

**DEVELOPMENT AND EVALUATION OF STRAWBERRY SQUASH
THESIS
SUBMITTED TO THE FACULTY OF POST-GRADUATE STUDIES
SHER-E-KASHMIR
UNIVERSITY OF AGRICULTURAL SCIENCES AND
TECHNOLOGY OF KASHMIR**

BY

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**DIVISION OF POST HARVEST TECHNOLOGY
IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE AWARD
OF
DEGREE OF MASTER OF SCIENCE IN AGRICULTURE
(POST HARVEST TECHNOLOGY)**

2003

REGISTRATION NO. 2000-A 606-M



Dedicated to

The loving and everlasting memories of my late daughter

(Anjum Saleem)

Words are not adequate to express my deepest heartfelt sense of gratitude and indebtedness to my esteemed teacher and guide Dr. Mohammad Ashraf Mir who helped me immensely with his valuable suggestion, continued encouragement, keen interest and healthy criticism, at every stage of this research programme without his considerate help the preparation of this thesis would have been rather difficult. It is a matter of proud privilege to be associated with such a dynamic, nobles disciplined and learned personality like Dr. M. A. Mir.

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CERTIFICATE-I

This is to certify that the thesis entitled “ Development and Evaluation of Strawberry Squash” submitted in partial fulfillment of the requirements for the degree of **Master Of Science** in Agriculture (Post Harvest Technology), to the Faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir is a record of bona fide research carried out by Mohammad Saleem Rather (Registration No. 2000-A-606-M) under my supervision and guidance and no part of the thesis has been submitted for any other degree or diploma.

It is further certified that such help or assistance received during the course of investigation have duly acknowledged.

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CERTIFICATE –II

We, the member of the advisory committee of Mr. Mohammad Saleem rather a candidate for the degree of **Master of Science** in Agriculture Post Harvest Technology) have gone through the manuscript of the thesis entitled “Development and evaluation of Strawberry Squash” and commended that it may be submitted by the student in partial fulfillment of the requirement for the degree.

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This is to certify that thesis entitled “ **Development and Evaluation of Strawberry Squash**” submitted by **Mr. Mohammad Saleem Rather (Registration No. 2000-A-606-M)** to the Faculty of Post-Graduate Studies Sher-e-Kashmir University of Agricultural Sciences and Technology, Kashmir in partial fulfillment of the requirements for the degree of **Master of Science** in Agriculture (Post Harvest Technology) was examined and approved by the Advisory committee and external, examiner on 17-07-2004.

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ACKNOWLEDGEMENTS

Interest, exorbitant help during the course of investigation and review of this manuscript.

I am highly obliged and thankful to Dr. G. M. Beigh, Professor and Head, Division of Post Harvest Technology, for his valuable suggestions, kind help, encouragement, sincere cooperation and affection throughout my research programme.

It gives me immense pleasure and honour to express my feelings of indebtedness and gratitude to Dr. M. Y. Ghani, Associate Prof., Division of Post Harvest Technology a man of humane character, diverse expertise and possessing an inherent knack of performing anything pertaining to academic or research work for his valuable guidance, enduring encouragement and thoughtful suggestions and review of this manuscript.

I also express my feelings of gratitude and sincere thanks to **Dr. Hafiza Ahsan**, Associate Professor and **Mr. Abdul Hamid Rather**, Assistant Professor Division of PHT for their help and valuable suggestions during my research programme.

I would like to thank my esteemed teachers Dr. Fayaz Ahmad banday Mr. Shazad Ahmad Mr. Abdul Hamid Lone and Mrs. Fozia Shafi for their help and encouragement they rendered to me during my research programme.

It is my pleasure to acknowledge and express my gratitude to my friends Mr. Fayaz Ahmad Qadri, Mr. Mehraj-u-din derzi, Mr. Mohammad Yousuf Dar, Mr. Manzoor Ahmad, Mr. Mukhtar Ahmad Chisti, Mr. A. A. Raina, Mr. Imtiyaz Dada, Mr. Mujtaba Makdoomi and Mr. Waseem Ahmad for their everlasting affection, help they rendered during my research programme.

I take this opportunity in expressing my gratitude to my colleagues and friends Mr. Mohammad Shafi Dar, Mr. Imtiyaz Ahmad, Mr. Waheed, Miss Abida and Mr. Peer Zada Rashid Ahmad for their help and cooperation during the course of investigations.

The help rendered by the staff members and the assistance provided by the laboratory staff of the Division of PHT and with a special mention of Mr. Abdul Hamid, Mr. Mohammad Iqbal, Mr. Fayaz Ahmad, Mr. Mohd Ramzan, Mir Ali Mohd and Mrs. Hajra is duly acknowledged.

The assistance provide by Mrs. jahan Ara Librarian Directorate of Horticulture Kashmir and the Staff members of the central Library SKUAST, Central Library Sanat Nagar (R.R.L) Srinagar and central library Kashmir University stands acknowledged.

I am highly thankful to Zahoor Ahmad Khan and Mukhtar Ahmad najar software and Hardware centre, Shalimar for composing the manuscript.

My heartiest devotion is due for my loving **parents**, whose blessing and good wishes will always guide me in right path in all walks of life. I am also thankful to my **Brothers, Sisters and relatives** whose blessing and wishes have always guided me in the right direction.

I am greatly indebted to my wife, her encouragement, support and timely understanding enable me to under take the investigations to its logical end.

My heartfelt devotion is due for my loving late daughter **Anjum Saleem** who rendered immense help me during my studies.

I am greatly thankful to my son **Shuja Saleem** for his patience, help and understanding he rendered during the course of my studies.

Appreciation is also extended to my well wishers for their encouragement during the course of the programme.

I am also grateful to Agriculture production Commissioner Government of Jammu & Kashmir and Directorate of Agriculture, Kashmir for sponsoring me to undertake post graduate Studies.

Last but not the least I again acknowledge my sincere thanks to my esteemed teacher and major Advisor whose able guidance, sustained encouragement, keen devotion and thought provoking suggestions will be remembered forever.

Place: Shalimar

Date: December

Mohammad Saleem Rather

ABSTRACT

SHER-E-KASHMIR

UNIVERSITY OF AGRICULTURAL SCIENCES AND TECHNOLOGY,

KASHMIR

SHALIMAR CAMPUS-191121, SRINAGAR

Title of the thesis : “Development and evaluation of strawberry squash”
Name of Student : Mohammad Saleem rather
Admission No. Regd. No. : 2000-A-606-M
Major Subject : Post harvest technology
Minor Subject : Pomology / Pathology
Major Advisor : Dr. Mohammad Ashraf Mir

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Date : 24-05-2003

ABSTRACT

Investigation were carried out in the Division Post Harvest Technology, SKUAST (K) during the year 2001-2002 on “ Development and Evaluation of Strawberry Squash”. The Strawberry fruits Cx. tioga after harvest were carried to the laboratory and analyzed for various physico-chemical quality attributes before product development studies. Strawberry pulp was prepared by hot break method and preserved with 1000 ppm sodium benzoate till use. The six formulations of squash were tried using three pulp concentrations viz, 25,30 and 35 percent with two TSS levels i.e 45 and 50 percent. The constant acidity of 1.5 percent (citric acid) was maintained in all formulations.

The squash samples after preparation were bottled in 250 ml capacity bottles, pasteurized at 85⁰ C for 30 minutes and were stored under ambient conditions for a period of 180 days. Periodical samples were evaluated at 0,120 and 180 days interval to monitor

physico-chemical and sensory quality changes. The TSS, reducing sugars, total sugars and acidity values showed gradual increase with storage time. The overall score for quality attributes by semi-trained panelists on 4.00 point scale adjudged the formulation of squash with (30 percent pulp, 50 percent TSS and acidity 1.5 percent) as significantly superior to other treatments. The product remained acceptable up to six months of storage and can be used as refreshing drink for summer by all the ages after dilution with water or milk. This type of product can be prepared by local entrepreneurs to meet the increasing demand of fruit based beverages by health conscious consumers of the society. The product diversification can ensure better returns to growers.



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INTRODUCTION

CHAPTER – I

INTRODUCTION

Horticulture plays a significant role in Indian agriculture. India is the second largest producer of fruits and vegetables in the world (Negi et al., 1999). Unfortunately average Indian does not get the basic daily requirement of fruits and vegetables which is mostly because of losses due to improper post harvest handling as a result there is a considerable gap between the gross production and net availability. Further more only a small fraction of fruits and vegetables are utilized for processing and export compared to other countries whose position is much below than India' s production level. It is a matter of great concern that in spite of being one of the world leaders in the production of horticultural crops, we are one of the tails Enders in the human development index. Therefore, to achieve our target of feeding the population as well as meeting the requirement of the processing industry and export trade, only increasing the production and productivity will not be enough, a lot more emphasis needs to be given to post harvest management of these highly perishable crops. It is evident that reduction in post harvest loss is essential to make available more foods from existing level of production. To achieve our target we shall have to adopt advanced technology in our postproduction system of horticulture produce.

Fruits are the major source of minerals, vitamins and dietary fiber. In addition, they contribute carbohydrates, proteins and some quantity of the fats to the human nutrition. Fruits are rich in calcium, phosphorous, iron and magnesium. They are good source of vitamin C, vitamin A and thiamine, riboflavin, niacin, pantothenic acid and folic acid (Kadam and Salunkhe, 1998). Strawberry fruit is known for refreshing quality and attractive appearance. It has very distinct pleasant aroma and delicate flavour, besides being rich in vitamin C. All these attributes make it an excellent table fruit; it can be successfully grown from beaches to the elevation of 1200 feet. It is specialized crop, which has wide adoption and can be grown in a wide range of soil and geographical regions. It is grown all over the world because of its quality attributes and popularity. The world production of strawberry was about 1.1 million tones in 1972, which increased to nearly 2 million tones in 1984 (Bose et al., 1991). The major world producers of strawberry include USA, Japan former USSR, Mexico, Spain and Italy.

In India strawberry is cultivated in Jammu & Kashmir, hilly areas of Himachal Pradesh (Nainital and Dehradun), Meerut, Muzaffar Nagar and Saharanpur, districts of Uttaranchal and Mahabaleshwar, Bangalore and Kalimpong and some districts of Punjab. Fruit production in general has made very rapid strides in post- independence era. Area under strawberry remained limited and scattered because of its perishable nature and non-exploitation of its vast germplasm resources. The varied agro climatic conditions of the state offer conditions for growing this high value and short duration crop over longer periods. The crop is

ready for harvesting in Srinagar during May and the crop from higher reaches is available during the month of July.

