STUDY ON THE PREPARATION AND STORAGE STABILITY OF CHIPS FROM GREEN PAPAYA

A THESIS

BY

MD. REZAUR RAHMAN
Student No. 1105041
Session: 2011-2012
Semester: January-June, 2012

MASTER OF SCIENCE (MS)
IN
FOOD ENGINEERING AND TECHNOLOGY

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY

HAJEE MOHAMMAD DANESH SCIENCE & TECHNOLOGY
UNIVERSITY, DINAJPUR

JUNE, 2012

STUDY ON THE PREPARATION AND STORAGE STABILITY OF CHIPS FROM GREEN PAPAYA

A THESIS

BY

MD. REZAUR RAHMAN
Student No. 1105041
Session: 2011-2012
Semester: January-June, 2012

Submitted to Dept. of Food Engineering and Technology
Hajee Mohammad Danesh Science & 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 & TECHNOLOGY
UNIVERSITY, DINAJPUR

JUNE, 2012

STUDY ON THE PREPARATION AND STORAGE STABILITY OF CHIPS FROM GREEN PAPAYA

A THESIS

BY

MD. REZAUR RAHMAN
Student No. 1105041
Session: 2011-2012
Semester: January-June, 2012

Approved as to style and content by

____

(Prof. Dr. Mohammad Shiddiqur Rahman)
Supervisor

____

(Prof. Md. Ruhul Amin)
Co-Supervisor

____

(Prof. Dr. Md. Kamal Uddin Sarker)
Chairman
Examination Committee
and

Chairman

DEPARTMENT OF FOOD ENGINEERING AND TECHNOLOGY
HAJEE MOHAMMAD DANESH SCIENCE & TECHNOLOGY
UNIVERSITY, DINAJPUR

JUNE, 2012

ACKNOWLEDGEMENT

All praises are due to "Almighty Allah" the greatest, most merciful and all powerful, whose blessings has enabled me to complete this research successfully for the degree of Master of Science in Food Engineering and Technology.

I express my deepest sense of appreciation and heartfelt indebtedness to my respected supervisor Prof. Dr. Mohammad Shiddiqur Rahman, Chairman, Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science & Technology University, Dinajpur, for his valuable suggestions, constructive criticism and constant encouragement from the very beginning to the end of this research.

I would like to extend my gratitude and appreciation to my honourable co-supervisor Md. Ruhul Amin, Professor, Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science & Technology University, Dinajpur, for his continuous assistance and necessary help in completing this research.

I would like to record a special word of gratefulness to Professor Dr. Md. Kamal Uddin Sarker, Head, Department of Food Engineering and Technology and all of my respected teachers, Assistant Professor, Dr. Maruf Ahmed and S.M. Kamrul Hasan, Assistant Professor, Department of Food Processing and Preservation, Md. Aslam Ali, Assistant Professor, Department of Food Science and Nutrition and Md. Sultan Mahomud, Assistant Professor, Department of Food Engineering and Technology, Hajee Mohammad Danesh Science & Technology University, Dinajpur, for their helpful suggestions and co-operation during the research period.

A special note of thanks to all of my friends and well wishers for their support and cordial thanks to the lab attendants of the Department of Food Engineering and Technology, for their excellent service during research period.

Finally, I express my deepest gratefulness to my beloved parents, brother and sister for their continuous inspiration, blessings and sacrifices which will never be forgotten.

The Author

ABSTRACT

The research was aimed at the development of standard methodology for preparation of chips from green papaya and to study the storage properties of fried papaya chips. The raw green papaya and the products were analyzed for their composition. The green papaya contained moisture 88.2%, protein 0.57%, fat 0.14%, ash 0.63%, vitamin C 40 mg/100 gm and total carbohydrate 10.43%. The average composition of fried papaya chips contained moisture 3.0%, protein 7.08%, fat 23.02%, ash 1.71%, salt 2.0% and total carbohydrate 63.18%. The results showed that minimum frying time required for chips to reach the final moisture content of 3% were 25 sec. at 140°C, 20 sec. at 150°C and 15 sec. at 160°C for oven dried papaya chips. For sun dried papaya chips it took 30 sec. at 140°C, 25 sec. at 150°C and 18 sec. at 160°C. For frying the papaya slices the ratio of papaya slices and oil was chosen 1:20 which gave the initial temperature drop of 10°C and frying times were determined at various temperatures. The products were subjected to sensory evaluation for their acceptance. From the study of sensory evaluation by statistical analysis on the response of taste panel revealed that the most acceptable fried papaya chips was attained at frying temperature of 140°C for 25 sec. in case of oven dried papaya slices and 30 sec. at 140°C for sun dried papaya slices. The study of different packaging systems and storage condition (at room temperature 25-30°C and 75±2% relative humidity) showed that the most acceptable storage stability (40 days) of fried papaya chips was found with chips packed in laminated aluminium foil followed by chips packed in double layer polyethylene, single layer polyethylene and kept in plastic container and single layer polyethylene respectively.

CONTENTS

CONTENTS (Contd.)

CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

APPENDICES

APPENDICES (Contd.)

ABBREVIATIONS AND ACRONYMS

KMS	:	Potassium Meta-Bisulphate
TSS	:	Total Soluble Solid
BBS	:	Bangladesh Bureau of Statistics
AOAC	:	Association of Official Analytical Chemists
p^H	:	Hydrogen Ion Concentration
mg	:	Milligram(s)
gm	:	Gram(s)
Kg	:	Kilogram(s)
ml	:	Millilitre(s)
cm	:	Centimeter(s)
m	:	Meter(s)
%	:	Percent
ANOVA	:	Analysis of Variance
DMRT	:	Duncan's Multiple Range Test
LSD	:	Least Significant Difference
et al.	:	and others

CHAPTER I
INTRODUCTION

CHAPTER I

INTRODUCTION

Papaya (*Carrica papaya* L.) is an important fruit crop of the tropics and is one of the most versatile fruit which is also used as vegetables and is available throughout the year in the local markets. It belongs to the family caricaceae and is rich in vitamins and minerals (Rashid *et al.*, 1987). As a dual or multi-purpose, space conserving, herbaceous crop, it is widely acclaimed, despite its susceptibility to natural enemies.

Papaya is a small to medium evergreen plant which is a native to tropical America, perhaps in southern Mexico and neighboring Central America. It is recorded that seeds were taken to Panama and then the Dominican Republic before 1525 and cultivation spread to warm elevations throughout South and Central America, southern Mexico, the West Indies and Bahamas and to Bermuda in 1616. Spanish and Portuguese sailors carried seeds to the Philippines about 1550 and the papaya traveled from there to Malacca and India.

In Bangladesh, papaya is grown all over the country particularly as a home yard fruit (Ahmed, 1984). In the years before 2005, growers of Bangladesh seldom go for commercial production of papaya but almost in every homestead one may find a few plants growing and production successfully for several years. However, now-a-days farmers have started growing papaya commercially from the year 2005.

Papaya is fat-free, cholesterol-free, rich in antioxidant carotenoid compounds and dense with folate, dietary fiber, vitamin C and vitamin A, iron, calcium, potassium and also contains small amounts of thiamin, riboflavin, magnesium and sodium. Papaya is the only food known to contain papain, the active proteolytic enzyme. Also known as the pawpaw or the mikana, papayas are available in over 40 varieties with flesh that ranges in color from green to dark orange. All contain edible seeds and can be consumed ripe or unripe, cooked or raw.

Green papayas are in great demand in Bangladesh, particularly for ailing people who suffer from dyspepsia indigestion or stomach disorder. The tropical papaya fruit has effective medicinal properties against disorders of liver, spleen and is an effective contraceptive.

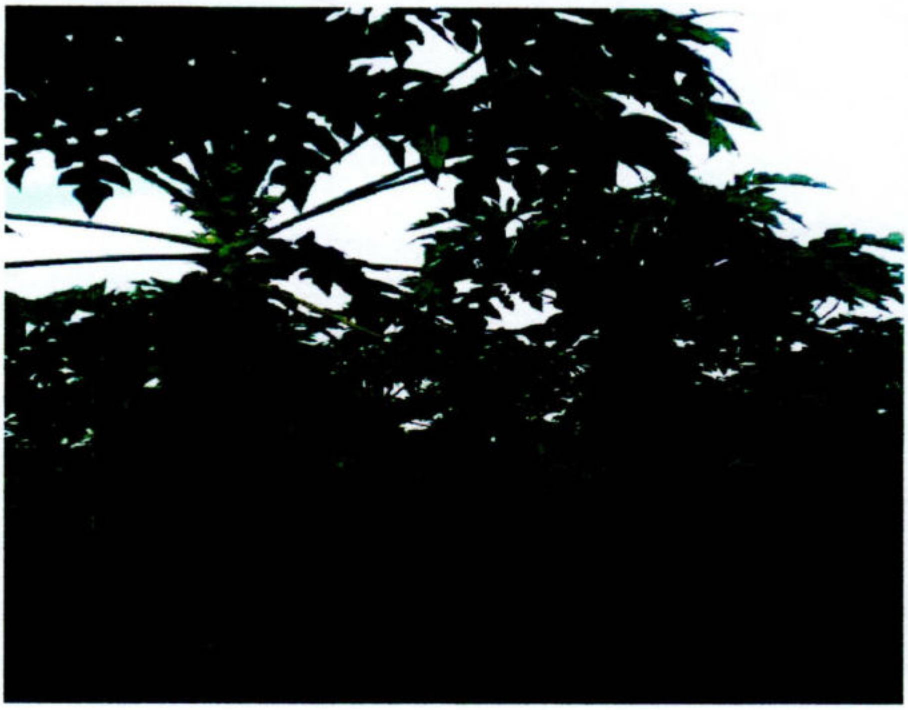

Figure 1.1: Papaya trees with fruits

Papaya occupies 2790 acreage of land and total production is about 1,12,770 Metric tons with an average yield of 40 Metric tons per acre of land in Bangladesh (BBS, 2010). Papaya is widely cultivated in the greater district of Pabna, Rajshahi, Jessore, Chittagong, Bandarban, Kushtia, Mymensingh, Dhaka, Rangpur, Faridpur, Rangamati etc.

Attempts are being made in many countries of the world to find ways and means to utilize this fruit. But no satisfactory results have yet been found out. However, some minor products are produced by the commercial food processors. In relation to food, two major problems are prevailing in Bangladesh. One is the food deficit and the other is the post harvest loss.

The farmers could be encouraged for more production if spoilage could be prevented by proper preservation and storage facilities. Moreover, substantial amount of foreign exchange could be earned by exporting fresh and processed papaya products. But unfortunately the present technology of production, processing and preservation of papaya in Bangladesh is not well developed to boast up the volume of its annual production.

There is a wide prospect of producing papaya products in Bangladesh such as papaya chips, slices, pulp, jam, squash, nectar, jelly, dried products, ready to serve beverages, candy etc. In some areas of Bangladesh papayas are very cheap during peak season due to the non-availability of storage, transportation and processing facilities. In this respect the physico-chemical processes during and after ripening of fruits need to be studied extensively for the development of proper storage methods.

Chips are the most popular snack item in many fast food outlets. Fried papaya chips may be one of the important potential papaya products in Bangladesh. Fried chips may be made by drying and deep oil frying of thin fresh slices of papaya. Papaya chips may be also easily salable snack food in the local markets. Papaya chips is an export promising product in Bangladesh and has an export market in near future.

For longer shelf life, crispiness and chips quality moisture content is the most important factor as far as storage stability is concerned. Bacteria and other microorganisms cannot grow easily in lower percentage of moisture content in chips. Visual colour is the major quality criterion for determining the commercial quality with respect to consumers' preferences and cost of the chips (Anand *et al.,* 1982) which depends on packaging and proper storage conditions. Packaging and storage condition are important quality control factors of chips preservation. Storage stability depends on packaging. Good packaging and storage condition extend the storage life of fried chips.

With the above views in consideration, this research work was undertaken to find out the processing technique, suitable packaging and quality aspects of fried chips from green papaya.

The specific objectives of the study were:

i) To analyze the chemical composition of green papaya.
ii) To standardize the methods for preparation of papaya chips and
iii) To assess the storage stability of the fried papaya chips.

CHAPTER II
REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

Papaya is an important fruit in Bangladesh but research works on prospect of processing of green papaya for preparing commercial products are insufficient. Some available research findings in this concern have been reviewed and presented as follows-

Carmen *et al.* (1978) studied on the papaya and described that papaya is one of the largest tropical fruits; it has pulpy flesh. Its flavour and aroma are controversial, they are not as abundant and exotic as other tropical fruits but are quite characteristics. Papaya is usually eaten alone or in the mixtures of tropical fruits, peeled and cut in segments, cubes or balls. In mixtures it is useful for its texture and well defined organoleptic properties. Fruit pleases or the puree can be dehydrated by different methods. Both types of products, however, are rarely found in commerce, as most of their flavour and aroma is either changed or lost. In order to process papaya it must be at the proper ripening stage. The fruits usually collected green mature and it ripens under storage. Because of its size and fragile skin, transport and handling are critical. The fruit is affected by climate, is injured by chilling and during ripening physical and chemical changes occur. Papaya pulp is one of the best sources, among fruits, of vitamins, especially vitamin A and vitamin C.

