observation of Prepared Juice from Three Samples at Refrigeration Temperature (4° C)

Storage condition	Storage period	Sample	color	Flavor	Sedimentation
Refrigeration Temperature	At the day of preparation	Sample 1	yellow	Natural	Uniformly distributed
		Sample 2	yellow	Natural	Uniformly distributed
		Sample 3	Dark yellow	Natural	Uniformly distributed
	After 15 days	Sample 1	yellow	Natural	Uniformly distributed
		Sample 2	Yellow	Natural	Uniformly distributed
		Sample 3	Dark yellow	Natural	Uniformly distributed
	After 30 days	Sample 1	yellow	Natural	Slightly sedimentation
		Sample 2	Fade	Natural	Sedimentation
		Sample 3	Dark yellow	Natural	Uniformly distributed
	After 45 days	Sample 1	Fade	Off flavor	Slightly sedimentation
		Sample 2	Fade	Off flavor	Slightly sedimentation
		Sample 3	Fade	Off flavor	Slightly sedimentation
	After 60 days	Sample 1	Reddish	Off flavor	Slightly sedimentation
		Sample 2	Fade	Off flavor	Slightly sedimentation
		Sample 3	Fade	Off flavor	Sedimentation

From the above table it was found that there was a slight variation in color among the three different vegetable juices during 60 days storage period. Color was found yellow/ dark yellow/ reddish on the day of preparation. The color faded and flavor deteriorated gradually with the increase of storage period both at room and refrigeration temperature.

Sample-1 **Sample-2** **Sample-3**

Figure 4.2: Mixed vegetable Juice at the Day of Preparation

The color, flavor and taste all were found same as the day of preparation. After 30 days discoloration and off flavor was found. But sample 1 was prepared with vinegar and spice, sample 2 was prepared without vinegar and spice and sample 3 was prepared with vinegar and citric acid. Vinegar and citric acid act as a preservative. Sample 1 and sample 2 were spoiled after 30 days but sample 3 was spoiled after 33 days.

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted to develop mixed vegetable juice from locally available vegetables and assess the quality in respect of consumer's acceptability and storage ability. The vegetables used for the preparation of juice were tomato, cucumber and pumpkin. The vegetables were cleaned, blended together, mixed spice and heated for certain periods, then cooled and bottled. Sensory and microbial examination was done during 60 days storage period. The chemical analysis (acidity, T.S.S. and vitamin C) of the prepared juice was done at an interval of 0, 15, 30, 45 and 60 days. Negligible change in chemical constituents except vitamin C was observed in the prepared juice throughout the 60 days storage period. There was slight variation in color and flavor in prepared juice from three samples during 60 days storage. Color was found yellow in vegetable juice on the day of preparation and at the end of storage period, the color of juice became fade. Regarding the retention of color and physio-chemical properties storage at refrigeration temperature is better. It was found that in room temperature, vegetable juice spoiled after three days because it produced off- flavor and the color became fade. Spoilage of juice was delayed at refrigeration temperature.

At refrigeration temperature in the prepared juice total bacterial count after 7 days storage was found for sample1 was 3.53 log cfu/ml, for sample 2 bacterial count was 3.19 log cfu/ml and for sample 3 bacterial count was 3.31log cfu/ml. Bacterial count after 15 days for sample 1 was 3.73 log cfu/ml, for sample 2 was 3.56 log cfu/ml and for sample 3 was 3.49 log cfu/ml. Bacterial count after 30 days storage was found for sample 1 was 4.63 log cfu/ml, for sample 2 was 4.42 log cfu/ml and for sample 3 was 4.89 log cfu/ml . So, it was observed that with the increase of time bacterial count was increased.

Sensory evaluation showed that there were no significant difference among the juices from three different samples considering color and overall acceptability. But considering flavor, juice from sample 3 was best and considering texture juice from sample 3 was best. The quality of vegetable juice from three samples may be improved by fine homogenization, proper capping, proper pasteurization and using sterilized bottles.

More research works would be needed to avoid fading of color and minimizing off-flavor and to minimize the loss of vitamin C content during storage of vegetable juice.