Although the investment per hectare for undertaking strawberry cultivation is high, the returns are equally attractive. There is no gestation period and flow of return is fast. More recently a number of strawberry cultivars have been introduced in the valley under Indo-Italian project, which has helped to expand the area under strawberry cultivation in the state.

Strawberry fruit is subjected to heavy spoilage during transportation and storage among all the perishable fruits. Strawberries are probably more sensitive to various maladies than any other fruit and, hence requires careful handling, sorting and storage before marketing.

The fruit surface is exposed to transportation and hence, more moisture loss occurs than apples and pears. The strawberry loses as much weight in two days as pears do in 60 days. Development in storage technology over the past decade had provided valuable contribution to scientific skill in making perishable products available over a longer period. Different methods have been reported to extend the shelf life of many fruits by maintaining firmness, minimizing the respiration rate, proteolysis, disease incidence, tissue breakdown and thus reducing the fruit loss.

There is lack of efficient post harvest management of strawberries in the valley owing to non-existence of pre-cooling and storage facilities, which leads to the rapid quality deterioration and sudden glut in the market reduces the producer's income. The post harvest loss can be reduced by converting strawberries into

various value added products by appropriate processing technologies, to ensure optimum returns to grower and offer employment opportunities in processing sector. In this context preparation of squash is one of the attempt. An experiment on processing of “Tioga” cultivar of strawberry for preparation of squash entitled “Development and Evaluation of Strawberry Squash” was conducted with the following objectives: -

1. To evaluate various formations for making acceptable strawberry squash.
2. to monitor quality changes during ambient storage of strawberry squash.

REVIEW
OF
LITERATURE

CHAPTER – II

REVIEW OF LITERATURE

2.1 Post harvest Physiology of Strawberries

The fleshy “fruit” of the strawberry is an enlarged receptacle with numerous achenes (the true fruit, commonly called “seeds”) embedded on the surface, and is classified as an aggregate accessory fruit (Green, 1971). The large cells and thin cell walls in strawberry fruits contribute to their high level of susceptibility to physical injuries (abrasions, cuts, bruising and juice leakage). Softening of the fruits as they ripe involves thinning of cell walls and liquification of cell content (Sczesnaik and Smith, 1969). Water vapour and respiratory gases (oxygen, carbon dioxide) can diffuse easily through strawberries due to the presence stomata and the open nature of the calyx and stem area.

Strawberries are non-climatic fruits that must be picked at or near the fully ripe stage to obtain the best eating quality. They do not ripen off the plant. Their respiration rate is high (about 15 mg/kg/hr at 0°C) and increases 4 to 5 fold when temperature is elevated to 10°C; between 10°C and 20°C the increase is 2 to 3 fold. Respiration rate is enhanced when the berries are mechanically injured (Rosen and Kader, 1989). It can be reduced by keeping the strawberries in low O₂ and or high CO₂ atmospheres. (Woodward and Topping, 1972; *El-Kazzaz et al.*, 1983; Li and Kader, 1989);

Strawberries produce very low (< 0.1 ul/kg/hr) levels of ethylene. They do not respond to ethylene by a stimulation of any their ripening processes (Mason and Jarvis, 1970). Siriphanich (1980) found that no advantages would be derived from the removal of C_2H_2 from around strawberries during post harvest handling because strawberry quality was not influenced by exposure to exogenous C_2H_4 at 1, 10 or 100 ppm at either 2.2 or 5°C for upto 14 days. However, El-Kazzaz *et al.*(1983) observed a dramatic increase in the disease development on inoculated fruits in the presence of 20ppm C_2H_4 , which suggests that there are some benefits in removing C_2H_4 from around strawberries. The decline in the concentration of auxin in the achenes as strawberry fruits mature modulated the rate of fruit ripening. Ethylene does not play an essential role in the regulation of ripening in strawberries and auxin may be the hormone controlling ripening.

Gray mold rot (caused by *Botrytis cinerea*) is the most serious disease of strawberry fruits (Ceponis and Butterfield. 1973; Wright and Billeter, 1975; Ceponis *et al.*, 1987). Other post harvest diseases of strawberries include Rhizopus rot (caused by *Rhizopus* spp.) and leather rot (caused by *Phytophthora cactorum*)

Sommer (1985) recommended the following procedures for post harvest disease control in strawberries: (1) avoid packing infected fruits, (2) avoid injuries to the fruits during harvesting and handling, (3) promptly cool the fruits to near 0°C, (4) keep transport and marketing time to a minimum, and (5) use CO_2 – enriched air.

Fruit rots, fruit shrivel ness and bruising were identified by Mitchell (1985) as the main problems in post harvest handling of strawberries include harvesting at optimum maturity, sorting to eliminate unmarketable fruits at harvest, minimizing physical injuries during harvesting and post harvest handling, and quickly cooling the berries to near 0°C (Mitchell, 1985).

2.2 Harvest Maturity and Quality

Strawberry quality components include appearance (color, size, shape, freedom from defects and decay), firmness, flavour and nutritional value. Color, firmness, flavour, nutritive value and compositional changes during post harvest handling. There are large genotypic variations in strawberry composition. Thus it is possible to develop new cultivars, which have good eating quality and maintain their firmness when fully ripe so they can withstand the post harvest handling system.

Maturity is determined in the U.S Standards for grades on the basis of fruit color, (Greater than $\frac{1}{2}$ or $\frac{3}{4}$ of surface showing red or pink color depending on grade). In California a minimum of $\frac{2}{3}$ of the fruit surface showing red or pink color is required. As strawberry fruit ripens, an increase in anthocyanin content is changes with ripening include increase in soluble solids, total sugars, total ascorbic acid, pH, water-soluble pectins and decrease in acidity, total phenols, protopectin, cellulose and activities of polyphenol oxidase and peroxidase (Spayd and Morris, 1981).

Appearance defects of strawberries may originate in the field (defects such as bird and insect damage, sunscald, irregular ripening and excessive softening), at

harvest (defects such as cap removal and physical injuries). Minor blemishes that would not detract from eating quality are acceptable, but more serious defects can influence appearance, firmness, water loss and susceptibility to decay. The presence of decay renders strawberries unmarketable.

Most consumers prefer firm strawberries which don not lose to much juice when sliced. Firmness affects the strawberries susceptibility to physical damage in firmness. Huber (1984) concluded that both polyuronides and hemicelluloses may be important in influencing the texture of strawberry fruits.

Strawberry flavour involves perception of the tastes and aromas of many chemical constituents. High sugars and relatively high acids are required for good flavour. High acids and low sugars produce a tart strawberry, while high sugars and low acids result in a bland taste. When both sugars and acids are low, the result is a tasteless strawberry. Volatile compounds are essential not only to the aroma but also to the overall flavour of strawberry. No single volatile compounds or group of compounds has been identified as responsible for the aroma of fresh strawberry.

2.3 Physico- Chemical Composition

Many preharvest and post harvest factors influence the composition and quality of strawberry. These include genetic and environmental factors such as climatic conditions (Temperature, relative humidity, light intensity) and cultural practices (Soil type, nutrient and water supply, use of pesticides). Maturity stage at harvest and postharvest handling procedures also affect strawberry quality and its maintenance. Sunny days and cool nights produce better-flavoured

strawberry than cloudy, humid days and warm nights (Sistrunk and Morris, 1985). Inadequate light intensity reduces ascorbic acid, pH, colour and soluble solids. Excessive levels of nitrogen applied to plants decrease firmness, total soluble solids and flavour of strawberry (Sistrunk and Morris, 1985).

2.3. 1 Berry weight

Large amount of variation in fruit weight have been noted among strawberry cultivars and natural population of different *Fragaria species*. Sharma et al, (1981) studied yield performance of nine strawberry cultivars viz. Blakemore, Catskill, Elista, Fairfax, Robinson, Senga sengana, Shasta, Tioga and Torrey under Himachal (Palampur) conditions. The average fruit weight varied from 3.54 – 6.96 g. Maximum fruit weight 6.96g was recorded in Tioga and minimum fruit weight 3.54g was observed in variety Fairfax.

Beniwal *et. al.*(1989) evaluated performance of ten strawberry cultivars i,e (Blakemore, Catskill, Elista, Fairfax. Florda-90 Howard – 17, Robinson, Shasta. Tioga and Torrey under subtropical conditions of Haryana. The berry weight varied from a minimum of 3.65g (Blakemore) to a maximum of 7.25g in Shasta variety of strawberry.

Banday (1992) evaluated seven cultivars of strawberry viz, Senga sengana, Kashmiri local, Cavalier, Kashmiri wild, Robinson, Shasta and Howard under local conditions of Kashmir. The berry weight was maximum 9.13g in Senga sengana and minimum 1.1g in Kashmiri wild.

Kaul (1996) evaluated five varieties of strawberry viz, Chandler, Gorella, Fern, Addie, Athena under agro- climatic conditions of Jammu region. The fruit weight varied from 9.63g in Gorella to a maximum of 16.04g in Chandler.

Hafiza (1999) evaluated the performance of seven strawberry cultivars viz, Confitura, Chandler, Gorella, Douglas, Brighton, Tioga and Senga sengana under Kashmir conditions. The fruit weight was observed to be maximum 18.55g in confitura and minimum 10.6g in Tioga.

2.3.2 Fruit Size

Strawberry genotypes shows a wide ranges in fruit size (Moore *et al.*, 1970; Cheng and Breen, 1992). Fruit size in strawberry depends on an interaction between blossom position, number of development achenes, fruit competition and plant vigour. Flower position has determinative influence. The decrease in flower size “down” the inflorescence is probably related to a decrease in cell number of receptable tissue and decrease in auxin contributed or stimulated by the developing achenes.

Beniwal *et al.*, (1989) reported fruit length of 2.85 – 3.77 cm and fruit breadth of 1.77 – 2.35 cm in screening test of ten strawberry varieties. The maximum length 3.77 cm was reported in Shasta and maximum breadth 2.35 cm was observed in Tioga.