Anuar *et al.* (2008) reported the traditional use of papaya to treat many diseases, especially skin conditions and its prohibition for consumption during pregnancy has prompted us to determine whether papaya extracts both from green and ripe fruits improve wound healing and also produce foetal toxicity. Aqueous extracts of green papaya epicarp (GPE) and ripe papaya epicarp' (RPE) were applied on induced wounds on mice. GPE treatment induced complete healing in shorter periods (13 days) than that required while using RPE (17 days), sterile water (18 days) and Solcoseryl ointment (21 days). These differences in composition may have contributed to the different wound healing and abortive effects of green and ripe papaya.

According to report on US department of health, education and welfare (1972) the composition and food value of unripe papaya fruit are: moisture 92%, protein 1.0%, fat 0.1%, carbohydrate 6.2%, fiber 0.9%, ash 0.6mg/100gm, calcium 3.8mg/100gm, phosphorous 20mg/100gm and ascorbic acid 40mg/100gm.

Parle Milind *et al.* (2011) reported that the nutritional composition of green papaya fruit per 100 gm is carbohydrate 9.81gm, sugar 5.90gm, protein 0.61gm, fat 0.14gm, dietary fibre 1.8gm, vitamin C 61.8mg, calcium 24mg, potassium 257mg and energy 163kJ.

Akin *et al.* (2008) investigated the production of ethanol from *Carrica papaya* (pawpaw) using dried active baker's yeast strain (*Saccharomyces cerevisiae*) was investigated. The fermented pawpaw fruit waste produced ethanol at 2.82-6.60% (v/v). Proximate analyses of the dry fruit showed that pawpaw waste contained 90.82 g/100 g carbohydrate, 2.60 g/100 g lipid, 1.63 g/100 g crude protein and 4.95 g/100 g ash. These results show that the rate of alcohol production through fermentation of pawpaw fruit waste by baker's yeast increases with fermentation time and peaked at 72 h. Alcohol production also increased with yeast concentration at a temperature of 30^{0}C. The optimum p^H for fermentation is 4.5.

Firmin (1997) investigated the physical and chemical changes during maturation of the local and solo variety of papaya. It was found no change was observed in total acidity, though there was a slight increase in the p^H of both types. Starch content decreased while total sugar, reducing sugar and ascorbic acid increased. A sensory panel preferred solo, confirming that it is suitable for the local and international market.

Chan and Kowrk (1975) reported that the total sugars, reducing and non- reducing sugars in papaya to be 5.8% and 0.3%, respectively.

Islam *et al.* (1993) harvested the fruits at edible maturity and observed the effects of thinning on size, yield and quality of papayas. Result Showed length and total soluble solids (TSS) of papaya increased with increasing of level of fruit thinning. The 75% fruit thinning level produce the lowest and heavier fruits, with the highest TSS (10.80%).

Akin-Osanaiye *et al.* (2005) observed that the effects of yeast strains on the percentage yield of ethanol, as well as the effects of yeast concentration, saccharification and different nutrient supplements on optimization of ethanol yield were investigated. The fermented pawpaw yielded ethanol contents of 3.83-5.19%. The reducing sugar content in pawpaw was highest (7.6-13.6 g /100 g) after 48 h of saccharification using *Aspergillus niger*.

Chavasit *et al.* (2002) showed that beta-Carotene loss in candied man^{g}o and papaya during, processing was 17-18%, and loss continued from 30-40% during storage over 3 months. In contrast, beta-carotene contents increased during fermentation of pickled Pak Sien and Chinese green cabbage, ranging from 30-40%. A 3-month storage of fresh whole pumpkin in the shade led to as much as a 12-63% increase of beta-carotene concentrations. On the other hand, vitamin A content was reduced about 50% during the processing of fried chicken liver chips and continued to lose 16% more during storage.

Wills and Widjanarko (1995) studied on the changes in physiology composition and sensory characteristics of Australian papaya during ripening. Pawpaw fruits were held at 20°C, 25°C, or 30°C and physicochemical and sensory changes occurring during ripening were observed. Fruits at 20°C showed a respiratory climacteric after 5 days, at which peel colour was 20-50% yellow. Maximum sensory characteristics were attained 2 days after peel showed a full yellow peel colour and more acceptable eating attributes. Australian papayas would therefore be more acceptable to consumers if ripened at elevated temperatures rather than at 20°C.

El-Buluk *et al.* (1996) conducted an experiment with four papaya cultivars and found that total ash for all cultivars was decreased slowly during the initial growing period followed by a sudden increase in the later stage of maturation and ripening, with maximum concentration varying from 5.2 to 7.9%.

El-Buluk *et al.* (1997) studied on the chemical composition of papaya fruits during development and ripening and reported that total sugar content increased significantly as fruits ripened. The maximum sugar content varied from 13.7 to 30.6 mg/100gm of juice. The highest of fructose, glucose and sucrose varied from 5.64-7.67, 1.90-8.00 and 6.20-7.78mg/100mg of juice respectively.

According to Goodenough *et al.* (1997) unripe fruit from Carica papaya contains several proteinase enzymes are used industrially, only of these, papain has been extensively characterized. Recently the separate use of other enzymes of the family has been considered.

Maluf *et al.* (1997) reported that inheritance of resistance to the papaya ring spot virus-watermelon strain (watermelon mosaic 1 potyvirus, PRSV-W) was studied in two

Cucurbita maxim accessions, ABLO10 and Redlands Trailblazer, considered to be resistant to the potyuirus. ABLO10 (ABL) derives its resistance from Brazilian accessions of *C. maxim*. Redlands Trailblazer (RT) is an Australian cultivar of *C. maxim*, the resistance of which traces back to *C. ecuadorensis*. In both cases, virus could be recovered from the inoculated (symptomless) plants via back-inoculation onto the susceptible *C. pepo* cultivar Caserta, indicating a tolerance type of resistance. Both ABL and RT were crossed to each other and to the standard PRSV-W-susceptible cuitivar Buttercup (B).

Gupta and Pathak (1988) studied on some new fungi associated with papaya fruits. It was found that during 1975-78, 22 fungi were detected on papaya fruits from markets in Jaipur, India. These were *Alternaria alternata, Ascochyta caricae, Aspergillus jlavus, A. jumigatus, A. nidulans, A. niger, A. tamarii, M. tabacinum* and *F. scirpi*. Of these, *F. scirpi* and *M. tabacinum* are reported from India for the first and there taxonomy is described.

Wills (1990) studied on the post harvest technology of banana and papaya in ASEAN (Association of South East Asian Nation). Post harvest handling techniques which have the potential for extending the market life of bananas and papayas by delaying ripening and avoiding undesirable physiological, biochemical and physical changes are examined, with reference to the marketing and export of these fruits from the ASEAN region Less information is available on handling techniques for papayas. Fruit ripening can be delayed by storing at low temperature; however, chilling injury occurs in many cultivars after one week at 15°C. Satisfactory colour and flavour develop in fruit ripened at 25°C. But not at 20°C Modified Atmosphere (MA) storage extends storage life and ethylene application can accelerate ripening by 25%.

Paull *et al.* (1997) investigated the post harvest handling and losses during marketing of papaya (*Carica papaya* L). It was found that papaya (pawpaw) fruit post harvest losses of up to 76% have been reported to Hawaii shippers by mainland USA wholesalers and retailers. These losses are often blamed on decay can be associated with storing colour-break fruits for more than 3 weeks at 10°C or lower temperatures. A number of non-pathological fruit disorders are seen in retail markets, with some confusion amongst personnel as to the cause. Soft fruit, for example, can be caused by mechanical impact injury of ripening fruits and by fruits with low flesh calcium at harvest that can be ripen at twice the normal rate. Evaluation of post harvest losses in relation to the variation and limitations in ripening and storage facilities in the current handling system. There is a need to develop methods to predict fruit yield and size distribution to allow orderly marketing and to accurately sort fruits as to their internal stage of ripening.

Vega-Mercado *et al.* (2001) reported that drying is a process in which water is removed to halt or slow down the growth of spoilage microorganisms, as well as the occurrence of chemical reactions. Drying is usually defined as the removal of moisture until equilibrium with the environment, while the removal of moisture to a very low moisture content, nearly bone-dry condition is called dehydration (Stuchly *et al.*, 1983).

Arriola *et al.* (1976) studied on characterization, handling and storage of papayas and made up a review that published by the Central American Research Institute for industries comprises data on fruit physical and chemical characteristics, fruit disinfestations before storage, and control of fungal disease during storage.

Nazeed and Broughton (1978) studied on storage condition and ripen of papaya 'Bentong' and 'Taiping' and found that optimum storage and ripened temperature for Bentong and Taiping papayas were approximately 20°C. Both CVS ripened earlier after exogenous application of C_2H_4 combined with the removal of CO_2. Storage life of the fruits could be extended by maintaining them in an atmosphere devoid of C_2H_2 but containing below 15°C when the papayas were stored for more than 7 days, the nutritional value of ripe fruit decreased rapidly with prolonged storage at the eating rip stage the glucose, protein and ascorbic acid contain are 2.23gm, 209mg and 33mg/100gm pulp in Benting and 2.15gm, 196 mg and 30mg/100gm pulp in Taiping.

Basuki *et al.* (1975) investigated the influence of storage conditions on the quality of fresh tomato (*Lycopercicon esculentum*) and papaya (*Carica papaya*). Local papaya and tomatoes were stored for 0, 10 or 20 days at 0-5°C, RH 55-65% or 10-15°C, RH 45-65% or ambient conditions of 26-30°C, RH 60-90%. For both crops storage at 10-15°C resulted in one longest shelf-life, with reasonably good quality.

Aziz *et al.* (1975) investigated the effect of different temperatures on the storage of papaya fruits and respiration activity during storage. Result was found that mature papaya fruits were stored for 16-20 days at 10°C or 15°C. The percentage weight loss of fruits increased as the storage period progressed and was greater at 15°C than at 10°C. The total soluble solids showed a slight and gradual increase up to the end of the storage period.

Ali (1997) studied on the biochemical basis at accelerated sulfating in papaya following storage at low temperature. Papaya fruits are susceptible to chilling injury in the temperature range 10-15°C. The significance of cell wall enzymes in accelerated softening of ripening chill-injured fruits was investigated.

Pesis *et al.* (1992) studied on coated with wax or heat-sealed in Cryovac polyethylene and stored at 17°C. The control fruits showed a normal climacteric rise of CO_2 and ethylene but the coated and wrapped papaya fruits did not do so. Internal O_2 was highest in the controls, dropping from 21 to 14% during 9 days of storage. The O_2 levels in both groups of treated fruits were much less than in controls. Internal CO_2 was highest in polyethylene-wrapped fruits, followed by the waxed fruits and was lowest in the control. None of the treated fruits accumulated fermentation products. The wrapped and untreated fruits showed normal colour development and softening, but ripening was inhibited in waxed fruit. Weight loss in fruits was in the order control > wax > plastic film.

Askar (1998) investigated the importance and characteristics of tropical papaya fruits. He discussed the properties of tropical fruits and their significance within the overall fruit and fruit juice industry. Aspects considered included: fruit production and consumption; the importance of quality management for successful production of tropical fruit products such as Juices, nectars etc; importance of correct harvesting time; compositional aspects; and nutritional and health benefits associated with tropical fruits.

Uddin (1991) conducted studies for preparing preserves and candies from pineapples, mango, watermelon, papaya and carrot. Fruits and vegetables cubes were treated with preservatives and vegetables cubes were treated with preservatives and firming agents, blanched and pricked before processing to preserve that mango and pineapple preserves were of excellent quality while those prepared from watermelon and papaya was categorized as "good product". The preserves and candies were shelf stable up to 12 months at ambient temperature (23-38°C).

Rodriguez and Iguina-de-George (1975) investigated the evaluation of papaya nectar prepared from unpeeled papaya puree. It was found that the mature- green papayas were ripened at room temperature, seeds were removed and unpeeled section were mashed and pulped. The pulp with 17.5% sugar added was heated at 87.8°C and frozen at 23.3°C. Water to dilute it to 33.3% pulp content, sucrose and citric acid were added. The resulting nectar was 12 pasteurized, canned and stored at 29.4°C for 12 months. The chemical composition of the nectar did not change significantly during storage although there were slight changes by the percentage of reducing sugar. Taste evaluation by a panel showed that the overall quality of the samples remained acceptable throughout the storage period.