Fresh vegetable juice is not practiced in Bangladesh. Drinking Vegetable Juice can be more beneficial to the body than simple eating the vegetables as juicing works to pre-digest the vegetables and we will assimilate more of the valuable nutrients. Processed vegetable juice can be used any time of the year. We should encourage the processing and preservation of vegetable juice. Processed vegetable juice can be sold in off season in both local and foreign exchange, which will enrich our national economy. After pasteurization, if sterilization is practiced the shelf life of vegetable juice will increase. Regular monitoring of the quality of fruit and vegetable juices for human consumption must also be enforced.

REFERENCES

REFERENCE

Alibas I (2007). Microwave, air and combined microwave-air-drying parameters of pumpkin slices. LWT, 40 (8): 1445-1451.

Anonymous (1984). Cited from undergraduates project report on the studies on processing and preservation of pineapple juice. Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, pp:2-3.

Bazzano L A, Serdula M K and Liu S (2002). Dietary intakes of F&V and risk of cardiovascular disease. Curr Atheroscler Rep 5:492_499.

Calbom C and Keane M (1992). Juicing for life. 4th ed. Avery Publishing Group, NY. pp. 46-49.

Deanna M M and Jeffrey S B (2007). Acid-alkaline Balance: Role in Chronic Disease and Detoxification. Alternative therapy 13(4):62-65.

Falcão J P Dias, Correa A M G and E F Falcão D P (2002). Microbiological Quality of Ice Used to Refrigerate Foods. Food Microbiology 19: 269-276.

Heldman D R and Singh R P (1981). *Food Process Engineering.* Second Edition. New York: Avi/ Van Nostrand Reinhold.

Hulme A C (1971). The pine apple: General, Edited by Dull, G.G. The Biochemistry of Fruits and their products. Academic press Inc, Ltd. London. 2:303-575.

Kuti J O and Konuru (2005). Effects of genotuype and cultivation environment on lycopene content in red-ripe tomatoes. *J. Sci. Food Agric.* 85: 2021-202.

Lee S K and Kader A A (2000). Pre-harvest and post-harvest factors influencing vitamin C content of horticultural crops. *Postharv. Biol. Technol.* 20: 207-220.

Liu S, Serdula M, Janket S J, Cook N R, Sesso H D, Willett W C, Manson J E and Buring J E (2004): A prospective study of fruit and vegetable intake and the risk of type 2 diabetes in women. *Diabetes Care* 27:2993–2996.

Mahale D P, Khade R G and Vaidya V K (2008). Microbiological Analysis of Street Vended Fruit Juices from Mumbai City, India, Internet Journal of Food Safety 10:31-34.

Martin Glickman (1969). Gum Technology in the food Industry. Academic Press. New York. pp: 314-317.

Mazur R E, Grace S M and Helen H J (2003). Diet and food insufficiency among Hispanic youths: acculturation and socioeconomic factors in the third National Health and Nutrition Examination Survey. *The American Journal of Clinical Nutrition* 78:1120-1127.

Mogren L (2006). Quercetin content in yellow onion (*Allium cepa* L.): Effects of cultivation methods, curing and storage.

Negri F (1991). Vegetable and fruit consumption and cancer risk. Int. J. Cancer. 48: 350-354. Pamplona-Roger G D (2003). Healthy Foods. 1st ed. Marpa Artes Publications European Union. pp. 32: 264-267, 346-351.

Rangana S (2000). "Handbook of analysis and quality control for fruit and vegetable products". *Tata McGraw-Hill Publishing Co. Ltd*, ED-6, pp. 300-380.

Rangana S(1977). Manual analysis of fruit and vegetable products. Mc.Graw Hill Publishing Company Limited. New Delhi.

Rattanathanalerk, M., C. Naphaporn and S. Walaiporn, 2005. Effect of thermal processing on the quality loss of pineapple juice. J. Food Eng., 66: 259-265.

Rickman J C, D M Barrett and C M Bruhn (2007). Review: Nutritional comparison of fresh, frozen, and canned fruits and vegetables. Part 1: Vitamin C and B and phenolics compounds. J. *Sci. Food Agric.* 87: 930-944.

Saha N N (2004). Fruit and Vegetable Juice Therapy, concentrates during storage. J. Food. Engineering, B. Jain publishers Pvt. Ltd, pp: 120.

Salunkhe D K and Kadam S S (1995). Handbook of fruit science and technology. Marcel Dekker, New York, NY, USA.