Banday (1992) observed minimum fruit length 1.70 cm in Kashmiri wild and maximum length 3.42 cm in Senga Sengana, where as the diameter varied from 1.10 cm in Kashmiri wild to 2.80 cm in Senga Sengana. Koul (1996) observed

maximum fruit length of 3.97 cm in Chandler and 2.90 cm in Gorella. Hafiza (1999) recorded minimum fruit length 3.23 cm in Tioga and maximum 4.31 cm in Gorella, where as maximum diameter 3.10 cm was observed in Confitura and minimum 2.4 cm in Tioga.

2.3.3 Moisture

Strawberry is a soft fruit in which moisture is the major component of fruit weight. The moisture content in strawberry varies from 87.8 to 89.9 per cent (Watt and Merrill. 1959 Gopalan *et al* and Salunkhe *et al.*, 1991).

2.3.4 Total Soluble solids

The total soluble content of strawberry varies with variety, season and stage of development and environmental conditions. Kader (1991) reported total solid content of 7.0 – 12.7 per cent in strawberry cultivars, based on data collected by various workers.

Sharma *et at.*, (1981) recorded minimum TSS of 6.76 per cent in Catskill and maximum 7.47 per cent in Fairfax. Bandy (1992) reported minimum TSS of 4.20 per cent in Kashmiri wild and maximum TSS 9.70 per cent in Douglas and maximum 7.8 per cent in Confitura.

2.3.5 Sugars

The sugars constitute a major portion of solids in the strawberries. Reducing sugars form a major portion of total sugars

Kader (1991) reported that strawberries contain 4.1 – 6.6 per cent total sugars and the reducing sugar content varied from 3.7 – 5.2 per cent. Among the

reducing sugars fructose is dominant 1.7 – 3.5 per cent, followed by glucose 1.4 – 3.1 per cent, and the non-reducing sugar sucrose varies from 0.2 – 2.5 per cent.

Beniwal et al (1989) reported total sugar content to vary from 3.98 – 8.79 per cent, reducing sugars 3.44 – 7.85 per cent and non-reducing sugars 0.37 – 0.94 per cent. Maximum total sugars 8.79 per cent were observed in Florida – 90 variety with 7.85 per cent reducing sugars and 0.94 per cent non-reducing sugars

Banday (1992) observed minimum total and reducing sugar 2.70 and 1.90 per cent respectively in Kashmiri wild variety of strawberry, while as maximum total sugars 9.30 per cent and 5.0 per cent reducing sugars were recorded in Howard variety of strawberry. Koul (1996) recorded minimum total sugar 2.38 per cent and reducing sugar 1.78 per cent in Gorella and maximum total sugar 4.23 per cent and 3.25 per cent reducing sugar in Athena. Hafiza (1999) recorded maximum sugar 6.50 per cent in Confitura and minimum total sugars 5.33 per cent in Douglas.

2.3.6 Titratable Acidity

The Titratable acidity in strawberries varies from 0.50 – 1.87 per cent with pH of 3.18 – 4.10. Citric acid is the major acid followed by malic acid. The citric acid content of strawberries varied from 0.42 – 1.24 per cent, where as malic acid is present to the extent of 0.09 – 0.68 per cent (Kader, 1991).

Sharma *et al* (1981) reported minimum acidity of 0.85 per cent in Tioga and maximum 1.41 per cent in Robinson variety of strawberry. Beniwal *at al.* (1989)

reported minimum acidity of 0.96 per cent in Tioga and maximum 1.69 per cent in Elista. Banday (1992) reported minimum acidity 1.0 per cent in Senga sengana, Kashmiri local, Cavalier and Shasta and maximum acidity of 2.1 per cent in Kashmiri wild. Koul (1996) observed minimum acidity of 0.64 per cent in Fern variety of strawberry and maximum 0.92 per cent in Gorella variety. Hafiza (1999) observed minimum of 0.92 per cent in Senga sengana and 0.92 per cent in Brighton.

2.3.7 Anthocyanin

Anthocyanin is major pigment of strawberries. Among the anthocyanins strawberries contain mainly 3 – glucosides of cyanidin and pelargonidin. Processing such as freezing and cooking affect the content of anthocyanins significantly. Kader (1991) reported anthocyanin content of 55 – 145 (mg per cent) in strawberry fruits. Hafiza (1999) reported that anthocyanin content varies with the season and variety. Maximum anthocyanin content 19.15 (mg per cent) was recorded in Chandler and minimum 10.70 (mg per cent) in Gorella under Kashmiri conditions.

2.3.8 Vitamins

Green (1971) reported that strawberries contain carotene (0.15 mg per cent); thiamine (0.03 mg per cent), riboflavin (0.27 mg per cent), nicotinic acid (0.6 mg per cent) and ascorbic acid (89 mg per cent)

Kader (1991) reported that ascorbic acid content of strawberries varied from 26 – 120 mg / 100 g. Beniwal et al (1989) observed maximum ascorbic acid

(93.0 mg per cent) in Florida – 90 and minimum (49.53 mg per cent) in Tioga variety of strawberry.

Banday (1992) recorded maximum ascorbic acid 52 (mg per cent) in Kashmiri wild. Koul (1996) recorded minimum ascorbic acid 47.16 (mg per cent) in Gorella and maximum 68.0 (mg per cent) in Senga sengana and maximum 71.55 (mg per cent) in confitura variety over a two year evaluation period under Kashmiri conditions.

2.3.9 Minerals

The mineral content of the strawberries has been reported to be 0.5 per cent and the berries contain (mg per cent) potassium (161), phosphorous (23), calcium (22), sodium (1.5) and magnesium (11.7), (Green, 1971)

2.3.10 Phenols

Ellagic acid is naturally occurring phenol present in strawberries, which has shown to be effective as an antimutagen, anticarcinogen and potential inhibitor of chemically induced cancer. The highest concentration of ellagic acid is found in leaves (14.7 mg per cent) and in fruit it is 7.2 and 8.5 mg per cent respectively in green and red achenes. However its concentration in fruit pulp is 3.4 and 1.6 mg per cent respectively for green and red fruit pulp. Maas *et. al.*(1991).

2.3.11 Flavouring Compounds

The flavour of strawberry is attributed to the presence of volatile esters which varies among cultivars. The concentration of the most important aroma compounds, ethyl hexanoate, ethyl butanoate, trans – 2 – hexenal, 2,5 – dimethyl – methoxy – 3 (2H) furanone and linalool were found higher in cvs. Senga sengana, Kristina and hybrid Lihamax Senga sengana. Dirinck *et al* (1981) reported methylthiol esters, methylthiol acetate and methylthiolbutyrate in strawberries.

2.3.12 Juice Content

Beniwal *et. al.*(1989) observed a variation of juice content in strawberries from 71.77 to 88.23 per cent. Maximum juice yield (88.23 per cent) was recorded in Tioga and minimum juice yield 71.77 per cent was recorded in Blackmore. Koul (1996) observed maximum juice content 79.60 per cent in Addie and minimum 49.25 per cent in Chandler. Hafiza (1999) observed maximum juice yield 54.60 per cent in confitura and minimum 45.50 per cent in Senga sengana.

2.4 Fruit Squash

Fruit squash is concentrated fruit beverage which is diluted before use as per F.P.O specifications (1995). Fruit squash should contain minimum 25 per cent fruit pulp and 40 per cent total soluble solids. Various workers have standardized techniques for preparation of fruit squash from fruits available in India and a brief description is as under: -

Sethi (1993) prepared squash from litchi fruits. The fully ripe and sound fruits were hand peeled and deseeded. The edible portion was blended and stewed.

The strained pulp was heated to 85°C and cooled, then preserved with 500 ppm sulphur dioxide and stored at 4 – 5 ° C till use.

The pulp was converted into squash with 33.33 per cent juice with 45° Brix TSS and 1 per cent acidity. Addition of rose essence @ 0.02 per cent enhanced the flavour of lithehi squash. The squash was fortified with 100 mg per cent of ascorbic acid to make it nutritious and to check browning during storage. The squash was preserved with 500 ppm of sulphur dioxide filled into clean glass bottles and stored at 25-35 °C or at low temperature of 4-5 °C for a period 6 months. The squash was found to be acceptable organoleptically for 4 months at room temperature (25-35 °C) and upto 6 months at low temperature (4-5 °C). addition of ascorbic acid (50-100 mg/ 100 ml squash) showed less browning during storage at low temperature whereas it accelerated browning at room temperature.

Mandhyan *et. al.*(2000) standardized a technique for preparation of guava squash under laboratory conditions, using different proportion of guava pulp and water with boiling. Guava fruits of uniform maturity level were washed thoroughly and peeled with the help of hand peeler. These were sliced into small pieces of two Guava were boiled with different quantities of water in the proportions of 1:2, 1:3 and 1:4 by weight (guava slices: water) of guava slice samples and time of boiling i.e. 200g and two hours, were respectively kept constant in an open pan as well as in pressure cooker. The mixture obtained after boiling the sample at different times was mashed in a grinder and filtered through muslin cloth. At this stage the TSS was measured and the extract so obtained was allowed to concentrate at 60 °C on a

hot water bath till it reached to level of 18⁰ Bx. At this stage sugar was added at the rate of 2g/ 25 ml. Sensory evaluation studies indicated the best organoleptic properties in sample having 1:4 (pulp: water ration) and boiled for one hour in pressure cooker followed by the same sample, but boiled for two hours.

Prassad and Mali (2000) Prepared squash from pomegranate fruits of Jalore seedless variety. The pomegranate were cut into pieces and arils separated. The arils were passed through the juicer for extraction of the juice. The juice was kept for 3-4 hours to settle down the coarse particles the supernatant solution was siphoned off, leaving the coarse particles. The squash was prepared having 32 percent juices with 4⁰ Bx and 0.58 per cent acidity. No synthetic colour and essence was added to squash it was preserved with 0.08 per cent sodium benzoate.

Roy and Singh (1979) Optimized the technique for preparation of Bael fruit squash using pulp concentration of 40,45 and 50 percent. The final TSS in the product was maintained at 50 percent with acidity of 1.00 and 1.5 percent. Formulation of squash with 50 percent pulp, 50⁰ Bx and 1.00 percent acidity was found ideal by the consumer panel.

Thakur and Barwal (1998) utilized unmarketable Kiwi fruits of Allison and Bruno cultivars for squash preparation. The ripened fruits were pulped by hot extraction method and squashes of 40 and 45⁰ Bx were prepared using 25 and 35 percent pulp concentration. The products were stored under ambient conditions up to 150 days of storage. It was found that squash of 45⁰ Bx with 25 and 30 percent

pulp of the cv. Allison had highest taste, flavour and acceptability scores during storage period.