Rangana and Bajaj (1992) reported that SO_2 is widely used throughout the world principally in treating food of plant origin. It is used in the preservation of fruits juices, pulps, beverages and concentrates. Concentration used may vary from 350 to 2000 ppm soluble salts (e.g. KMS) are usually used in treating fruits and vegetable products. The activity is higher at p^H below 4.0.

Shams-Ud-Din (2002) reported the studies on the processing of cassava chips. The slices were blanched in hot water (95°C) for about 4 minutes and were then soaked in potassium metabisulphite for 4 minutes before frying in oil. Salt was then added to the chips at the rate of 15 gms to every 1 kg of chips before consumption. He also reported the preparation of dried cassava chips which contained 7-8% moisture on wet basis.

Islam and Shams-Ud-Din (2003) indicated procedure for the production of chips from cassava as follows. The cassava roots were first thoroughly washed in clean water. The cleaned roots were then peeled by knives. The peeled roots were cut into slices by using rotary slicer with thickness 1.5mm. The slices were pre-treated by blanching /sulphiting. The pretreated slices were fried at 100°C, 110°C or 120°C and frying time was 3-5 minutes for fried cassava chips.

Islam and Ali (1997) reported that rotary type slicer is used for chips production in most plants with capacity up to 7,000 lb of potato per hour. Slice thickness is varied between 1.3 and 2.0 mm to suit the condition of the potato, such as age, variety turgidity, sugar content, and temperature of the fat and cooking time. Generally slices are washed in rotating reels with jets of water under high pressure to remove starch from the cut surfaces and to separate the slivers from the desirable slices. Slices are then transported to a rinse tank and by conveyor belt they are discharged into the frying kettle. Moreover, at the surface of Potato slices is removed just before they drop into the fat by one or more of the following methods, perforated revolving drum, sponge rubber covered squeeze roller, compressed air and blow fans for blowing off moisture, vibrating mesh belt, heated and centrifugal extraction.

Sandhu and Bhupinder (1990) reported that blanching greatly improved the colour of potato chips. He also stated various pre-treatments for improving chips colour such as shaking with absolute ethanol (5 min) and dipping in 0.2% potassium metabisulphate (KMS) solution (5 min.), Shaking with absolute ethanol for 5 min. and dipping in 0.1 % KMS solution for 5 min, dipping in 0.25 calcium chloride solution at 90°C for 5 min. followed b) dipping in 0.2% KMS solution for 5 min. was found to be the best chemical treatment.

Reddy and Das (1993) stated that blanching of potato slices in hot water lowers the reducing sugars and improved colour they also suggested that blanching of potato slices for 60-70 sec. gave the best results. Temperature of frying is an important parameter, and literature shows that frying temperature for potato chips may be either 145°C or 165°C or 185°C. As the chips are elevated from the fryer they receive an application of salt from a hopper immediately above the elevator beef generally 1.5-2 1b of salt is applied to each 100 1b of potato chips. Blanching of slices in hot water lowers the reducing sugars and improves the colour. For best colour chips desired blanching time and temperature determination is necessary. Colour of chips depends on frying temperature and time. Pre-teatment of potato slices improves colour of chips. Monosodium glutamate intensifies the flavour of potato chips. It is used should be mixed with the salt and applied in the operation. Barbecue, hickory smoke, and cheese or other flavouring materials are added to some chips. This usually is done by dusting or spraying the flavour materials on the chips in a rotating drum, which distributes the flavour materials uniformly on the chips. After salting, the chips drop on to a belt conveyor which is used for inspecting and cooling the chips as well as transporting them to the weighing and packaging machines for packaging chips flexible packages of many sizes are used. Waxed glassine, cellophane, various types of laminated materials and some aluminum foil are used as flexible packages.

Sandhu and Bhupinder (1990) stated various pre-treatments such as blanching of potato slices and various chemicals pre-treatment. Chips colour measurement by several processes, Davis and Smith (1962) used the Agtron Model F reflectance colorimeter to measure potato chips colour objectively.

Several factors are involved in processing of good quality chips. These are colour of chips, moisture content of chips, oil content of chips, frying temperature of chips, frying time of chips, texture or crispness of chips and packaging system and storage condition of chips. A number of studies have been conducted on various factors affecting the chips colour quality such as storage period and condition of potatoes, blanching time and temperature of potato slices, frying time and temperature of chips, various pre-treatments of potato slices, storage and packaging of chips etc. are main colour control factors (Ali and Islam, 1997).

Visual colour is major quality criterion for potato chips which is also related with texture and flavour of the product. The maintenance of desirable colour is the most important problem. Colour is the most important factor, which determines the quality and cost of the chips (Anand *et al.*, 1982). Good appearance calls for a light yellow colour (Misra and Premchand, 1988).

Moisture content in any food in the most important factor in so far as storage stability is concerned. Bacteria and other microorganisms can grow easily in higher percentages of moisture content in food and damaged it very quickly. Moisture content in chips is an important factor of chips quality. For longer shelf life and for crispy texture, moisture content is an important factor. Simpson (1969) stated that the moisture content of chips should be within 2-3%.

Oil content of chips is an important quality factor in chips processing. From the economic point of view the oil content of the chips should also be as low as possible. Factors affecting oil content of chips are: i) Dry matter content of potatoes, ii) Thickness of slices, iii) Type of fat, iv) Temperature of fat during frying, v) Length of frying time, vi) Leaching slices with hot water of solution, and vi) Partial drying of raw slices. Dry matter content of potatoes affects oil content of chips probably constituents comprising dry matter of potatoes absorbed oil at different rates and amounts during the flying process. By using a model food system, a low amount of fat adsorbed when amylase was used in the system. As amylopectin content increased the amount of fat absorbed increased (Racenis, 1959). Fal (1973) reported that soybean oil had greater heat stability than palm oil. Both oils could be used as fats frying potato chips.

Packaging and storage are quality control criterion of chips. Good packaging and storage condition extend the storage duration. Chips are packed in packages of various dimensions and materials, including cellophane and waxed glassine. Fibreboard cartons are used for casing the packages of chips (Ahmed, 1977).

CHAPTER III
MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted in the laboratory of the Department of Food Engineering & Technology, under the Faculty of Post Graduate Studies, Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh during the period of January, 2012 to June, 2012.

3.1 Materials

The fresh green papayas (*Carrica papaya* L.) collected from local market were used in this study. Good quality soybean oil was purchased from local market. The chemicals and reagents required were used from laboratory stock. Chemicals and solvents used in the study were of analytical reagent grade and distilled water was used in the experiment.

3.2 Methods for preparation of papaya chips

The fresh green papayas were selected for processing of fried chips. The fruits were first thoroughly washed in clean tap water to remove adhering gum, soil and other unwanted materials. The cleaned fruits were then peeled by a knife. The peeled fruits were then cut into 8-10 cm longitudinal sections and these sections were cut into 2.0 mm thick slices. Slices were washed to remove surface gum and seeds. There are two methods used for the preparation of papaya chips. The flow sheet for preparation of chips from green papaya is presented in Figure 3.2.

Figure 3.1: Fresh green papaya

Green papaya

⇩

Washing

⇩

Peeling

⇩

Cut into longitudinal section

⇩

Cut into 2.0 mm thick slices

⇩

Blanching for 2 minutes (95°C)

⇩

Oven Drying / Sun Drying

⇩

Frying in oil

⇩

Salting

⇩

Serving/ packaging

⇩

Storing the product at room temperature (25-30°C)

Figure 3.2: The flow sheet for preparation of fried papaya chips

3.2.1 Pre-treatments of the papaya slice

To improve sensory attributes of chips several pre-treatments of papaya slices were made.

i. Pre-treatment by blanching

Blanching of papaya slices was done to reduce sugar content, inactivation of enzyme and for improvement of the chips color. The slices were blanched in water for 2 minutes at 95°C.

ii. Pre-treatment by 0.1% potassium meta-bisulphate (KMS) solution

Papaya slices were dipped in 0.1 % KMS solution for 5 minutes.

3.2.2 Drying the slices

Papaya slices were dried using both the oven drying (60°C for 7 hours) and sun drying (30±1°C for 3 days) method.

Figure 3.3: Dried papaya slices

3.2.3 Frying the slices

Pre-treated dried slices were fried in hot soybean oil in an electrically heated aluminium container at 140°C, 150°C and 160°C. Here relatively small amounts of papayas were utilized. Temperature was controlled by a controlling electrical heater and Temperature was measured by a thermometer. Papaya slices and oil ratio of 1:20 was chosen which gave an initial temperature drop of 10°C. Papaya slices were placed in hot oil when the temperature was 5°C lower than the set temperature. Fried papaya slices were taken out and surface oil was removed by soaking. The frying medium was changed at every hour of frying.

Figure 3.4: Fried papaya chips

3.2.4 Salting the slices

After frying, salt was added to the chips at the rate of 20 gm per kg of papaya chips before serving or packing.

3.2.5 Determination of frying time

The final moisture content of fried chips should be 3-4%. So, the frying time should be that time when initial moisture content of dried papaya slices are reduced to final moisture content of 3-4%. Frying time varied with frying temperature. Fried papaya slices were taken out and its moisture content was determined at every 5 sec. interval by oven drying method. When moisture content was 3-4%, then that time was the desired frying time for that temperature.

3.2.6 Frying temperature

Papaya slices were fried at 140°C, 150°C and 160°C and processed chips were tasted by a panel of 10 Judges.

3.2.7 Measurement of oil content

Oil content in final product was estimated by extracting in hexane in Soxhlet apparatus for 12 hours. After 12 hours, oil was stored in crucible. The stored oil is the oil content in chips. For determining oil content in chips, 5 gm sample was taken in Soxhlet apparatus. The percent of oil content was calculated as follows:

$$\%\ \text{Oil content} = \frac{\text{Weight of oil}}{\text{Weight of sample}} \times 100$$

3.3 Chemical analysis of papaya chips

The fresh sample of green papaya and fried papaya chips was analyzed for moisture, protein, fat, ash, carbohydrate and vitamin C content.

3.3.1 Moisture content

Moisture content of the chips was determined by oven drying method. 5 gm sample was taken and dried in an oven at 105°C for 24 hours until the weight became constant. The loss in weight was taken as the moisture loss of the sample and the percent of moisture content was calculated by using the following formula:

$$\% \text{ Moisture content} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.3.2 Protein content

Protein content was determined using AOAC (1975) method. The accepted method was as follows:

Reagent required

1. Concentrated H_2SO_4
2. Digestion mixture
   - Potassium Sulphate = 100 gm
   - Copper Sulphate = 10 gm and
   - Selenium dioxide = 2.5 gm well mixed in a mortar and kept in a dry place
3. Boric acid solution = 2% solution in water
4. Alkali solution = 400 gm sodium hydroxide in water and diluted to 1 litre
5. Mixed indicator solution = Bromocresol: 0.1 gm and Methyle red: 0.2 gm dissolved in 250 ml ethyl alcohol
6. Standard HCl = 0.1 N

Procedure

2 gm sample was taken in a 250 ml of Kjeldahl flask. Two gram of digestion mixture was added with the sample. 25 ml of concentrated sulfuric acid was added for oxidation. The flask was placed in an inclined

position on the stand in digestion chamber, heated continuously until frothing ceased and then simmered briskly. The solution became clean in 15-20 min., continued heating for 45 min. After cooling, 100 ml water was added and transferred quantitatively to a 1 litre round bottom flask; the final volume was about 500 ml. Added gently down the side enough NaOH solution to form a precipitate at cupric hydroxide and immediately connected the flask to stream-trap and condenser. In a 500 ml conical flask, 50 ml of boric acid solution, 50 ml distilled water and 5 drops of indicator solution were added. Positioning the condenser distillation was carried out for 40 to 45 minutes or until about 250 ml of distillate was obtained. The content receiving was filtrated with hydrochloric acid, the end point was marked by a pink colour. A reagent blank was also determined and deducted from the titration.

1 ml of 0.1 N hydrochloric acid contain = 0.0014 g of N_2. A protein conversion factor of 5.7 was used to calculate the percent protein from nitrogen determination. Percentage of nitrogen and protein calculated by the following equation:

$$\%\ \text{Nitrogen} = \frac{(T_s - T_b) \times \text{N. of acid} \times \text{Meq of } N_2}{\text{Weight of sample}}$$

Where,

T_s = Titre volume of the sample (ml)
T_b = Titre volume of the blank (ml)
Meq. of N_2 = 0.014

$$\%\ \text{Protein} = \%\ \text{Nitrogen} \times 5.7$$

3.3.3 Fat content

AOAC method (1975) was used to determine crude fat content of the sample.