Sánchez-Mata M C, Cámara M and Díez-Marqués C (2003). Extending shelf-life and nutritive value of green beans (*Phaseolus vulgaris* L.), by controlled atmosphere storage: macronutrients. Food Chem. 80(3): 309-15, March.

Temple N J and Gladwin K K (2003). Fruit vegetables and the prevention of cancer: research challenges. Nutrition 19(5):467–70.

Titarmare A P, Dabholka and Godbole S (2009). Bacteriological Analysis of Street Vended Fresh Fruit and Vegetable Juices in Nagpur City, India, Internet Journal of Food Safety (11):1-3.

Tombak M (2000). Start Healthy Life. 2nd ed. Healthy life press inc. Korea. pp. 59-62.

Trout D L (1991). Vitamin C and Cardiovascular Risk Factors. American J. Clin. Nutr., 53: 322-325.

Van't Veer P, Jansen M, Klerk M and Kok F J (2000). Fruits and vegetables in the prevention of cancer and cardiovascular disease. Public Health Nutr 3:103_107.

Weinstein J S Vogt T M & Gerrior S A (2004). Healthy eating index scores are associated with blood nutrient concentrations in the third National Health and Nutrition Examination Survey. Journal of the American Dietetic Association, 104(4), 576–584.

Wills R Mc Glasson W B Graham D and Joyce D C (1999). Introduction a lafisiologiay manipulación poscosecha de frutas, hortalizas y plantas ornamentales. Editorial Acribia, S.A., Zaragoza, Spain.

APPENDICES

APPENDICES

Appendix 4.1: Rating Score for Taste of the Mixed Juice

Judge No	Sample Code			
	S-1	S-2	S-3	Total
1	7	6	8	21
2	5	6	7	18
3	6	5	7	18
4	7	6	8	21
5	7	5	8	20
6	5	6	6	17
7	7	5	7	19
8	7	6	8	21
9	7	6	7	20
10	6	5	8	19
Total	57	56	71	182
Mean	5.7	5.6	7.1	

Hedonic Scale Used; Like Extremely=9, Like Very Much=8,

Like Moderately=7, Like Slightly=6, Neither Like nor Dislike=5,

Dislike Slightly=4, Dislike Moderately=3, Dislike Very Much=2,

Dislike Extremely=1

Appendix 4.1.1: Analysis Of Variance (ANOVA) for Taste

Source of Variance	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	
				Calculated	Tabulated
Replication	9	6.133	0.681	1.7358	3.597074
Factor	2	16.267	8.133	20.7170	6.012905
Error	18	7.067	0.393		
Total	29	29.467			

Appendix 4.1.2: Duncan's Multiple Range Test (DMRT) for Taste

LSD=0.5734

Treatment	Original order of means	Treatment	Ranked order of means
S-1	6.4^{b}	S-3	7.4^{a}
S-2	5.6^{c}	S-1	6.4^{b}
S-3	7.4^{a}	S-2	5.6^{c}

Appendix 4.2: Rating Score for Color of the Mixed Juice

Judge No	Sample Code			
	S-1	S-2	S-3	Total
1	7	7	8	22
2	7	6	7	20
3	6	5	6	17
4	8	7	8	23
5	4	7	8	19
6	4	5	6	15
7	5	6	7	18
8	5	7	6	18
9	6	5	7	18
10	5	7	8	20
Total	57	62	71	190
Mean	5.7	6.2	7.1	

Hedonic Scale Used; Like Extremely=9, Like Very Much=8,

Like Moderately=7, Like Slightly=6, Neither Like nor Dislike=5,

Dislike Slightly=4, Dislike Moderately=3, Dislike Very Much=2,

Dislike Extremely=1

Appendix 4.2.1: Analysis Of Variance (ANOVA) For Color

Source of Variance	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	
				Calculated	Tabulated
Replication	9	16.667	1.852	2.3923	3.597074
Factor	2	10.067	5.033	6.5024	6.012905
Error	18	13.933	0.774		
Total	29	40.667			

Appendix 4.2.2: Duncan's Multiple Range Test (DMRT) for Color

LSD=0.8047

Treatment	Original order of means	Treatment	Ranked order of means
S-1	5.7^{b}	S-3	7.1^{a}
S-2	6.2^{b}	S-2	6.2^{b}
S-3	7.1^{a}	S-1	5.7^{b}