Pruthi and La (1958) prepared passion fruit squash with 45^o, 1.00 percent acidity containing 25 percent juice and preserved with 175 ppm sulphur dioxide and 500 ppm sodium benzoate. The squash was also fortified with the 50, 100, 150 mg percent of ascorbic acid. Storage temperature was the most important factor governing retention of ascorbic acid. The squash irrespective of level of fortification had normal life of about a year at ordinary temperatures.

Sogi and Singh (2001) prepared squash from Kinnow fruit. The fruits were peeled manually and juice was obtained using screw press. The squash possessed TSS of 41.8^o Bx and acidity of 1.49 per cent initially, which was stored for 120 days at ambient temperature (16 – 20^oC) as well as at elevated temperatures (38^oC).

Kumar and Manimegalai (2000) prepared strawberry squash from Sujata and Labella varieties. The strawberry pulp was extracted using pulper. The sugar syrup was prepared by adding 172 g of sugar with 1020 ml of water and citric acid 37.8 g. The sugar syrup after preparation was filtered and allowed to cool. Then the extracted fruit pulp was added to syrup and mixed well. The squash prepared was packed in sterilized bottles of 600 ml capacity and capped airtight. The squash possessed TSS of 45^o Bx, acidity 1.2 per cent, pH 2.56, reducing sugars 1.85 per cent, total sugars 35.44 per cent and vit. C 15.00 mg percent. The squash samples were evaluated by a panel of semi – trained judges on 4 – point hedonic scale and were possession overall acceptability score pf 3.6 and consumer index of 0.364.

Kumar and Manimegalai (2003) reported storage quality changes in squash samples prepared from Sujata and Labella stored at room temperature conditions in colourless bottles. There was an increase in acidity and reducing sugars where as a decreasing trend in pH, total sugars, ascorbic acid and anthocyanin content. The TSS did not change during storage. The sensory quality attributes were found to be highly acceptable after storing the product for 180 or more.

Sharma et al. (2002) tried different combinations of fruit pulp and spice recipe at two levels (40 and 45⁰ Brix) of TSS for the standardization of spiced plum squash. A combination of 30 percent fruit pulp with spice recipe (0.1 percent cardamom., 0.25 percent cumin, 0.4 percent black pepper, 0.5 percent common salt, 1.0 percent black salt, 1.5 percent ginger extract and 1.0 percent min extract) at 40⁰ Brix TSS was found best by a panel of semi trained judges. The developed squash was analysed for various physico chemical and sensory characteristics during a period of 180 days storage. There was an increase of TSS, and decrease in acidity, total sugars and ascorbic acid of squash samples. Also the squash samples possessed over all acceptability score of 7.30 on 9- point hedonic scale and it was still acceptable after 180 days of storage with over all acceptability score of 7.05.

Barwal et al. (2002) developed the method for development of dietetic apricot squash using non-nutritive sweeteners viz; cyclamate and saccharine for health conscious population. Apricot fruits of new castle cultivar were pulped by hot break method and sweetness proportion (Sucrose equivalent) of 25, 50, 75 and 100 percent along with sugar were used to prepare squash. The TSS, reducing and

total sugar contents decreased significantly as the share of non-nutritive sweeteners increased. Cyclamate sweetened squashes net 25 and 50 percent sweetness proportion had higher taste score in comparison to saccharin. The overall acceptability mean score of dietetic squash sweetened with cyclamate at 25 percent was higher and statistically at par with standard indicating that cyclamate can be an appropriate sweetener for the preparation of dietetic apricot squash. The calories reduction could be achieved upto 25 percent per serving, without compromising quality.

Barwal et. Al. (2002) prepared seasoned plum squash by using sorbitol for the benefit of diabetics, obese and health conscious people. The preserved plum pulp of Santa Rosa was heated to $97 \pm 0.50^{\circ}$ C for 10 minutes. Sugar 400g, black pepper 4g, cardamom 1g, cumin 2.5g, common salt 5g, black salt 10g, ginger extract 15 l and mint extract 10 ml were used for preparation of one litre of standard seasoned squash from 300 ml of pulp. Low calorie seasoned squashes were prepared by replacing 25,50, 75 and 100 percent sucrose by sorbitol sugar content of the product which decreased with the increased percent share of sorbitol sweetness. Moreover, with the increased in the proportion of sorbitol sweetness, the organoleptic score for colour, body and flavour increased, standard (100 per cent sucrose sweetened) had higher overall acceptability, which remained non-significant with T₅ (100 percent sorbitol sweetened). The mean value for overall acceptability during storage period were found to be similar to starting product.

Saikia and Saikia (2002) tested three methods for preparation of squash from ripe OU-tenga (*dillenia indica*) fruit at its optimum maturity stage by using fruit pulp, water, sugar, citric acid. The squash samples stored for 60 days at room temperature 30-34⁰ C, R.H 81 percent exhibited significant effects of storage on pH, TSS titratable acidity and sugars. The study also indicated significant effect of storage on organoleptic parameters of colour, taste and appearance.

MATERIALS

AND

METHODS

CHAPTER – III

MATERIALS AND METHODS

The present investigations entitled “Developed and evaluation of strawberry squash” were carried out in Division of Post Harvest technology Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir Shalimar, Srinagar during the year 2001-2002.

3.1. Raw Material

Strawberry fruits of cultivar “Tioga” were procured from local strawberry grower from an orchard located at (Theed) Srinagar in farm fresh condition. The fruits were packed in card board boxes (2 kg capacity) and carried to the laboratory on the same day of harvest.

3.1.1 Preparation of fruit pulp

The fruits were washed with running tap water to remove any adhered dirt and dust particles. The calyx was removed manually. Fully ripened fruits were selected for the pulp preparation. The fruits were pulped by hot break method. The pulp was obtained by heating the fruit to 85⁰ C for 15 min, with occasional stirring.

The pulp obtained was preserved with 1000-ppm sodium benzoate and bottled in presterilized glass bottles still use.

3.1.2. Product Development

Six formulations of squash with varying pulp, total soluble solids and acid levels were prepared as given below.

Formulations	Pulp (%)	TSS (%)	Acidity (% Citric acid)
T ¹	25	45	1.5
T ²	30	45	1.5
T ³	35	45	1.5
T ⁴	25	50	1.5
T ⁵	30	50	1.5
T ⁶	35	50	1.5

The squash samples prepared were filled in 250 ml bottles, with a head space of 25 mm and pasteurized at 85 C for 20-25 min. the bottles after cooling were stored under ambient conditions and evaluated at periodical intervals of 0,60, 120 and 180 days for monitoring changes in quality parameters.

3.2. Physical Observations

3.2.1 fruit Length and diameter (cm)

Fruit length and diameter were recorded on representative samples of 20 fruits in triplicate using digital verier caliper.

3.2.2. Fruit Weight (g)

A representative of (20) fruits triplicate were weighed on electric balance and average fruit weight calculated.

3.3 Analytical Methods

3.3.1 Total Soluble solids (%)

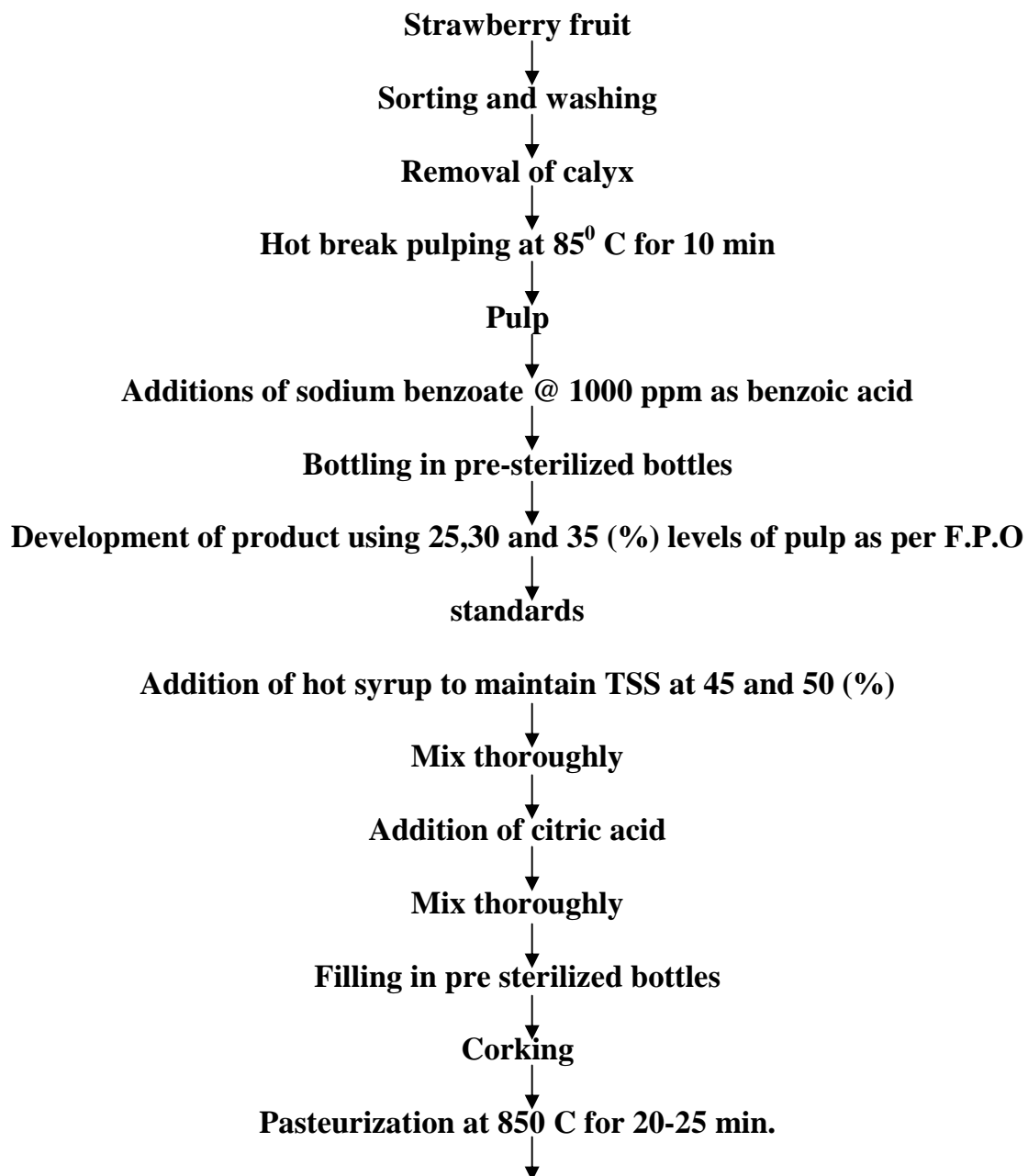
Two hand refractometers of range (0-32⁰ Brix) “Erma” make Japan and (28-62⁰ Brix) “Sipcon” India was used to determine total soluble solids in fresh fruit samples as well as squash samples. The values were corrected at 20⁰ C (Ranganna, 1986).