Procedure

The sample remaining after moisture determination was transferred to a thimble and plugged the top of the thimble with a wad of fat free cotton. Dropped the thimble into the fat extraction tube of a soxhlet apparatus. The bottom of the aspiration tube was attached to a soxhlet flask. Approximately 75 ml or more of anhydrous ether was poured through the sample in the tube into the flask. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hours or longer on a water bath at 70-80°C. At the end of the extraction period, the thimble from the apparatus was removed and distilled off most of the petroleum ether by allowing it or collected in soxhlet tube. The petroleum ether was poured off when the tube was nearly full. When the petroleum ether had reached small volume, it was poured into a small, dry (Previously weighed) backer through a small funnel containing plug cotton. The flask was rinsed and filtered thoroughly using ether. The ether was evaporated on steam bath at low temperature and was then dried at 100°C for 1 hour, cooled and weighed. The difference in the weights gave the ether soluble material present in the sample. The percent of crude fat was expressed as follows:

$$\%\ \text{Crude fat} = \frac{\text{Weight of petroleum ether soluble material}}{\text{Weight of sample}} \times 100$$

3.3.4 Ash content

AOAC method (1975) was used to determine the total ash content.

Procedure

Two gram sample was taken in a dry, clean porcelain dishes and weighed accurately. Hot air oven method was applied to remove the moisture. Then the sample was burned on a gas burner. This was done to avoid the loss of sample in the muffle furnace under higher temperature. Then sample was transferred into the muffle furnace and burned for 4 to 6 hours at a temperature of 550°C and ignited until light gray ash resulted (or to constant weight). The sample was then cooled in a desiccator and weighted. The ash content as expressed as:

$$\%\ \text{Ash} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

3.3.5 Total carbohydrate content

Total carbohydrate content of the sample was determined as total carbohydrate by difference that is by subtracting the measured protein, fat, ash and moisture from 100.

3.3.6 Vitamin C (Ascorbic acid) content

Vitamin C content was determined using the method of Ranganna (1992). The accepted method was as follows:

Reagent required

i) Metaphosphoric acid (3%)

ii) Standard ascorbic acid solution

iii) Dye solution

Standardization of dye solution:

5 ml standard ascorbic acid solution and 5 ml Metaphosphoric acid (HPO_3) was taken in a conical flask 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

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

Titration

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

$$\text{Mg of ascorbic acid/100 gm of sample} = \frac{T \times D \times V_1}{W \times V_2} \times 100$$

Where,

T = Titre

D = Dye factor

V_1 = Volume made up

W = Weight of sample taken for estimation

V_2 = Aliquot of extract taken for estimation

3.3.7 P^H

The P^H meter was first standardized using buffer of P^H 7.00. Then for determining the P^H of green papaya and papaya chips, a buffer of P^H 4.00 was sufficed. Again the P^H meter was standardized using this buffer and checked the P^H of sample.

Packed in single layer polyethylene

Packed in double layer polyethylene

Packed in single layer polyethylene
and kept in plastic container

Packed in laminated aluminium foil

Figure 3.5: Fried papaya chips packed in various packaging systems

For observing shelf-life of papaya chips at various storage conditions, each of 20 gm sample was packed in the above packaging systems and stored at room temperature (25-30°C) and 75±2% relative humidity. The moisture uptake by chips at every 5 days interval was determined gravimetrically from known initial moisture content of samples until 40 days.

CHAPTER IV
RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Chemical composition of green papaya

The green papayas were analyzed for moisture, ash, protein, fat, vitamin C and total carbohydrate contents. The results are presented in Table 4.1. The green papaya contained moisture 88.2%, protein 0.57%, fat 0.14%, ash 0.63%, vitamin C 40 mg/100 gm and total carbohydrate 10.43%. The composition of green papaya under study was more or less similar to those reported by US Department of Health, Education and Welfare (1972) and Parle Milind *et al.* (2011). US Department of Health, Education and Welfare (1972) reported that papaya contained moisture 92%, protein 1%, fat 0.1%, ash 0.66%, carbohydrate 6.2% and ascorbic acid 40mg/100gm.

Table 4.1: Chemical composition of green papaya

Components	Quantity
Moisture (%)	88.2
Protein (%)	0.57
Fat (%)	0.14
Ash (%)	0.63
Vitamin C (mg/100 gm)	40
Carbohydrate (%)	10.43

The variation in chemical composition of green papayas might be due to varietal differences, variation in stage of maturity, time elapsed between harvesting and analysis and the growing conditions of the fruits.

4.2 Determination of the ratio of papaya slice and oil

When oven dried and sun dried papaya slices were placed in hot oil then initial temperature dropped. Here, dried papaya slices were fried at oil temperature of 140°C, 150°C and 160°C. To maintain these desired temperatures papaya slices and oil ratio was chosen to give an initial temperature drop of 10°C. Papaya slices were placed in hot oil when the temperature was 5°C lower than the set temperature. For determining papaya slices and oil ratio by trial and error method, different ratio of papaya slices and oil such as 1:10, 1:15 and 1:20 were chosen. The results are shown in Table 4.2.

Table 4.2: Temperature dropping during papaya slices and oil ratio

Papaya slices : Oil	Initial temperature drop (°C)
1:10	17
1:15	14
1:20	10

The results showed that the lowest and desired temperature drop 10°C was given by a papaya and oil ratio of 1:20. It was reported that during cassava chips frying, the cassava and oil ratio was also 1:25 (Islam, 2003) which was nearly same.

In all cases (140°C, 150°C and 160°C), same initial temperature drop was observed for both oven and sun dried papaya chips. It was however observed that in case of higher temperature, temperature quickly returned to the original temperature compared to the cases of lower temperature for a constant mass of oil as predicted by equation, sensible heat gain = Mass × Specific heat × Temperature gain.

Finally the most acceptable papaya slices and oil ratio and temperature drop were 1:20 and 10°C respectively. Nearly same observations were found in potato chips processing (Ali, 1997) and cassava chips processing (Islam, 2003).

4.3 Determination of moisture content

The oven drying method was used for determination of moisture content in dry matter of oven and sun dried papaya chips at various frying time. Moisture content of samples undergoing frying was determined at different time interval for various frying oil temperatures such as 140°C, 150°C and 160°C. Moisture contents of papaya slices during frying at different temperatures are shown in Figure 4.1, Figure 4.2, Table 4.3 and Table 4.4.

The result show that the minimum frying time required for oven dried papaya chips to reach desired final moisture content of 3% were 25 sec. at 140°C, 20 sec. at 150°C and 15 sec. at 160°C and the minimum frying time required for sun dried papaya chips to reach desired final moisture content of 3% were 30 sec. at 140°C, 25 sec. at 150^0C and 18 sec. at 160°C. The moisture content (Figure 4.1, Figure 4.2) follows a linear relationship with time for the greater part of the frying period for all cases of frying temperature.

An analysis of the data shows that rate of water removal depends on temperature and the higher the temperature, the higher the rate of water removal. However, the rate of moisture removal from papaya slices at the initial period was the highest. Simpson (1969) suggested that for longer shelf-life the moisture content of chips should be 2-3%.

Table 4.3: Influence of frying time and temperature on moisture content and oil content of oven dried papaya chips

Frying temp(°C)	Original dry matter(gm)	Frying time (sec.)	Moisture content(%)	Oil content (%)
140	25	15	14.0	19.7
		20	7.5	25.4
		25	3.0	28.6
150	25	10	12.3	17.6
		15	6.4	25.2
		20	3.0	29.2
160	25	5	15.0	15.5
		10	7.3	25.3
		15	3.0	29.7

Table 4.4: Influence of frying time and temperature on moisture content and oil content of sun dried papaya chips

Frying temp(°C)	Original dry matter(gm)	Frying time (sec.)	Moisture content(%)	Oil content (%)
140	20	13	18.0	19.6
		22	9.1	27.0
		30	3.0	29.2
150	20	10	15.2	19.6
		20	7.7	28.2
		25	3.0	30.1
160	20	8	16.3	18.7
		13	8.1	26.2
		18	3.0	29.7

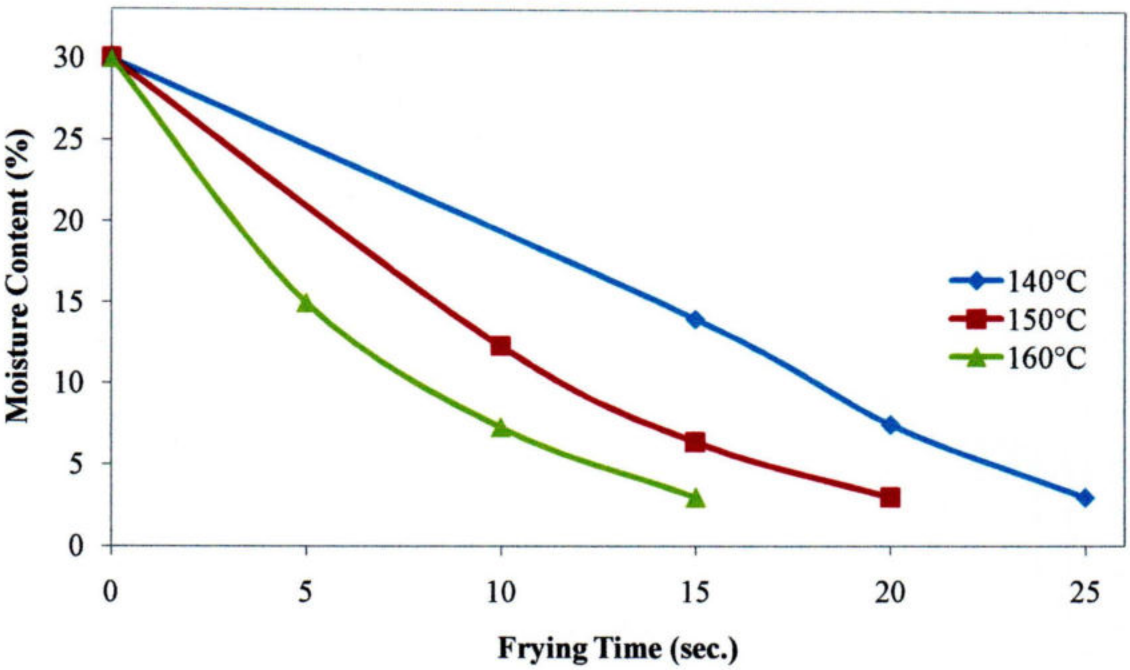

Figure 4.1: Relationship between moisture content and frying time of oven dried papaya chips during frying at 140°C, 150°C and 160°C

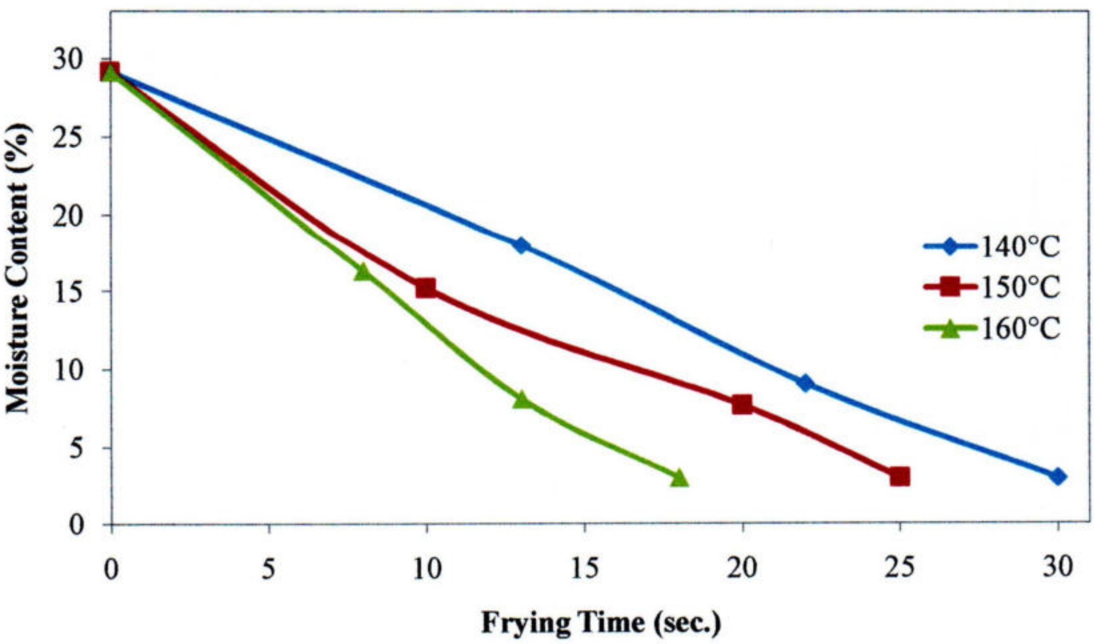

Figure 4.2: Relationship between moisture content and frying time of sun dried papaya chips during frying at 140°C, 150°C and 160°C

4.4 Determination of oil content of chips

From the economic point of view, oil content of chips should also be as low as possible. So, determination of oil content of chips is essential. An experiment was conducted to show the time dependence of oil content of papaya chips at different frying temperatures such as 140°C, 150°C and 160°C. The results are shown in Table 4.3 and Table 4.4.