Appendix 4.3: Rating Score for Flavor of Vegetable Juice

Judge No	Sample Code			
	S-1	S-2	S-3	Total
1	7	6	7	20
2	7	5	7	19
3	5	5	6	16
4	6	4	7	17
5	7	5	7	19
6	5	4	6	15
7	6	7	8	21
8	6	6	7	19
9	6	6	8	20
10	7	5	7	19
Total	62	53	70	185
Mean	6.2	5.3	7	

Hedonic Scale Used; Like Extremely=9, Like Very Much=8,

Like Moderately=7, Like Slightly=6, Neither Like nor Dislike=5,

Dislike Slightly=4, Dislike Moderately=3, Dislike Very Much=2,

Dislike extremely=1.

Appendix 4.3.1: Analysis of Variance (ANOVA) for Flavor

Source of Variance	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	
				Calculated	Tabulated
Replication	9	10.833	1.204	3.1553	3.597074
Factor	2	14.467	7.233	18.9612	6.012905
Error	18	6.867	0.381		
Total	29	32.167			

Appendix 4.3.2: Duncan's Multiple Range Test (DMRT) for Flavor

LSD= 0.5646

Treatment	Original order of means	Treatment	Ranked order of means
S-1	6.2^{b}	S-3	7.0^{a}
S-2	5.3^{c}	S-1	6.2^{b}
S-3	7.0^{a}	S-2	5.3^{c}

Appendix 4.4: Rating Score for Texture of Mixed Juice

Judge No.	Sample Code			
	S-1	S-2	S-3	Total
1	6	5	7	18
2	7	5	7	19
3	7	6	8	21
4	6	5	7	18
5	7	6	8	21
6	7	5	7	19
7	6	4	6	16
8	7	8	9	24
9	5	4	7	16
10	6	4	8	18
Total	64	52	74	190
Mean	6.4	5.2	7.4	

Hedonic Scale Used; Like Extremely=9, Like Very Much=8,

Like Moderately=7, Like Slightly=6, Neither Like nor Dislike=5,

Dislike Slightly=4, Dislike Moderately=3, Dislike Very Much=2,

Dislike Extremely=1

Appendix 4.4.1: Analysis Of Variance (ANOVA) for Texture

Source of Variance	Degree of Freedom	Sum of Squares	Mean Squares	F-Value	
				Calculated	Tabulated
Replication	9	18	2	5.6250	3.597074
Factor	2	24.267	12.133	34.1250	6.012905
Error	18	6.4	0.356		
Total	29	48.677			

Appendix 4.4.2: Duncan's Multiple Range Test (DMRT) for Texture
LSD=0.5457

Treatment	Original Order of Means	Treatment	Ranked Order of Means
S-1	6.4^{b}	S-3	7.4^{a}
S-2	5.2^{c}	S-1	6.4^{b}
S-3	7.4^{a}	S-2	5.2^{c}

Appendix 4.5: Rating Score for Overall Acceptability of Mixed Juice

Judge No	Sample code			
	S-1	S-2	S-3	Total
1	6	5	7	18
2	6	6	8	20
3	7	5	8	20
4	6	5	7	18
5	5	4	6	15
6	7	6	8	21
7	5	4	6	15
8	7	6	7	20
9	5	4	6	15
10	7	6	8	21
Total	61	51	71	183
Mean	6.1	5.1	7.1	

Hedonic Scale Used; Like Extremely=9, Like Very Much=8,
Like Moderately=7, Like Slightly=6, Neither Like nor Dislike=5,
Dislike Slightly=4, Dislike Moderately=3, Dislike Very Much=2,
Dislike Extremely=1.

Appendix 4.5.1: Analysis of Variance (ANOVA) for Overall Acceptability

Source of variance	Degree of Freedom	Sum of Squares	Mean Squares	F- Value	
				Calculated	Tabulated
Replication	9	18	2.078	18.7	3.597074
Factor	2	20	10	90	6.012905
Error	18	2	0.111		
Total	29	40.7			

Appendix 4.5.2: Duncan's Multiple Range Test (DMRT) for Overall Acceptability

LSD=0.3047

Treatment	Original Order Of Means	Treatment	Ranked Order Of Means
S-1	6.1^{b}	S-3	7.1^{a}
S-2	5.1^{c}	S-1	6.1^{b}
S-3	7.1^{a}	S-2	5.1^{c}