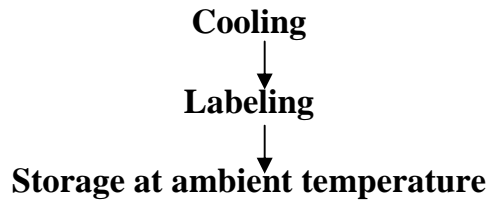
3.3.2. pH

The squash samples were taken in 100 ml capacity beakers and the pH recorded by using digital pH meter model “Tanco DB-1011”, using appropriate buffer solution for calibration purposes.

3.3.3 Titratable acidity 9%)

Titrateable acidity was determined by titration method. A known weight (10 g) of prepared sample was taken and diluted by distilled water to 100 ml. An aliquot





FLOW SHEET FOR STRAWBERRY SQUASH PRODUCTION

910 ml) of this diluted solution was taken and titrated against standard 0.1 N NaOH using phenolphthalein as indicator and acidity was calculated using equation 1 (Rangana, 1986).

$$\text{Normality of NaOH} \times \text{Volume of NaOH}$$

$$\text{Titrateable acidity (\%)} \text{ as } = \frac{\text{used} \times \text{volume made} \times 64}{\text{Wt. Of sample taken} \times \text{Aliquot taken for Titration} \times 1000} \times 100 \text{ Eq. (1)}$$

3.3.3 Reducing sugars

The reducing and total sugars were determined according to the method described by Lane and Eynon (1923). Ten gram samples plus 100 ml distilled water was boiled for half an hour. The samples were neutralized with 1 N NaOH; 2ml of lead acetate was added and subsequently after waiting for 10 minutes, it was freed from lead by the addition of 2ml of Potassium oxalate. The volume was made up to 250 ml with distilled water and filtered. The filtrate was designated as (A). 5 ml each of Fehling's solution A and B plus 10 ml of distilled water were heated on burner and titrated against sugar solution (A) using methylene blue as an indicator and the percentage of reducing sugars was calculated using equation 2.

$$0.05 \times \text{Vol. Made}$$

$$\text{Reducing sugars (\%)} = \frac{\text{Titre value}}{\text{Titre value} \times \text{weight of sample}} \times 100 \text{ Eq. (2)}$$

3.4.4 Total sugars

A known quantity of solution (A) 50 ml plus of distilled water plus 5g of citric acid was boiled for 30 minutes. After cooling, the solution was neutralized with 1 N NaOH. The volume was made up to 250 ml of distilled water. Again 5 ml of each Fehling' s A and B plus 10 ml of distilled water were taken in titration flask and heated on burner and titrated against prepared sugar solution using methylene blue as an indicator and percentage of total sugars was calculated using equation 3,

$$\text{Total sugars (\%)} = \frac{0.05 \times \text{volume made}}{\text{Titre value} \times \text{vol. Of sample to be Calculated in 50 ml of sol.}} \times 100 \text{ Eq. (3)}$$

3.3.5 Anthocyanin

ten gram of sample was blended with 70 ml of ethanolic hydrochloride acid, transferred to 100 ml volumetric flask and make up to volume. The extracted samples were up to volume. The extracted samples were stored overnight in a refrigerator at 4⁰C filtered through Whatman No. 1 filter paper and optical density of the filtrate recorded at 535 mm. The anthocyanin content was calculated as per Eq. 4 & 5.

$$\text{Total O.D/ 100g} = \frac{\text{O.D} \times \text{Vol, made up}}{\text{Weight of sample}} \times 100 \text{ Eq (4)}$$

$$\text{Total anthocyanin (mg/ 100g)} = \frac{\text{Total OD / 100g}}{98.2} \text{ Eq. (5)}$$

3.5. Sensory Evaluation

Sensory Evaluation sensory quality attributes such as colour, flavour and overall acceptability of squash were evaluated by semi-trained panel of (15) members drawn from faculty members of various divisions of SKUAST (K), Shalimar. The panelists were provided with coded samples of the strawberry squash and were requested to assign scores on the basis of colour, flavour and overall acceptability using 4 point numerical scale as under: -

Excellent = 4

Good = 3

Fair = 2

Poor = 1

3.7 Statistical Analysis

The data was statistically analyzed by using CPCSII package programme developed by Dr. h.S Cheema Department of statistics Punjab Agriculture University, Ludhiana, using completely Randomised Design (CRD) Factorial Experiment.

EXPERIMENTAL

RESULTS

CHAPTER – IV

EXPERIMENTAL RESULTS

The present investigations were carried out to optimize the processing parameters for preparation of strawberry squash and to study the effect of storage on the squash quality. Fresh strawberry fruits of Tioga were converted into pulp by hot break method and pulp at various concentrations viz; 25,30 and 35 (%) level was used to produce squash with 45⁰ and 500 Brix. Keeping acidity of 1.5 percent constant in all six formulations. Physico-chemical and sensory evaluation of the product was carried out under ambient temperature (15-35 ⁰ C, RH 60-80 percent) at 60 days of interval during 180 days of storage. The quality parameters evaluated at various sampling periods comprised of TSS (mg %), acidity (percent), reducing sugars (percent), total sugars (percent), anthocyanin (mg %) and sensory evaluation of product on the basis of colour, flavour and overall acceptability. The salient features of various parameters are given as under: -

4.1 Physico- Chemical parameters of fresh strawberry fruits cv. Tioga.

Table (1) reveals the Physico-chemical characters of fresh strawberry fruits. The fruits possessed an average fruit weight of 13.95g (with calyx) and 13.0g (without calyx). The fruits were characterized with L/D ratio of 1.064 having average fruit length of 3.45 cm and average fruit breadth of 3.24 cm. the pH of the fruit was 4.06 with an acidity of 0.55 percent as citric acid. The fruit possessed the TSS of 7.66 percent having 6.00 percent total sugars and 3.72 percent reducing sugars. The anthocyanin content 9.36 mg percent was recorded in fresh fruits.

4.2 Physico-chemical components of strawberry pulp.

The Physico-chemical composition of strawberry pulp cultivar Tioga prepared by hot break method is indicated in table (2). The pulp yield was 71.43 percent.

Table 1: - Physico-chemical Characteristics of Fresh Strawberry Fruit Cv. Tioga

S. No.	Parameters	Values
1.	Average fresh fruit weight with calyx (g.)	13.95
2.	Average fresh fruit weight without calyx (g.)	13.00
3.	Average fruit length (cm)	3.45
4.	Average fruit breadth (cm)	3.24
5.	L/D ratio	1.064
6.	Titrateable acidity (Citric acid %)	0.55
7.	pH	4.06
8.	Total soluble solids (TSS %)	7.66
9.	Total sugars (%)	6.00

10.	Reducing sugars (%)	3.72
11.	Anthocyanin	9.36

Table 2: - Physico – Chemical composition of strawberry pulp cv. (Tioga)

S. No.	Parameters	Values
1.	Total soluble solids (TSS %)	8.00
2.	pH	6.20
3.	Titrateable acidity (citric acid %)	0.70
4.	Total sugars (%)	6.20
5.	Reducing sugars (%)	3.77
6.	Anthocyanin (mg %)	16.96
7.	Pulp yield on fresh fruit basis (%)	71.43

The pulp was viscous with anthocyanin content of 16.96 mg percent having reddish colour. The pulp contained TSS of 8.0 percent total sugar 6.20 percent and reducing sugar 3.77 percent. The pulp had a pH of 3.60 with an acidity of 0.70 percent as citric acid.

4.3 Chemical quality changes during storage

4.3.1 Total Soluble solids

Effect of various formulations on TSS of squash during storage is depicted in Table (3). The TSS of squash formulations exhibited significantly increasing trend during storage. In squash formulations $T_1 - T_3$ the initial TSS was maintained 45° Brix and the values increased to 45.33 , 45.80 and 46.20° Brix respectively after 60, 120 and 180 days of storage.

The pulp concentration influenced the changes in TSS of squash significantly during storage. Maximum TSS 45.70° Brix and 45.445° Brix in case of samples prepared by using 25 and 35 per cent pulp respectively.

In the second set of squash formulations $T_4 - T_6$, where an initial TSS of 50° Brix was maintained in the samples by using 25 – 35 per cent pulp concentrations and acidity 1.5 per cent, the TSS values increased to 50.30 , 50.83 and 51.23° Brix respectively after 60, 120 and 180 days of storage. Among the tree treatments in this set of formulations squash samples prepared with 30 per cent pulp possessed mean TSS of 50.8° Brix during storage followed by 50.5° Brix in case of both samples prepared with 25 per cent or 35 per cent pulp concentrations.

The storage period and initial TSS level had significantly influenced the changes in the TSS during storage and all the interaction effects were non-significant.

Table 3: - Effect of storage on TSS (%) of strawberry squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	45.00	45.40	45.80	46.20	45.60
T ₂	30	45	1.5	45.40	45.40	46.00	46.40	45.70
T ₃	35	45	1.5	45.00	45.20	45.60	46.00	45.45
Mean				45.00	45.33	45.80	46.20	45.58
T ₄	25	50	1.5	50.00	50.20	50.70	51.10	50.50
T ₅	30	50	1.5	50.00	50.40	51.10	51.60	50.80
T ₆	35	50	1.5	50.00	50.30	50.70	51.00	50.50
Mean				50.00	50.30	50.83	51.23	50.60

CD at 0.05 %

Treatment

Concentration= NS

Interaction

Concentration X TSS = NS

TSS	=	0.203	Concentration X Storage	=	NS
Storage	=	0.288	TSS X Storage	=	NS

4.3.2 pH

Effect of various formulations on pH of squash during storage is depicted in Table (4). The squash formulations irrespective of pulp concentration per cent and TSS per cent showed decrease in pH during storage. The mean values of pH decreased significantly with storage. The squash samples with initial TSS of 45° Brix to the mean pH of 2.10 after 180 days of storage. Maximum mean pH of 2.44 was recorded in squash formulations with 25 per cent pulp concentration followed by 2.39 and 2.37 in formulations with 30 and 35 per cent pulp concentrations respectively.