It can be seen from Figure 4.3 and Figure 4.4 that oil content of oven dried and sun dried papaya chips increased with increasing frying time for all frying temperature. Frying of papaya slices due to evaporation by heat transferred from hot oil, while the hot fat is diffused into the slices filling the space emptied by water. It was well known that diffusion process is strongly dependent on temperature by an Arrhenius equation type of relationship (Islam, 1980).

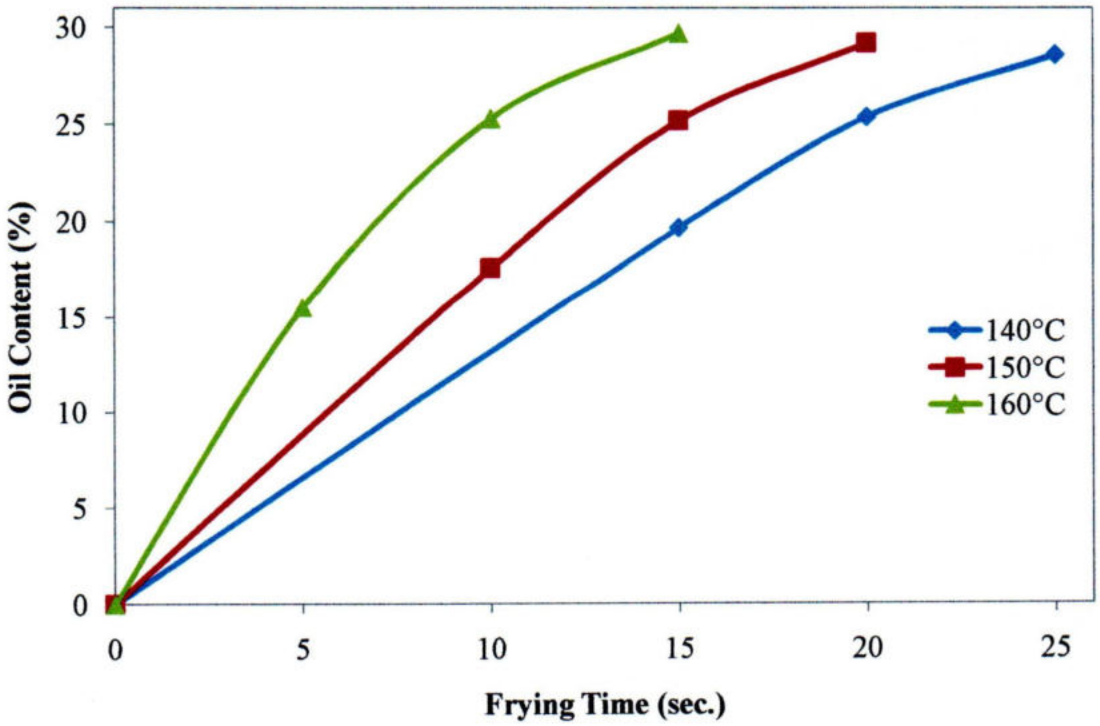

Figure 4.3: Relationship between oil content and frying time of oven dried papaya chips during frying at 140°C, 150°C and 160°C

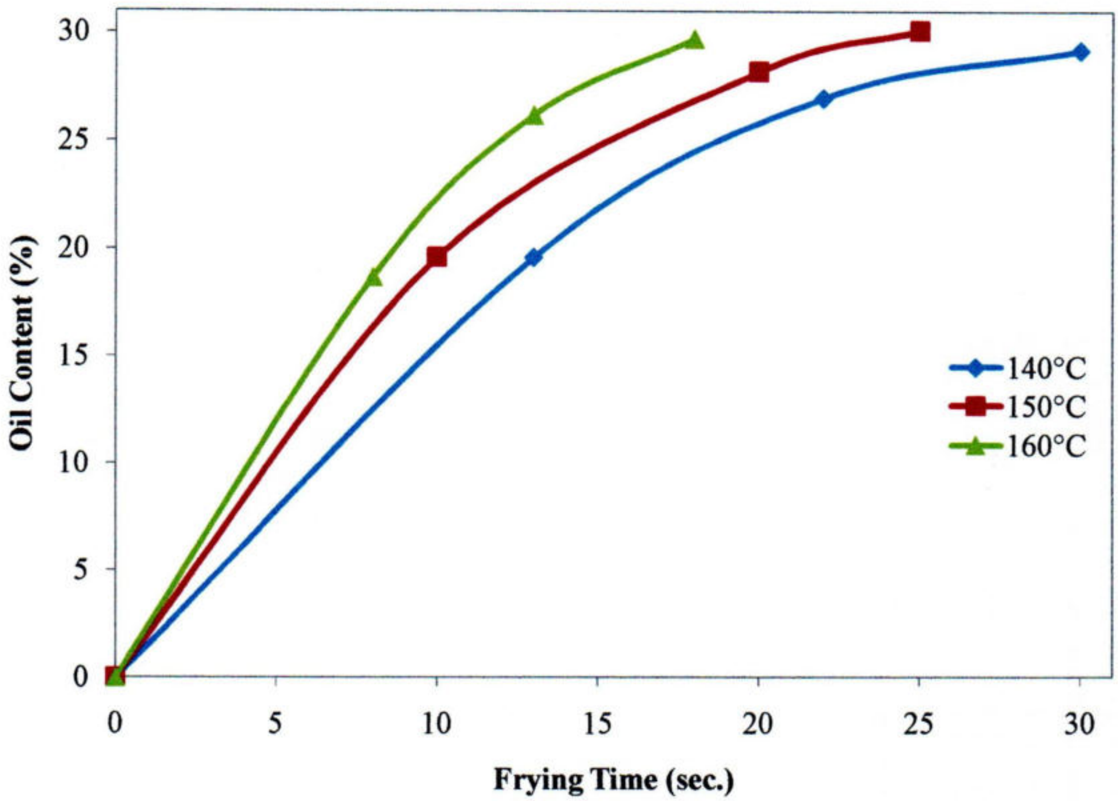

Figure 4.4: Relationship between oil content and frying time of sun dried papaya chips during frying at 140°C, 150°C and 160°C

4.5 The relationship between oil content and moisture content of papaya chips during frying

As indicated in the previous section that frying of papaya slices is a two-way diffusion process. Further analyzing the experimental results of frying the products at constant temperature and determining both moisture content and oil content of fried chips at definite time interval are shown in Figure 4.5 and Figure 4.6. It is clearly seen that decrease in moisture content gives increased oil uptake indicating that water in papaya slices is replaced by frying oil. Similar analysis was reported during potato chips processing (Ali, 1997) and cassava chips processing (Islam, 2003).

Form Figure 4.5 and Figure 4.6 it was also seen that at a moisture content of about 2-3%, the oil content in the chips varies between 29 to 30% for both sun dried and oven dried papaya chips at all frying temperatures such as 140°C, 150°C and 160°C. It means at desired moisture content as recommended by Simpson (1969), the oil content is not influenced by frying temperature. This is probably due to the fact that both the rate of water removal and the rate of oil uptake are strongly dependent on temperature as shown in the previous sections.

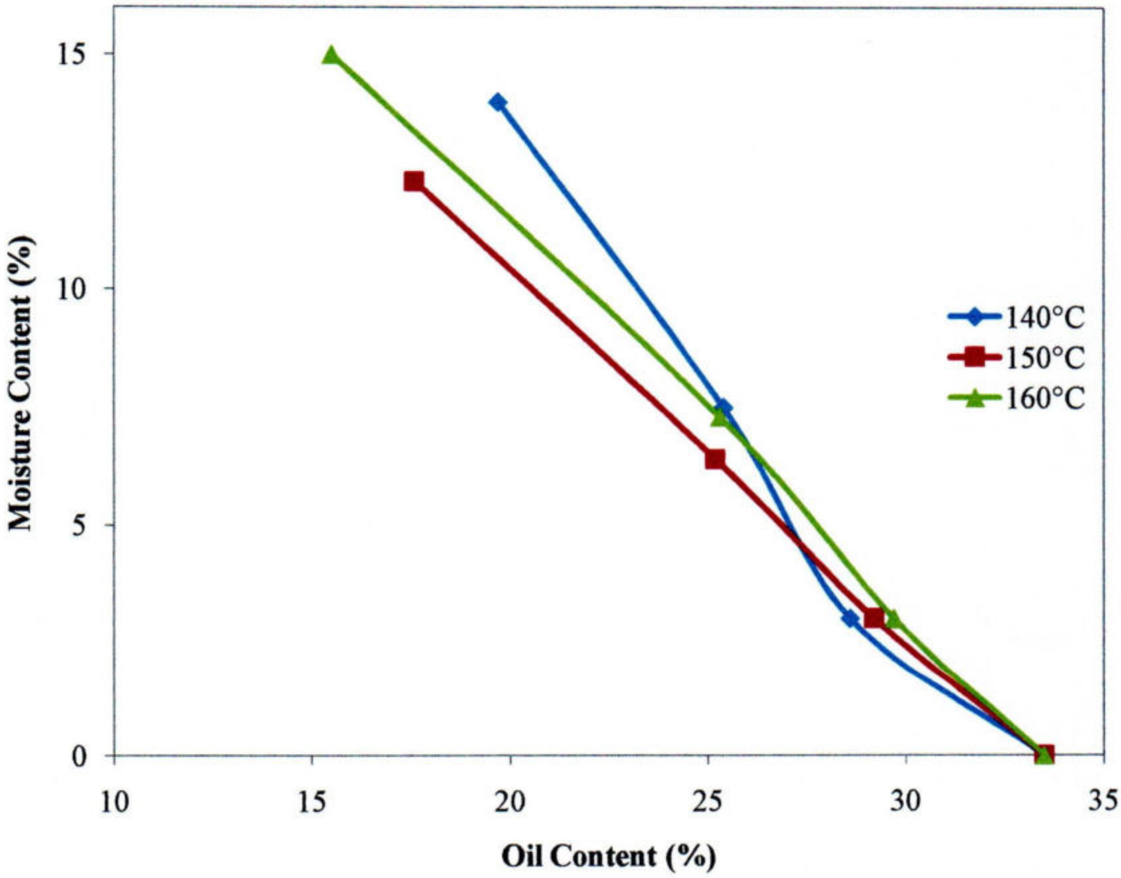

Figure 4.5: Relationship between oil content and moisture content of oven dried papaya chips during frying at 140°C, 150°C and 160°C

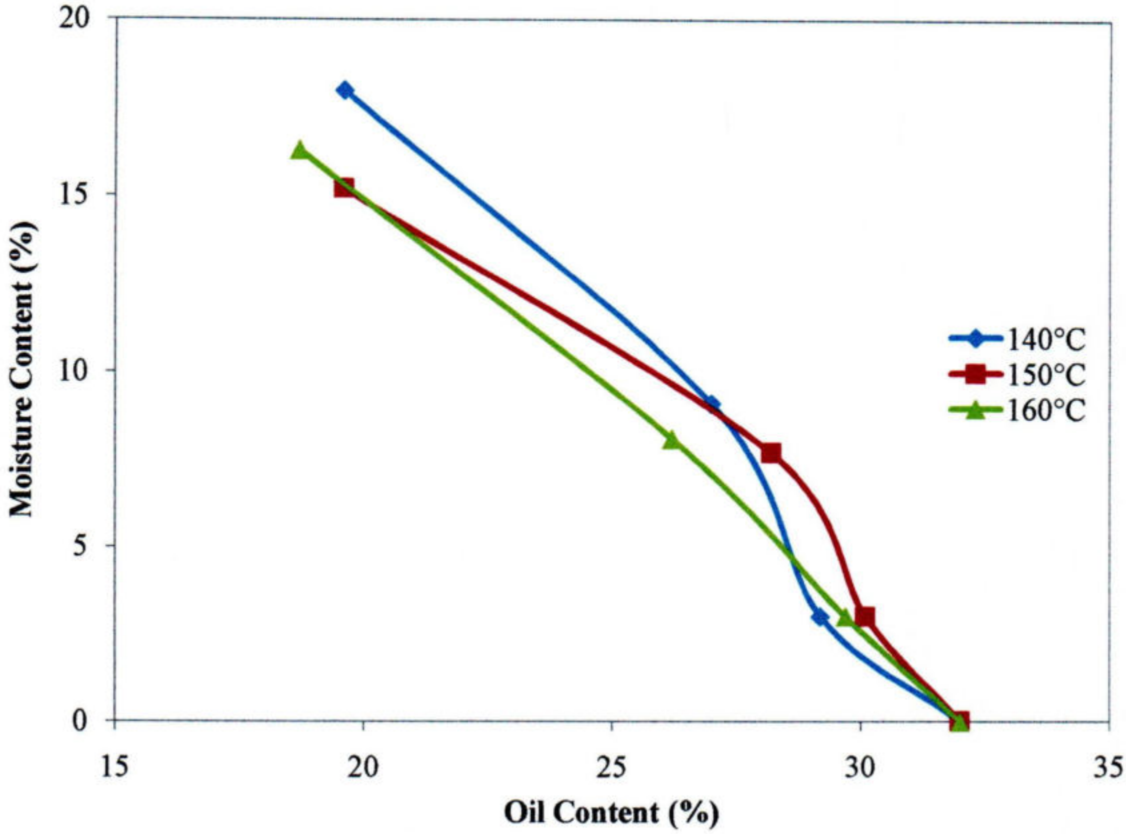

Figure 4.6: Relationship between oil content and moisture content of sun dried papaya chips during frying at 140°C, 150°C and 160°C

4.6 Chemical composition of fried papaya chips

The average chemical composition of fried papaya chips contained moisture 3.0%, protein 7.08%, fat 23.02%, ash 1.71%, salt 2.0% and total carbohydrate 63.18%. Total energy contained per 100 gm of papaya chips is equal to 488 Kcal. During frying most of the water in the papaya chips vaporizes and oil uptake occurs. For this reason the moisture content is so less. But the rate of moisture vaporization and oil uptake is not just the same. The fat content of fried papaya chips has increased because of oil uptake.

4.7 Sensory evaluation of fried papaya chips

A panel of 10 judges tested colour, texture, flavour and overall acceptability of oven dried and sun dried papaya chips. The mean score for colour, texture, flavour and overall acceptability of oven dried and sun dried papaya chips containing 3 samples each are presented in Table 4.5 and Table 4.6.

Table 4.5: Mean score for colour, texture, flavour and overall acceptability of oven dried papaya chips

Sample Type	Sensory attributes			
	Colour	Texture	Flavour	Overall acceptability
S_1	7.3^a	5.1^b	6.8^a	6.5^a
S_2	6.2^b	7.0^a	5.9^b	5.2^b
S_3	5.2^c	3.9^c	5.0^c	3.8^c
LSD ($p<0.05$)	0.6981	0.693	0.8425	0.7945

S_1 = Papaya chips sample 1 fried at 140°C for 25 sec.
S_2 =Papaya chips sample 2 fried at 150°C for 20 sec.
S_3 = Papaya chips sample 3 fried at 160°C for 15 sec.

Table 4.6 Mean score for colour, texture, flavour and overall acceptability of sun dried papaya chips

Sample Type	Sensory attributes			
	Colour	Texture	Flavour	Overall acceptability
S_1	7.1^a	5.8^b	7.4^a	6.8^a
S_2	5.9^b	7.0^a	5.7^b	5.4^b
S_3	4.7^c	4.2^c	5.0^b	4.4^b
LSD ($p<0.05$)	0.7186	0.8632	0.7075	1.045

S_1 = Papaya chips sample 1 fried at 140°C for 30 sec.
S_2 =Papaya chips sample 2 fried at 150°C for 25 sec.
S_3 = Papaya chips sample 3 fried at 160°C for 18 sec.

4.7.1 Influence of frying temperature on colour of papaya chips

Papaya slices were fried at 140°C, 150°C and 160°C and fried for different periods to obtain final moisture content of 3%. The colour developed at the end of minimal frying times to obtain the desired colour, samples were evaluated visually. The results are shown in Table 4.7 and Table 4.8 for both oven dried and sun dried papaya chips respectively.

Table 4.7: Effect of frying temperature on the colour of oven dried papaya chips

Sample type	Oil temperature	Time required (sec.)	Colour
S_1	140°C	25	Light yellow
S_2	150°C	20	Yellow and light spot present
S_3	160°C	15	Dark and spot present

Table 4.8 Effect of frying temperature on the colour of sun dried papaya chips

Sample type	Oil temperature	Time required (sec.)	Colour
S_1	140°C	30	Light yellow
S_2	150°C	25	Yellow and light spot present
S_3	160°C	18	Dark and spot present

It is observed from Table 4.7 and Table 4.8 that frying at 150°C and 160°C results in unacceptable colour as per specifications given by Misra and Premchand (1988). However, the light yellow colour given by frying at 140°C for a period of 25 sec. for oven dried (Table 4.7) and 30 sec. for sun dried papaya chips (Table 4.8) are acceptable.

For a detailed evaluation of colour development, chips were processed using 140°C, 150°C and 160°C frying temperature. Samples were evaluated by a panel of 10 judges.

A two way analysis of variance (ANOVA) was carried out for colour preference of 3 samples for both oven dried and sun dried papaya chips.

In case of oven dried papaya chips, ANOVA analysis (Appendix-1) showed that there was significant ($P<0.05$) difference in colour acceptability among the chips samples. This indicates that the colour of different samples of chips were not equally acceptable. As shown in Table 4.5 (DMRT test), sample S_1(fried at 140°C for 25 sec.) was more acceptable than Sample S_2(fried at 150°C for 20 sec.) and S_3(fried at 160°C for 15 sec.). Sample S_1 secured highest score 7.3 out of 9. The second highest score 6.2 was obtained by sample S_2. So, the frying time of 25 sec. was selected for an oil temperature of 140°C to achieve the best colour at desired moisture content (3%).

In case of sun dried papaya chips, ANOVA analysis (Appendix-5) showed that there was also significant ($P<0.05$) difference in colour acceptability among the chips samples. This indicates that the colour of different samples of chips were not equally acceptable. As shown in Table 4.6 (DMRT test), sample S_1(fried at 140°C for 30 sec.) was more acceptable than Sample S_2(fried at 150°C for 25 sec.) and S_3(fried at 160°C for 18 sec.). Sample S_1 secured highest score 7.1 out of 9. So the frying time of 30 sec. was selected for an oil temperature of 140°C to achieve the best colour at desired moisture content (3%). Although the frying can be reduced by using oil at higher temperature, this is likely to lead to a loss of chips quality.

4.7.2 Influence of frying temperature on texture of papaya chips

To obtain the desired texture, 3 samples of chips each produced from oven dried and sun dried papaya slices were evaluated by a panel of 10 judges.

In case of texture of oven dried papaya chips, ANOVA analysis (Appendix-2) showed that there was significant difference in texture acceptability among the samples tasted at 5% level of statistical significance. However, it can be seen from Table 4.5 that sample S_2(fried at 150°C for 20 sec.) obtained the highest score 7.0. So, sample S_2 has the most texture acceptability than sample S_1 (5.1) and S_3 (3.9).

In case of texture of papaya chips dried using sun drying method, ANOVA analysis (Appendix-6) showed that there was also a significant ($p<0.05$) difference in texture acceptability among the samples. From Table 4.6, it is seen that sample S_2(fried at 150°C for 25 sec.) obtained the highest score 7.0 for texture and was ranked as "Like moderately".

4.7.3 Influence of frying temperature on flavour of papaya chips

For flavour preference among the oven dried papaya chips samples, a two-way analysis of variance (ANOVA) (Appendix-3) showed that there was significant ($p<0.05$) difference in flavour acceptability since, the calculated F (10.078) value was greater than the tabulated F (3.55) value. The results of DMRT(Table 4.5) showed that sample S_1(fried at 140°C for 25 sec.) was the most preferred one having score 6.8.

In case of papaya chips that was previously dried using sun drying method, ANOVA analysis (Appendix-7) showed that there was also significant ($p<0.05$) difference in flavour acceptability and the results of DMRT(Table 4.6) showed that there was no significant difference for flavour between the samples S_2 (5.7) and S_3 (5.0). Although sample S_1(fried at 140°C for 30 sec.) is the most preferred one securing the highest score 7.4.

4.7.4 Influence of frying temperature on overall acceptability of papaya chips

A two way analysis of variance (ANOVA) (Appendix-4) was carried out for overall acceptability of oven dried papaya chips and results revealed that there was significant ($p<0.05$) difference in overall acceptability among the chips as the calculated F (25.508) value was greater than the tabulated value of F (3.55). This indicates that so far as overall acceptability in concern the samples of chips were not equally acceptable. It can be seen from the Table 4.5 that the sample S_1 fried at 140°C for 25 sec. is the most acceptable sample receiving 6.5 out of 9.0 compared to the other samples.

In case of sun dried papaya chips, ANOVA analysis (Appendix-8) showed that there was significant ($p<0.05$) difference in overall acceptability among the samples. From Table 4.6, it is seen that the sample S_1 fried at 140°C for 30 sec. obtained the highest score 6.8 out of 9.0 for overall acceptability.

The colour, flavour and overall acceptability of sample S_1 (6.5) (Table 4.5) were the most preferred attributes for oven dried papaya chips fried at 140°C for 25 sec. (Table 4.7) and also for sun dried papaya chips fried at 140°C for 30 sec. (Table 4.8). In case of texture, although sample S_1 was not the best one but it was acceptable for both types of chips.

4.8 Packaging studies of fried papaya chips

This study was conducted to determine the storage stability in terms of moisture gain by using different packaging materials and equilibrium relative humidity. Papaya chips with 3% moisture content were packed in single layer polyethylene package, double layer polyethylene package, packed in single layer polyethylene package and putting into plastic container and laminated aluminium foil and kept in the laboratory at room temperature 25-30°C and 75±2% relative humidity.

4.9 Storage studies of fried papaya chips

The moisture contents of papaya chips were determined at (from initial known moisture content) every 5 days interval up to 40 days. The results are shown in Table 4.9.

Table 4.9: Moisture content of papaya chips stored in various packaging systems during storage period

Storage intervals (days)	Moisture content (%)			
	Packed in single layer polyethylene	Packed in double layer polyethylene	Packed in single layer polyethylene and kept in plastic container	Packed in laminated aluminium foil
5	5.5	4.0	4.8	3.1
10	7.5	5.5	6.3	3.2
15	9.8	6.6	8.4	3.2
20	12.6	8.1	10.2	3.4
25	15.2	9.2	11.8	3.6
30	17.4	10.5	13.6	3.9
35	19.5	12.0	15.2	4.3
40	21.7	13.9	17.5	4.7

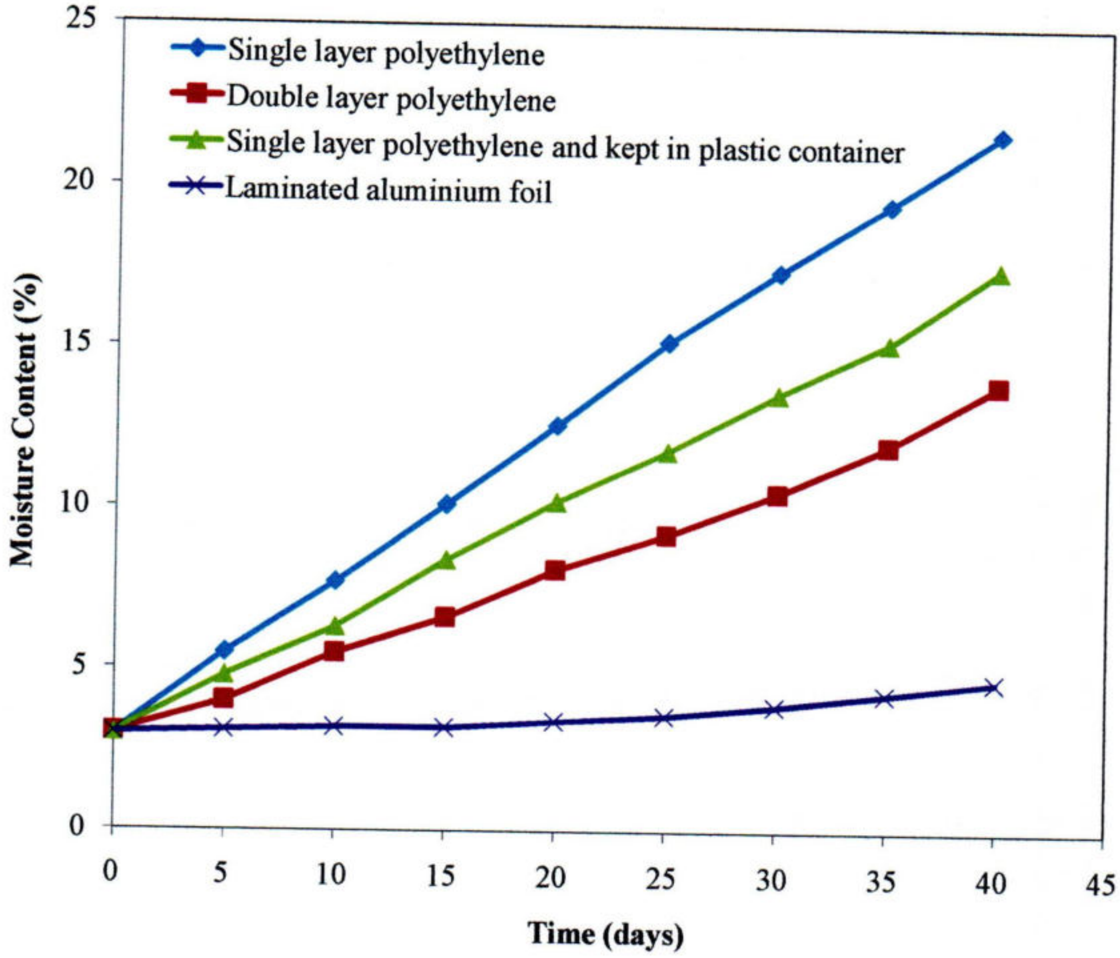

Figure 4.7: Moisture contents of papaya chips stored in various packaging systems during storage

4.9.1 Effect of storage time and temperature on the moisture content of papaya chips stored in single layer polyethylene

As can be seen from Table 4.9 and Figure 4.7 that initial moisture content was 3% and increased in single layer polyethylene from 5.5% in 5 days to 21.7% in 40 days. The above study clearly indicated that chips packed in single layer polyethylene could not be kept for longer period.