In the second set of squash formulations (TSS maintained at 50° Brix) the initial mean pH of 2.62 decreased significantly to the mean value of 1.96 after 180 days of storage. Maximum mean pH of 2.39 was recorded in squash formulation with 25 per cent pulp concentrations respectively.

Except the interaction effect of (pulp concentration X TSS), all other interactions showed significant effect with respect to the decrease in pH of squash samples during storage.

4.3.3 Acidity

Effect of TSS and pulp concentrations on acidity percent of squash samples during storage is presented in Table (5). There was significant increase in acidity of squash samples during storage. The acidity maintained at 1.50 per cent initially showed

significant increase irrespective of squash formulations during storage. The squash samples with initial TSS of 45° Brix showed significant increase in mean

Table 4: - Effect of storage on pH of strawberry squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	2.60	2.46	2.40	2.30	2.44
T ₂	30	45	1.5	2.60	2.52	2.40	2.00	2.39
T ₃	35	45	1.5	2.60	2.46	2.42	2.00	2.37
Mean				2.60	2.48	2.40	2.10	2.40
T ₄	25	50	1.5	2.62	2.48	2.38	2.10	2.39
T ₅	30	50	1.5	2.62	2.50	2.40	1.90	2.35
T ₆	35	50	1.5	2.63	2.48	2.38	1.90	2.34
Mean				2.62	2.48	2.38	1.96	2.36

CD at 0.05 %

Treatment

Interaction

Concentration=	0.042	Concentration X TSS	=	NS	
TSS	=	0.034	Concentration X Storage	=	0.084
Storage	=	0.048	TSS X Storage	=	0.069

Table 5: - Effect of storage on Acidity (%) of Strawberry Squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	1.50	1.69	1.69	1.70	1.62
T ₂	30	45	1.5	1.50	1.61	1.67	1.76	1.63
T ₃	35	45	1.5	1.50	1.67	1.69	1.74	1.64
Mean				1.50	1.63	1.65	1.73	1.63
T ₄	25	50	1.5	1.50	1.60	1.68	1.78	1.64
T ₅	30	50	1.5	1.50	1.64	1.70	1.82	1.66
T ₆	35	50	1.5	1.50	1.60	1.72	1.76	1.66
Mean				1.50	1.61	1.70	1.78	1.65

CD at 0.05 %

Treatment

Interaction

Concentration	=	0.005	Concentration X TSS	=	0.008
TSS	=	0.004	Concentration X Storage	=	0.011
Storage	=	0.006	TSS X Storage	=	0.009

acidity per cent from an initial value of 1.50 per cent to 1.73 per cent after 180 days of storage. The acidity increased with the increase in pulp percentage in squash samples and maximum mean acidity of 1.64 per cent was recorded in the formulation with 3.5 per cent pulp concentration followed by 1.62 per cent and 1.63 per cent in formulations with 30 and 35 per cent pulp concentrations respectively.

However, the squash samples prepared with TSS of 50° Brix showed significant increase in mean acidity per cent from an initial value of 1.50 per cent to 1.78 per cent after 180 days of storage. Maximum mean acidity of 1.66 per cent was recorded in squash formulations with 30 and 35 per cent pulp concentrations followed by 1.64 per cent in formulation with 25 per cent pulp concentration.

All the interaction effects viz; (concentration X TSS), (concentration X storage) and (TSS X storage) showed significant change with respect to increase in acidity per cent of squash samples during storage.

4.3.4 Reducing Sugars

Effect of various formulations on reducing sugars percent squash samples during storage is depicted in Table (6). The squash samples showed significant increase in reducing sugars during storage irrespective of pulp concentrations per cent and TSS per cent. The squash samples with initial TSS of 45° Brix possessed mean reducing sugars of 33.64 per cent at 0 days of storage which increased to the

mean value of 35.23 per cent after 180 days of storage. The reducing sugars were recorded maximum 34.62 per cent in the squash formulation with 245 per cent pulp concentration followed by 34.39 per cent and 34.26 per cent in formulations with 30 and 25 per cent pulp concentrations respectively.

Table 6: - Effect of storage on Reducing Sugars (%) of strawberry squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	33.55	33.80	34.60	35.10	34.26
T ₂	30	45	1.5	33.60	34.12	34.64	35.20	34.39
T ₃	35	45	1.5	33.78	34.40	34.90	35.40	34.62
Mean				33.64	34.10	34.71	35.40	34.42
T ₄	25	50	1.5	35.00	35.70	36.30	36.60	35.90
T ₅	30	50	1.5	35.70	36.10	36.70	37.10	36.40
T ₆	35	50	1.5	35.70	36.10	36.44	37.10	36.33
Mean				35.46	35.96	36.48	36.93	36.21

CD at 0.05 %

Treatment

Interaction

Concentration=	0.325	Concentration X TSS	=	0.460	
TSS	=	0.265	Concentration X Storage	=	NS
Storage	=	0.375	TSS X Storage	=	NS

Similarly, the mean reducing sugars in the squash samples with 50° Brix TSS increases significantly from an initial value of 35.46 per cent to 36.93 per cent after 180 days of storage. Maximum reducing sugars of 36.40 per cent were recorded in 35.90 per cent in formulations with 30 and 25 per cent pulp concentrations respectively.

Except, the interaction effect of (pulp concentration X TSS), all other interactions increased non-significantly in squash samples during storage.

4.3.5 Total Sugars

Table (7) depicts the effect of various formulations on total sugars per cent of squash samples during storage. The total sugars increased significantly in squash samples during storage. In the first set of squash formulation with 40° Brix TSS value of 41.11 per cent at 0 days of storage to the mean value of 42.90 per cent after 180 days of storage. Maximum total sugars of 42.11 per cent were recorded in the formulation with 35 per cent pulp concentration followed by 42.05 per cent and 41.70 per cent in formulations with 30 and 25 per cent pulp concentrations respectively.

The second set of formulation with initial TSS of 50° Brix showed significant increase in total sugars from an initial mean value of 45.67 per cent at 0 days of storage to the mean value of 47.70 per cent after 180 days of storage. The

mean total sugars were recorded maximum 47.12 per cent in the formulation with 35 per cent pulp concentration followed by 46.40 per cent and 46.08 per cent with 30 and 25 per cent pulp concentrations respectively.

Table 7: - Effect of storage on Total Sugars (%) of strawberry squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	41.10	41.50	41.90	42.30	41.70
T ₂	30	45	1.5	41.10	41.60	42.30	43.20	42.05
T ₃	35	45	1.5	41.15	41.70	42.40	43.20	42.11
Mean				41.11	41.60	42.20	42.90	41.95
T ₄	25	50	1.5	45.45	45.70	46.10	47.10	46.08
T ₅	30	50	1.5	45.46	45.94	46.30	47.90	46.40
T ₆	35	50	1.5	46.10	46.48	47.80	48.10	47.12
Mean				45.67	46.04	46.73	47.70	46.53

CD at 0.05 %

<i>Treatment</i>		<i>Interaction</i>	
Concentration	= 0.449	Concentration X TSS	= 0.635
TSS	= 0.366	Concentration X Storage	= NS
Storage	= 0.518	TSS X Storage	= NS

The interaction effects in total sugars were in consonance with reducing sugars in all the squash formulations during storage.

4.3.6 Anthocyanin

Table (8) depicts the effect of pulp concentration per cent and TSS per cent on anthocyanin content of squash during storage. The squash formulation with TSS maintained at 45° Brix showed significant decrease in anthocyanin content from an initial value of 5.53 mg per cent at 0 days of storage to the mean value of 2.03 mg per cent after 180 days of storage. The maximum anthocyanin 4.42 mg per cent content during storage was recorded in the formulation with 35 per cent pulp concentration followed by 4.35 mg per cent and 3.95 mg per cent in the formulations with 30 and 25 per cent pulp concentrations respectively.

Except (TSS X Storage), all other interactions showed significant change with respect to decrease in the anthocyanin content of squash samples during storage.

4.4.0 Organoleptic evaluation of strawberry squash during storage.

The changes in the mean sensory scores for quality attributes (Colour, flavour and overall acceptability) of squash samples conducted at periodical intervals during 180 days of storage is as under: -

Table 8: - Effect of storage on Anthocyanin (mg %) of Strawberry Squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	5.30	4.60	4.00	1.90	3.95
T ₂	30	45	1.5	5.60	5.40	4.30	2.10	4.35
T ₃	35	45	1.5	5.70	5.40	4.50	2.10	4.42
Mean				5.53	5.13	4.26	2.03	4.24
T ₄	25	50	1.5	5.40	4.17	3.10	1.90	3.64
T ₅	30	50	1.5	5.80	5.60	4.30	2.00	4.42
T ₆	35	50	1.5	5.90	5.70	4.60	2.30	4.62

Mean			5.70	5.15	4.00	2.06	4.22
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CD at 0.05 %

<i>Treatment</i>			<i>Interaction</i>		
Concentration	=	0.180	Concentration X TSS	=	0.254
TSS	=	NS	Concentration X Storage	=	0.360
Storage	=	0.208	TSS X Storage	=	NS

4.4.1 Colour

Table (9) shows the mean colour scores of strawberry squash samples evaluated at various time intervals by trained panelists

The squash formulations T₁ – T₃ formulated by using 25 to 35 per cent pulp and maintained at TSS of 45° Brix, acidity of 1.5 per cent possessed mean colour score 3.51 and 4 point scale. The colour scores showed declined values during storage in all the three formulations in this set of samples. The colour scores recorded were 3.12, 2.36 and 1.33 respectively after 60, 120 and 180 days of storage.

In the first set of formulations from T₁ – T₃ mean maximum colour scores 2.68 during storage was recorded in the squash sample formulated with 30 per cent

pulp, followed by scores of 2.63 and 2.43 respectively in samples prepared by using 25 and 35 per cent pulp concentrations.