4.9.2 Effect of storage time and temperature on the moisture content of papaya chips stored in double layer polyethylene

As can be seen from Table 4.9 and Figure 4.7 that initial moisture content was 3% and increased in double layer polyethylene from 4.0% in 5 days to 13.9% in 40 days. So we can say that chips packed in double layer polyethylene had a little longer shelf life compared to the shelf of chips packed in single layer polyethylene and packed in single layer polyethylene and kept in plastic container.

4.9.3 Effect of storage time and temperature on the moisture content of papaya chips stored in single layer polyethylene and kept in plastic container

The data from Table 4.9 and Figure 4.7 showed that initial moisture content of chips in single layer polyethylene plus kept in plastic bottle was 3% and was increased from 4.8% in 5 days to 17.5% in 40 days. So, it is seen that chips packed in single layer polyethylene and kept in plastic container also had a little longer shelf life compared to the shelf life of chips packed in single layer polyethylene but a little shorter shelf life from chips packed in double layer polyethylene.

4.9.4 Effect of storage time and temperature on the moisture content of papaya chips stored in laminated aluminium foil

In case of papaya chips packed in laminated aluminium foil gave the best results as shown in Table 4.9 and Figure 4.7. It gave the longest shelf life as only 4.7% moisture content in 40 days of papaya chips compared to the other packaging systems. Islam and Shams-Ud-Din (2003) recommended that laminated aluminum foil is suitable for long time storage of chips. Therefore, the results are an agreement with them and packaging of chips in laminated aluminum foil is established here as the best one among the four packaging systems. Additional packing in paper cartoon would give even longer shelf life.

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

This reesearch was carried out in the laboratory of the Department of Food Engineering and Technology, under the Faculty of Post Graduate studies, Hajee Mohammad Danesh Science & Technology University, Dinajpur, Bangladesh. The objectives of this research work were to develop a standard methodology for preparation of papaya chips and suitable packaging system of the product.

The green papaya fruits were collected from local market and analysed for its chemical composition. The fresh green papaya contained moisture 88.2%, protein 0.57%, fat 0.14%, ash 0.63%, vitamin C 40 mg/100 gm and total carbohydrate 10.43%. The fruits were peeled, washed and then sliced. The slices were washed by water and pretreated. After pre-treating, the slices were dried using oven drying and sun drying method then fried in deep oil and then salted and packed for storage study. The average composition of fried papaya chips contained moisture 3.0%, protein 7.08%, fat 23.02%, ash 1.71%, salt 2.0% and total carbohydrate 63.18%.

For frying the papaya slices the ratio of slices and oil was chosen 1:20 which gave the initial temperature drop of 10°C. Then slices were fired up to the desired moisture content (3%) of chips. The result showed that minimum frying time required to reach desired final moisture content of 3% were 25 sec. at 140°C, 20 sec. at 150°C and 15 sec. at 160°C for oven dried papaya chips. For sun dried papaya chips it took 30 sec. at 140°C, 25 sec. at 150°C and 18 sec. at 160°C.

Frying of papaya slices can be considered as a two-way diffusion process in which water is removed due to evaporation by heat transferred from hot oil while the hot fat is diffused into the slices filling the space emptied by water. The rate of water removal and the rate of fat uptake found to be dependent on temperature.

The fried chips produced from papaya slices were subjected to sensory evaluation. A statistical analysis was given by the panelists on the sensory properties of various samples showed that color, texture, flavor and overall acceptability were significantly ($p<0.05$) affected.

The statistical analysis showed that for oven dried papaya chips, the color of sample S_1 (fried at 140°C for 25 sec.) was more acceptable than sample S_2 (fried at 150°C for 20 sec.) and S_3 (fried at 160°C for 15 sec.). For sun dried papaya chips sample S_1 (fried at 140°C for 30 sec.) also gave the best colour of chips.

In case of texture, statistical analysis showed that the texture of sample S_2 (fried at 150°C for 20 sec. & fried at 150°C for 25 sec.) were the best for both oven dried and sun dried papaya chips respectively.

The results of statistical analysis showed that the flavour of samples S_2 and sample S_3 were less acceptable than sample S_1 (fried at 140°C for 25 sec.) for oven dried papaya chips. For sun dried papaya chips Sample S_1 (fried at 140°C for 30 sec.) gave the best result.

From the statistical analysis, it is showed that the overall acceptability of sample S_1 (fried at 140°C for 25 sec. & fried at 140°C for 30 sec.) had the best criteria for both oven dried and sun dried papaya chips respectively. So it is concluded that sample S_1 is the best product for both type of papaya chips.

The results of packaging and storage studies of papaya chips showed that moisture content of chips packed in laminated aluminium foil was the lowest compared to packed in single layer polyethylene, double layer polyethylene and stored in single layer polyethylene and subsequently kept in plastic container. For long time storage, laminated aluminium foil is recommended as the best packaging system.

This research has demonstrated that green papaya is a potential source for production of fried chips with acceptable colour, texture and flavour. It is standardized that the most acceptable fried papaya chips was attained at frying temperature of 140°C for 25 sec. than other temperatures and times for oven dried papaya slices and 30 sec. at 140°C for sun dried papaya slices. The minimum moisture content of 3% of the fried chips was also found at these temperature and time of frying. The most acceptable storage stability of fried papaya chips was found, papaya chips packed in laminated aluminium foil which was followed by chips packed in double layer polyethylene, single layer polyethylene and kept in plastic container and single layer polyethylene respectively.

Recommendations: In rural areas where modern facilities of processing do not exist, sun drying method for preparing fried papaya chips can be easily achieved. Many food industries also can adopt both the procedure for medium and large scale processing. Establishment of small scale processing unit at grower's level could utilize the green papaya for processing of chips, ultimately minimizes postharvest losses of papaya and generates income to the growers.

REFERENCES

REFERENCES

Ahmed, K.U. 1977. Potatoes for the Tropics 1st Ed., Published by Mrs, Mumtaz Kamal, Bangalow No. 2, Farm Gate Dhaka, pp.1-8, 71,72,155.

Ahmed, K. 1984. Papaya cultivation. In: Plant, Animal, Bird and Fish Wealth. 4th ed. Sarbajanin Grantha Laya, 140 New Market, Dhaka, pp. 300-304.

Akin-Osanaiye, B. C.; Nzelibe, H. C. and Agbaji, A. S. 2005. Production of ethanol from *Carica papaya* (pawpaw) agro waste: effect of saccharification and different treatments on ethanol yield. African Journal of Biotechnology, 4(7): 657-659.

Akin-Osanaiye, B. C.; Nzelibe, H. C. and Agbaji, A. S. 2008. Ethanol production from *Carica papaya* (pawpaw) fruit waste. Asian Journal of Biochemistry, 3(3): 188-193.

Ali, M.H. 1997. Processing and storage studies of potato chips. M.S. Thesis, Department of Food Technology. Bangladesh Agricultural University.

Anand, J.C. Maini. S.B. and Diwan B. 1982. A sample way to preserve potato for chips making J. Food Sci. Technol. 19: 267.

Anuar, N. S., Zahari, S.S., Talib, I. A. and Rahman, M.T. 2008. Effect of green and ripe Carica papaya epicarp extracts on wound healing and during pregnancy. Food and Chemical Toxicology, 46(7): 2384-2389.

AOAC, 1975. Offical methods of Analysis of the Association of official Analytical chemistry. 15th Ed. Washington, D.C.

Askar, A. 1998. Importance and characteristics of tropical fruits. Fruit processing- 8(7): 273-276.

Aziz, A. B. A., EL-Nabawy, S. M., Zaki, H. A. and Abou Aziz, A. B. 1975. Effect of different temperatures on the storage of papaya fruits and respirational activity during storage. Seientia Horticulturae, 3(2): 173-177.

Bangladesh Bureau of Statistics. 2002. Statistical Year Book of Bangladesh, Stat.

Bangladesh Bureau of Statistics. 2010. Statistical Year Book of Bangladesh, Stat.

Basuki, A.; Winarno, F.G. and Rahman, A. 1975. Influence of storage condition on the quality of fresh tomato and papaya. Bulletin-pepelitial-teknologi-Hosil-perlanian. No. 15.

Carlin, G.T. 1958. Getting the most profit out of the chipping potato. Natl Potato chips Inst. Proc. Prod. and Tech. Div. Meetings 1958, 9-10.

Carmen -de-Arrioca, M.; Menchn, J.F.; Rolz, C.; Garcia, R. and Calzada, F. 1978. The papaya abstracts of papers American Chemical Society. 179: AGFD 43.

Chan, H.T. and Kowrk, S.C.M. 1975. Identification and determination of sugars of some tropical fruit products. J. Food Sci., 40: 41-49.

Chavasit, V., Pisaphab, R., Sungpuag, P., Jittinandana, S. and Wasantwisut, E. 2002. Changes in beta-carotene and vitamin A contents of vitamin A-rich foods in Thailand during preservation and storage. Journal of Food Science, 67(1): 375-379.

Desresier, N. W. (1977) Elements of Food Technology. The AVI publishing Co., Inc., U.S.A. 20-301.

Dhillon, B.S., Singh, N. and Gill, S.S. 1987. Development Physiology of Papaya. Punjab Hort. J., 27 (1-2): 28-33.

El-Buluk, R., Babiker, E.E.E. and El-Tiany, A. H. 1996. Changes in sugar, ash and minerals in four papaya cultivars during ripening. Plant-Foods for Human Nutrition, 49 (2): 147-154.

El-Buluk, R.; Babiker, E.E.E. and El-Tiany, A. H. 1997. Changes in chemical composition of papaya fruits during development and ripening. Food Chemistry, 59 (3): 395-399.

Fal, U. 1973. Features and properties of fat suitable for frying chips. 11 usefulness of hydrogenated soybean and palms oils. Tluszeze Jadalne 17. No. 3, 127-137.

Firmin, A. 1997. Physico-chemical in papaya during storage. Centre lvoirien de Recherches Technologiqes, 09 BP 922 Abidjan 09.

Gomez, A. K. and Gomez, A. A. 1984. Statistical procedures for Agriculture Research Second Edition, Jone Weily and Sons, pp. 95-109.

Goodenough, D. W. and Owen, J. 1987. Chromatographic and electrophoretic analysis of papya proteinase. Food structures Department, Reading RG 29 AT.

Gupta, A.K and Pathak, V.N. 1988. Some new fungi associated with papaya fruits. India-Phytopathology. 41:3, 479-480.

Hamilton, R. A. 1987. Papaya production in Hawaiian Island Res. Extn. Series, No 085. Collage of Trop Agric. University of Hawaii. Pp. 5-6.

Hoover, E.F. and Xquder, P.A. 1963. Influence of specific compositional factors of potatoes on chipping color. Am. potato J. 40,17-24.

Hossain, S. M. M.; Hossain A.K.M.A.; Rahman M.A. and Rahman, M.T. 1990 Proc. Fifth Nat. Hort. Symp., Bangladesh Society for horticultural science, Bangladesh. p.11.

Islam, M. F. and Shams-Ud-Din, Md. 2003. Studies on processing and storage of cassava chips, M.S. thesis, Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, May, 2003.

Islam, M. M.; Bhuyan, M. A. J.; Biswas, M. and Islam, M. S. 1993. Fruit size, yield and quality of papaya Cv. Kazi piara as affected by fruit thinning. South Indian Horticulture. Bangladesh, 40 (2): 71-72.

Islam, M. N. 1980. Use of solar energy for development of shelf-stable potato products with special reference to Bangladesh. Ph. D. Thesis RVAU. Copenhagen.

Iyer, C.A.A. 1987. Fruit crops. Trop and Subtrop. Nat Symp. Bangalore. p.15.

Jayaraman, K. S. and Das Gupta, D. K. 1978. Develpoment and storage stability of intermediate moisture carrot. Journal of Food Science, 43: 1880-1881.

Maluf, W. R.; Pereira, J. J. and Figuira, A. R. 1997. Inseritance of resistance to the papaya ring spot potyvirus-Water melon strain from two different accession of winter squash Cucurbita maxima dues. Emphytica. 94(2): 163-168.

Misra, J.B. and Premchand, 1988. Improvement of chips colours by removal of colour reactants from potato tube slices by water washing. J. Food Sci. Technol. 25: 99-100.

Nazeed, M. and Broughton, W. J. 1978. Storage conditions and ripening of papaya, Bentang and Taiping. Scientia-Horticulturae. 9(3): 265-277.

Parle, M. and Gurditta, S. 2011. International Research Journal of Pharmacy. 2 (7) pp. 6-12.

Paull, R.E.; Nshijima, W.; Reyes, M. and CMoore, M.D.; Van Blaricom, L.D. and Senn. T.L. 1963. The effect of storage temperature of Irish potatoes on thavaletto, *C.* 1997. Post harvest handing and losses during marketing of papaya *(Carica papaya L.).* Post harvest, Biology and Technology 11:3, 165-179.

Pesis, E.; Marinansky, R. and Subhadrabanhu, S. 1992. Influence of fruit coating on papaya quality. International symposium on tropical fruit: frontier in tropical fruit research, Pattaya city, Thailand.

Racenis, V. 1959. Factors affecting browning of potato chips new type of model systems of studies of browning. Diss. Abs. 20, No. 1, 268-269.

Rangana, S. and Bajaj, K. 1992. Hand Book of Analysis of quality control for fruit and vegetable products.2[nd.] Ed. Tata MeGraw-Hill Co. Ltd., New Delhi.

Rashid, M. M.; Quadir, M. A. and Hossain, M. M. 1987. Bangladesh phal (Fruits of Bangladesh). Rashid Publishing house, Bangladesh Agricultural research Institute campus, Gazipur, Bangladesh.pp. 130-137.

Reddy, G.V. and Das, H. 1993. Keinetics of Deep-fat-frying potato and oftimization of process variables. Dairy and food Engg. discipline, Dept. of Agril. Engg. Indian Institute of Technology, Kharagpur. India. Am. Potato J. 105.

Rodriguez, A. J. and Iguina-de-George, L. M. 1975. Evaluation of papaya nectar prepared from unpeeled puree. Journal of Agriculture of the University of Puerto Rico. 65(1): 79-80.

Sandhu and Bhupinder K. 1990. Potato chips processing Dept. of Food science and Tech. I.I.T. India, pp. 112.

Shams-Ud-Din, Md. 2002. Training manual on cassava processing. Dept. of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh. Sponsored by the REFPI Project of Department for International Development (DFID), UK.

Shaw, R.; Evans, C.D.; Munson, S.; List, G.R. and Warner, K. 1973. Potato chips from unpeeled potatoes. Am Potato J. 50. 424- 430.

Simpson, T. W. 1969. Method of Cooking Potato Chips to Increase Fluffiness and Prevent Browning. pp. 426-438.

Smith, O. 1964. Recent research of value to the potato chips industry. proc. prod. and Tech. Div. Meeting, Potato Chips Inst. Intern. 2-4.

Smith, O. 1966. Factors affecting quality of potatoes. Symp. Proc. Frntiers in Food Research (Cornell Univ.), 5-29.

Stuchly, S.S. & Stuchly, M.A. (1983). Microwave Drying: Potential and Limitations. In: Mujumdar, A.S. Advances in Drying, Volume II. Washington, New York, London: Hemisphere Publishing Corporation. 53-71.

Tressler, D. K. 1961. Blended Fruit Juices and Nectars, Avi. Publishing Co. west Port, Conn.

US Department of Health Education and Welfare, 1972. Food Composition Table for use in East Asia. A research project sponsored. pp. 103.

Vega-Mercado, H, Gongora-Nieto, M.M. & Barbosa-Canovas, G.V. (2001). Advances in dehydration of foods. Journal of Food Engineering, 49, 271-289.

Waterman J.J. 1976. The Production of Dried fish. FAO, of the United Nations Rome, 1976.

Weiser, H. H.; Mountiney, G. J. and Gruld, W. A. (1971). Spoilage of fresh fruits, "Food Microbiology and Technology." The Avi. Publishing company, Inc. p. 201.

Wills, R. B. H and Widjanarko, S. B. 1995. Change in physiology, composition and sensory characteristics of Australian papaya during ripening, Australian Journal of Experiment, Agricultural. 35(8): 1173-1176.

Wills, R.B.H. 1990. Post harvest technology of banana and papaya in ASEAN. ASEAN-Food Journal. 5(2): 47-50.

APPENDICES

APPENDICES

APPENDIX-1

Table 1.1: Rating score for colour of oven dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	7	5	4	16
2	8	6	6	20
3	6	7	6	19
4	8	7	5	20
5	7	6	6	19
6	8	7	5	20
7	7	7	4	18
8	8	6	5	19
9	7	6	6	19
10	7	5	5	17
Total	73	62	52	187
Mean	7.3	6.2	5.2	

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

Table 1.2: ANOVA (Analysis of variance) for colour of oven dried papaya chips

Source of variance	Degree of freedom	Sum of squares	Mean squares	F value	
				Calculated	Tabulated (5% level)
Products	2	22.067	11.033	19.993	3.55
Judges	9	5.367	0.596	1.081	2.46
Error	18	9.933	0.552		
Total	29	37.367			

Table 1.3: Duncan's multiple range test (DMRT) value for colour of oven dried papaya chips

LSD value = 0.6981; $p<0.05$
S/X = 0.2349

Sample code	Original order of means	Sample code	Ranked order of means
S_1	7.3^a	S_1	7.3^a
S_2	6.2^b	S_2	6.2^b
S_3	5.2^c	S_3	5.2^c

APPENDIX-2

Table 2.1: Rating score for texture of oven dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	5	8	3	16
2	5	7	4	16
3	4	7	4	15
4	6	7	4	17
5	5	6	5	16
6	6	8	4	18
7	6	8	3	17
8	5	7	5	17
9	4	6	3	13
10	5	6	4	15
Total	51	70	39	160
Mean	5.1	7.0	3.9	

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

Table 2.2: ANOVA (Analysis of variance) for texture of oven dried papaya chips

Source of variance	Degree of freedom	Sum of squares	Mean squares	F value	
				Calculated	Tabulated (5% level)
Products	2	48.867	24.433	44.878	3.55
Judges	9	6.0	0.667	1.224	2.46
Error	18	9.8	0.544		
Total	29	64.667			

Table 2.3: Duncan's multiple range test (DMRT) value for texture of oven dried papaya chips

LSD value = 0.693; $p<0.05$
S/X = 0.2332

Sample code	Original order of means	Sample code	Ranked order of means
S_1	5.1^b	S_2	7.0^a
S_2	7.0^a	S_1	5.1^b
S_3	3.9^c	S_3	3.9^c

Table 3.3: Duncan's multiple range test (DMRT) value for flavor of oven dried papaya chips

LSD value = 0.8425; $p<0.05$
S/X = 0.2835

Sample code	Original order of means	Sample code	Ranked order of means
S_1	6.8^a	S_1	6.8^a
S_2	5.9^b	S_2	5.9^b
S_3	5.0^c	S_3	5.0^c

APPENDIX-4

Table 4.1: Rating score for overall acceptability of oven dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	7	5	5	17
2	7	6	4	17
3	6	6	3	15
4	7	5	3	15
5	7	4	4	15
6	6	5	5	16
7	5	6	4	15
8	6	5	3	14
9	7	6	3	16
10	7	4	4	15
Total	65	52	38	155
Mean	6.5	5.2	3.8	

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

Table 4.2: ANOVA (Analysis of variance) for overall acceptability of oven dried papaya chips

Source of variance	Degree of freedom	Sum of squares	Mean squares	F value	
				Calculated	Tabulated (5% level)
Products	2	36.467	18.233	25.508	3.55
Judges	9	2.833	0.315	0.44	2.46
Error	18	12.867	0.715		
Total	29	52.167			

Table 4.3: Duncan's multiple range test (DMRT) value for overall acceptability of oven dried papaya chips

LSD value = 0.7945; $p<0.05$
S/X = 0.2674

Sample code	Original order of means	Sample code	Ranked order of means
S_1	6.5^a	S_1	6.5^a
S_2	5.2^b	S_2	5.2^b
S_3	3.8^c	S_3	3.8^c

APPENDIX-5

Table 5.1: Rating score for colour of sun dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	8	6	4	18
2	8	7	6	21
3	8	7	5	20
4	7	6	4	17
5	6	5	5	16
6	7	5	6	18
7	7	6	5	18
8	6	5	4	15
9	8	5	4	17
10	6	7	4	17
Total	71	59	47	177
Mean	7.1	5.9	4.7	

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

Table 5.2: ANOVA (Analysis of variance) for colour of sun dried papaya chips

Source of variance	Degree of freedom	Sum of squares	Mean squares	F value	
				Calculated	Tabulated (5% level)
Products	2	28.8	14.4	24.608	3.55
Judges	9	9.367	1.041	0.143	2.46
Error	18	10.533	0.585		
Total	29	48.7			

Table 5.3: Duncan's multiple range test (DMRT) value for colour of sun dried papaya chips

LSD value = 0.7186; $p<0.05$
S/X = 0.2419

Sample code	Original order of means	Sample code	Ranked order of means
S_1	7.1^a	S_1	7.1^a
S_2	5.9^b	S_2	5.9^b
S_3	4.7^c	S_3	4.7^c

APPENDIX-6

Table 6.1: Rating score for texture of sun dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	5	8	5	18
2	6	8	4	18
3	7	6	4	17
4	5	7	5	17
5	7	6	5	18
6	5	6	3	14
7	6	6	4	16
8	5	7	5	17
9	7	8	4	19
10	5	8	3	16
Total	58	70	42	170
Mean	5.8	7.0	4.2	

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

Table 7.3: Duncan's multiple range test (DMRT) value for flavor of sun dried papaya chips

LSD value = 0.7075; $p<0.05$
S/X = 0.2381

Sample code	Original order of means	Sample code	Ranked order of means
S_1	7.4^a	S_1	7.4^a
S_2	5.7^b	S_2	5.7^b
S_3	5.0^b	S_3	5.0^b

APPENDIX-8

Table 8.1: Rating score for overall acceptability of sun dried papaya chips

Judge No.	Sample No.			Total
	S_1	S_2	S_3	
1	6	5	3	14
2	7	4	4	15
3	8	5	4	17
4	7	6	3	16
5	7	5	5	17
6	6	4	6	16
7	8	6	3	17
8	7	5	5	17
9	6	7	5	18
10	6	7	6	19
Total	68	54	44	166
Mean	6.8	5.4	4.4	

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

Table 8.2: ANOVA (Analysis of variance) for overall acceptability of sun dried papaya chips

Source of variance	Degree of freedom	Sum of squares	Mean squares	F value	
				Calculated	Tabulated (5% level)
Products	2	29.067	14.533	11.749	3.55
Judges	9	6.133	0.681	0.551	2.46
Error	18	22.267	1.237		
Total	29	57.467			

Table 8.3: Duncan's multiple range test (DMRT) value for overall acceptability of sun dried papaya chips

LSD value = 1.045; $p<0.05$
S/X = 0.3517

Sample code	Original order of means	Sample code	Ranked order of means
S_1	6.8^a	S_1	6.8^a
S_2	5.4^b	S_2	5.4^b
S_3	4.4^b	S_3	4.4^b

APPENDIX 9

TASTE TESTING OF FRIED CHIPS FROM GREEN PAPAYA
(Hedonic Rating Test)

Name of the Taster : ____________________ Date: ____________________

Please taste these samples and check how much you like or dislike each one on four sensory attributes such as Colour, Flavour, Texture and Overall Acceptability. Use the appropriate scale to show your attitude by checking at the point that best describes your feeling about the sample. Please give a reason for this attitude. Remember you are the only one who can tell what you like. An honest expression of your personal feeling will help us:

Hedonic Scale	Colour			Texture			Flavour			Overall acceptability		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Like Extremely												
Like very much												
Like moderately												
Like slightly												
Neither like nor dislike												
Dislike slightly												
Dislike moderately												
Dislike very much												
Dislike extremely												

Extra comments on each sample, if any-