The squash formulations from T₄ – T₆ prepared by using 25 – 35 per cent pulp concentration and maintaining acidity of 1.5 per cent, TSS of 50° Brix exhibited mean maximum colour score of 3.54 at 0 days storage. The panelists awarded lesser scores to the squash samples with the advancement of storage period. The scores were significantly lesser i.e. 3.14, 2.40 and 1.40 respectively after 60, 120 and 180 days of storage.

Mean maximum colour score 2.79 was recorded in samples prepared by using 30 per cent pulp in the set of formulations from T₄ – T₆. Squash samples prepared by using 25 and 35 per cent pulp awarded mean colour scores of 2.64 and 2.42 respectively.

Table 9: - Effect of storage on Colour Scores of Strawberry Squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	3.45	3.10	2.48	1.50	2.63
T ₂	30	45	1.5	3.64	3.18	2.50	1.40	2.68
T ₃	35	45	1.5	3.43	3.10	2.10	1.10	2.43
Mean				3.51	3.12	2.36	1.33	2.58
T ₄	25	50	1.5	3.48	3.21	2.45	1.40	2.64
T ₅	30	50	1.5	3.68	3.20	2.60	1.70	2.79

T ₆	35	50	1.5	3.46	3.00	2.15	1.10	2.42
Mean				3.54	3.14	2.40	1.40	2.62

CD at 0.05 %

Treatment

Interaction

Concentration=	0.118	Concentration X TSS	=	NS		
TSS	=	NS	Concentration X Storage	=	0.237	
Storage	=	0.136	TSS X Storage	=	NS	
* Point Scale	4	=	Excellent	3	=	Good
	2	=	Fair	1	=	Poor

The overall mean colour score of 2.62 was awarded to formulations from T₄ – T₆ where in 50 per cent TSS was maintained followed by mean score of 2.58 in formulations T₁ – T₃ in which case 45 per cent was maintained in the squash preparations

4.4.2 Flavour

Table (10) indicates the flavour scores awarded by panelists to the squash formulations T₁ – T₃ evaluated at periodical intervals during storage.

The flavour scores exhibited significant decrease during storage irrespective of the treatments. In the first set of formulations from T₁ – T₃ prepared by using 25 – 35 per cent pulp, and maintaining TSS of 45° Brix and acidity of 1.5 per cent, the

initial flavour scores at 0 days were 3.16. The scores recorded at 60, 120 and 180 days of storage were 2.40, 2.06 and 1.13 respectively.

The squash formulations with 35 per cent pulp possessed significantly maximum scores of 2.28 during storage followed by scores of 2.16 and 2.12 observed in case of samples prepared by using 30 and 25 per cent pulp in the first set of formulations.

In the second set of squash formulations from T₄ – T₆ prepared by using 25 – 35 per cent pulp, maintaining acidity of 1.5 per cent and TSS of 50° Brix. The initial scores at 0 days of storage were 2.51, 2.13 and 1.35 respectively.

The flavour scores were influenced by pulp concentration significantly and maximum flavour score (2.58) was awarded during storage to the squash sample

Table 10: - Effect of storage on Flavour Scores of Strawberry Squash

Treatment	Pulp Concentration Ratio	TSS (%)	Acidity (%)	Storage period (Days)				Mean
				0	60	120	180	
T ₁	25	45	1.5	3.08	2.30	2.02	1.10	2.12
T ₂	30	45	1.5	3.10	2.40	2.06	1.10	2.16
T ₃	35	45	1.5	3.30	2.50	2.10	1.20	2.28
Mean				3.16	2.40	2.06	1.13	2.19
T ₄	25	50	1.5	3.12	2.36	2.06	1.08	2.15
T ₅	30	50	1.5	3.18	2.50	2.10	1.18	2.24

DISCUSSION

CHAPTER-V

DISCUSSION

The agro climatic conditions of J & K State favourable for growing a variety of temperate fruits of which strawberry is the season' s first fruit followed by cherry. In recent years due to introduction of new strawberry varieties and awareness among growers, the area under strawberry is increasing in the state as the crop promises quick returns to the growers. However, the post harvest life of strawberry is limited deterioration of quality in absence of the adequate post harvest management systems in the valley. Strawberries are converted into variety of products such as frozen strawberries, strawberry jam, sauce, squash and canned strawberries. However, in quantity is converted into jam. Keeping in view the short shelf life an attempt has been made in the present investigation to develop formulation for strawberry squash and to monitor the quality changes in the product developed under ambient storage conditions.

5.1 Physico – chemical parameters of fresh strawberry fruits cv. (Tioga).

The physico-chemical characteristics of strawberry fruits vary with variety, soil conditions, season, climatic conditions and stage of maturity. In modern strawberry culture, various cultural and plant conditions are used to increase plant vigor and improve fruit quality. The strawberry fruits of cultivar Tioga used in the present investigations were oblong in shape and reddish in colour with an

anthocyanin content of 9.36 mg percent. The average fruit weight of strawberries varied from 13.0 to 13.95g without and with calyx respectively. The fruit calyx contributed 6.6 percent to the average fruit weight. The fruits were having an average fruit length (3.45 cm), fruit breadth (3.24 cm) and L/D ratio (1.064). these measurements with regard to fruit weight and size are in the range reported by Hafiza (1999) in Tioga cultivar grown under Kashmir conditions. The fruits were acidic (0.55 percent citric acid) and possessed pH value (4.06). the total soluble solids of the fruits were 7.66 percent of which total sugars accounted for 78.33 percent (6.00 percent) and reducing sugars were 21.67 percent (3.72 percent) of total soluble solids. These chemical parameters with regard to TSS, acidity, pH total sugars and reducing sugars are in the range reported by Hafiza (1999).

The strawberry puree prepared after hot break method possessed TSS of 8.0 percent due to evaporation of water and concentration of solids. The acidity of puree (0.70 percent as citric acid) was lower than the fresh fruit. Total sugars (6.20 percent) and reducing sugars (3.77 percent) were higher in puree than in fresh fruits and anthocyanin content (16.96 mg percent) was higher as compared to that of fresh fruit.

5.2 Storage change in quality parameters of strawberry squash

5.2.1 total soluble solids

The squash samples prepared by using 25, 30, 35 percent pulp concentrations were adjusted to TSS of 45 of 50⁰ Brix and acidity of 1.5 percent before storage. The data indicated that there was an increase in total soluble solid concentration in

all the squash formulations irrespective of the pulp concentrations used. The squash with initial TSS of 51.23 percent after 180 days of storage. Where as squash samples with initial TSS of 45 percent showed increased TSS of 46.20 percent. Squash samples prepared with 30 percent pulp concentration possessed maximum TSS of 45.70⁰ Brix in samples maintained initially at 45⁰ Brix and 50.80⁰ Brix in samples maintained initially at 50⁰ Brix during storage. There was non-significant effect of two factor interactions. However, storage period and initial TSS contributed significantly for the increase in TSS of squash samples during storage. Sethi (1993), Prasad and Mali (2000), Barwal *et. al.*(2002) and Saikia and Saikia(2002) reported increase in TSS of the squash samples during storage prepared from fruit like Lithehi, pomegranate, apricot and ou-tenga. Where as Kumar and Manimegalai (2003) observed no change in TSS of squash prepared from strawberry cultivars. Sujata and Labella. Sogi and Singh (2001) also observed insignificant changes in TSS of kinnow squash during storage.

The possible reason for increase in TSS may be due to degradation of starch and other complex carbohydrates into simple sugars during storage (Mehta and Bajaj 1983)

5.2.2 Acidity (Percent)

The acidity of strawberry squash was maintained initially at 1.5 percent in all the treatments. There was a significant increase in acidity with storage time and it attained a value of 1.73 in formulation from T₁ to T₃ and value of 1.78 percent in formulation from T₄ to T₆ after 180 days of storage. The mean value of acidity was

maximum 1.64 percent with the use of 35 percent pulp in formulations with initial TSS of 45⁰ Brix and minimum acidity (1.62 percent) with the use of 25 percent pulp, whereas use of 30 or 35 percent pulp in formulations T₅ to T₆ contributed to the mean maximum acidity of 1.66 percent during storage. The interaction effects as well as the main effects of pulp concentration, TSS and storage period showed significant variation with respect to the increase in acidity in all the squash samples. Similar trend with respect to increase in acidity was observed by Palaniswamy *et. al.*(1974), Sethi (1993), Prasad and Mali (2000), Krishnaveni *et. al.*(2001) and Kumar and Manimegalai (2003) in different fruit squash samples during storage. However, Saikia and Saikia(2002) reported decrease in acidity of ou- tenga (*Dillenia indica*) fruit squash during storage. The increase in acidity may be due to the formation of organic acids by ascorbic acid degradation, which is a temperature dependent transformation process.

5.2.3 pH

In contrast to acidity percent, pH of all the squash samples declined during storage irrespective of pulp concentration and TSS percent maintained in the formulations. The pH of squash samples T₁ to T₂ initially at 2.60 decreased to lower value of 2.10 after 180 days of storage and squash samples T₄ to T₆ showed decrease in mean pH value from an initial of 2.62 to a minimum of 1.96 after 180 days of storage. Irrespective of TSS in the formulation the pH value showed decrease with the increase in pulp concentrations used for squash formulations. Minimum pH of 2.37 and 2.34 was recorded in formulations T₃ to T₆ respectively

in case of squash with TSS of 45 and 50⁰ Brix by use of 35 percent pulp concentration in the product. There was significant interaction effect on pH values in all the squash samples except in case of (concentration x TSS) interaction which was noted as non-significant.

The decline in pH values of various fruit squash samples during storage was also observed by Sethi (1993), Prasad and Mali (2000), Krishnaveni *et. al.*(2001) and Kumar and Manimegalai (2003). However, increase in pH during storage was observed by Tahkur and Barwal (1998) and Saikia and Saikia (2002)

5.2.4 Reducing Sugars (Percent)

There was significant increase in reducing sugars (Percent) during storage irrespective of pulp concentrations and TSS maintained in the squash samples. The reducing sugars increased in formulation T₁ to T₃ maintained at 45⁰ Brix TSS from an initial value of 33.64 to maximum of 35.23 percent after 180 days of storage and maximum reducing sugars (34.62) percent during storage were observed in T₃, where in 35 percent pulp was used in squash formulation adjusted at 45⁰ Brix. Higher values of reducing sugars were observed in formulations T₄ to T₆. The mean reducing sugars were 35.46 percent at 0 days which increased to a maximum value of 36.93 percent after 180 days. Maximum reducing sugars during storage were recorded in T₆ where in 35 percent pulp was used in squash preparation and TSS was adjusted to 50⁰ Brix. There was a significant effect of pulp concentration on reducing sugars of squash samples irrespective of TSS in the formulation. Except the (Concentration x TSS) interaction, all other interaction effects were significant

in all the squash samples with respect to increase in reducing sugars. The increase in reducing sugars during storage has been reported by different workers. Sethi (1993), Krishnaveni *et. al.*(2001 Barwal *et. al.*(2002), Saikia and Saikia (2002) and Kumar and Manimegalai (2003) reported increase in reducing sugars in different fruit squash samples during storage. The rise in levels of reducing sugars content is apparently due to the conversion of non-reducing sugars into reducing sugars due to acid hydrolysis.

5.2.5 Total Sugars (Percent)

The total sugars showed increase in all the squash samples during 180 days of storage. Squash samples prepared by maintaining initial TSS of 45⁰ Brix (T₁ to T₃) possessed total sugar content of 41.11 percent at 0 days which enhanced to a level of 42.90 percent after 180 days of storage, and maximum total sugar (42.11 percent) were observed in formulation T₃ in which 35 percent pulp was used.

In case of formulation T₄ to T₆ wherein 50⁰ Brix TSS was maintained total sugars were higher initially compared to T₁ to T₃ formulations. The initial mean total sugars 45.67 percent in these formulations after 180 days of storage and formulation of squash with 35 percent pulp had maximum 47.12 percent total sugars during storage. Irrespective of pulp concentrations, squash samples with 45 percent TSS after 180 days of storage. The total sugar in the formulations increased with the use of pulp concentration.

All the interactions except (Concentration x TSS) interaction effect showed insignificant variation with respect to the increase in total sugars (percent) of all squash samples during 180 days of storage.

The increasing trend of total sugars in fruit squash samples was also observed by Saikia and Saikia (2002). In contrast, Thakur and Barwal (1998), Krishnaveni et al. (2001), Barwal et al. (2002), Kumar and Manimegalai (2003) reported decrease in total sugars in different fruit squash samples during storage.

5.2.6 Anthocyanins (mg percent)

The anthocyanin content of squash samples declined during 180 days of storage. Initially, the mean anthocyanin content in squash formulation T₁ to T₃ was 5.53 mg percent, which decreased to a level of 2.03 mg. Percent after 180 days of storage. Maximum anthocyanin content 4.42 mg percent was recorded in squash samples prepared by using 35 percent pulp in T₃ formulations during storage. The mean anthocyanin content of squash sample T₄ to T₆ initially at 5.70 mg percent decreased to a lower value of 2.06 mg percent after 180 days of storage and maximum anthocyanin content of 4.62 mg percent was recorded in T₆ by use of 35 percent pulp and TSS of 50⁰ Brix. The main effect of TSS on anthocyanin content was non-significant irrespective of storage period and pulp concentration. The anthocyanin content showed increased value with the increase in pulp concentrations in the formulations.

The interaction effects showed significant variation with respect to the decline in anthocyanin content except the storage and TSS interaction which showed non-significant change in squash samples.

5.2.7 Sensory Evaluation of the strawberry squash samples: -

5.2.7.1 Colour

The colour scores awarded by panelists to squash formulations from T₁ to T₆ exhibited decreasing trend with storage period. The pulp concentrations used for squash samples decreased with storage period.

In the squash formulation from T₁ to T₃ maintained at 45⁰ Brix acidity of 1.5 percent maximum colour score of 3.51 at 0 days attained a minimum colour score of 1.33 after 180 days of storage. Maximum colour score (2.68) was awarded during storage to squash formulated with 30 percent pulp and having TSS of 45⁰ Brix and acidity of 1.5 percent.

The squash formulations T₄ to T₆ having TSS of 50⁰ Brix and acidity of 1.5 percent were awarded maximum colour score 3.54 at 0 days of storage and a minimum score of (1.40) after 180 days of storage. However maximum colour score 2.79 was awarded to sample (T₃) prepared by using 30 percent puree concentration.

The loss of colour score in Jamun beverage during storage have been reported by Khurdiya and Roy (1985) and by Starr and Francis (1968) due to the anthocyanin degradation. The results of present investigation on anthocyanin

content indicated at Table 8 are in support of the same view. The decrease in colour scores may be due to the non-enzymatic browning reactions encountered during storage; Prasad and Mali (2000), Krishnaveni et al. (2001). The decreased colour scores may also be attributed to the increased rates of oxidation of ascorbic acid, organic acids and enhanced Maillard reaction which contributed to the browning of squash samples.

5.2. 7.2 Flavour

The panelists awarded maximum flavour score (3.16) at 0 days storage to squash samples T₁ to T₃ prepared by using different pulp concentration 25-35 percent, but maintained to TSS of 45⁰ Brix and acidity of 1.5 percent. The flavour scores decreased due to storage effect and a minimum score (1.13) was awarded to the samples T₁ to T₃ after 180 days of storage. Higher pulp concentration used in formulation of squash samples significantly enhanced flavour scores. Maximum flavour score (2.28) was awarded during storage to squash prepared by using 35 percent pulp TSS 45⁰ Brix, acidity 1.5 percent.

The initial TSS of squash formulations significantly enhances flavour scores. Higher flavour scores were awarded to squash samples T₄ to T₆ maintained with TSS of 50⁰ Brix and acidity of 1.5 percent. These formulations had flavour score minimum of 1.35 after 180 days of storage. Maximum flavour score (2.58) was observed during storage to sample prepared by using 35 percent pulp and with TSS of 50⁰ Brix and acidity of 1.5 percent.

The flavour scores of all squash samples decreased with storage period. Maximum flavour scores were observed in case of squash samples formulated with 35 percent pulp concentration at 0 days of storage and lower values after 180 days. The lower scores for flavour attribute is due to the loss of volatile flavouring compounds upon storage, and the observations are in agreement with the findings of others workers. Thakur and Barwal (1998) also reported reduction of flavour scores during storage of Kiwi fruit squash prepared from different varieties. Khurdiya and Roy (1985) also observed similar results for flavour score in jamun juice and nectar during storage. Prasad and Mali (2000) and Krishnaveni et al. (2001) too observed decrease in flavour score due to storage in fruit squash of pomegranate jack fruit respectively.

5.2.7.2 Overall Acceptability

The overall acceptability scores awarded by panelists varied with the squash formulations and storage period.

Maximum overall acceptability score (2.93) at 0 days of storage in squash samples T₁ to T₃ lowered to a minimum overall acceptability score of (1.17) after 180 days of storage.

Maximum overall acceptability score (2.28) was awarded during storage to the sample containing 30 percent pulp and having TSS 45⁰ Brix and acidity of 1.5 percent in the formulations from T₁ to T₃

Squash samples maintained at TSS of 50⁰ Brix (T₄ to T₆) were awarded maximum overall acceptability score (3.29) at 0 days of storage and with the elapse

of 180 days storage period panelists awarded lower overall acceptability score (1.37) to these formulations. Among these formulations (T₃) prepared by using 30 percent pulp, TSS 50⁰ Brix and with acidity of 1.5 percent was awarded maximum overall acceptability score 2.53 during storage.

The overall acceptability scores indicated that product remained acceptable up to 180 days of storage under ambient conditions and no microbial spoilage was detected during this period. The decrease in overall acceptability scores may be attributed to loss of colour, flavour and taste contributing bio-molecules.

Thakur and Barwal (1998) also reported decreased overall acceptability scores of kiwi fruit squash samples during storage. Khurdiya and Roy (1985) observed similar results for overall acceptability scores in case of jamun juice and nectar during storage. Prasad and Mali (2000) and Krishnaveni et al. (2001) also reported lower overall acceptability scores in the squash samples prepared from pomegranate and jackfruit during storage.

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SUMMARY AND CONCLUSION

The investigations entitled “*Development and Evaluation of Strawberry Squash*” were carried out in the food Processing Laboratory of the Division of Post Harvest Technology, Shalimar, during the year 2001 - 2002 with the following objectives : -

- 1) To evaluate various formations for making acceptable strawberry squash.
- 2) To monitor quality changes during ambient storage of strawberry squash.

Fresh strawberry fruits of cultivar (Tioga) were procured from the local strawberry grower. The fruits were sorted, washed and subjected to pulping by hot break method after removing the calyx. The pulp obtained was preserved with 1000 ppm sodium benzoate and stored in pre-sterilized glass containers till use. The preserved pulp was utilized for squash preparation as per different formulation, using 25,30 or 35 percent pulp maintaining TSS of 45⁰ Brix or 50⁰ Brix and keeping the acidity of 1.5 per cent. The six formulations of squash prepared were bottled in pre-sterilized glass bottles of (200 ml) capacity and kept at room temperature (15 – 30°C, R.H. 60 – 80 per cent) for 180 days. The quality parameters of squash samples were evaluated at 0, 60 120 and 180 days after storage.

The salient features of the results are summarized as below: -

The strawberry fruits of variety Tioga were bigger with an average fruit weight of 13.95 g with calyx and 13.0 g without calyx. The fruit possessed L/D ratio of 1.064 having 3.45 cm average length and breadth 3.24cm. the fruits were acidic with pH of 4.06 and acidity of 0.55 per cent as citric acid. The fruits possessed total soluble solid content of 7.66 per cent having sugar acid ratio of 13.93. The total sugar content of fruits was 6.0 per cent of which reducing sugars were up to 3.72 per cent. The fruits were reddish in colour with anthocyanin content of 9.36 mg per cent.

The pulp yield from strawberries by hot break method was 71.43 per cent. The waste material in the form of calyx was recorded to be 7.31 per cent. The pulp was viscous, reddish in colour with anthocyanin content of 16.96 mg percent. The pulp was characterized with soluble solid content of 8.0 percent, pH 3.60 and acidity 0.70 percent as citric acid and sugar acid ration of 11.4. The total and reducing sugars present in pulp were 6.20 and 3.77 percent respectively.

Quality changes in squash during storage

Six formulations of squash from strawberry were prepared by using hot extracted pulp at 25, 30 or 35 percent levels and maintaining TSS of 45 or 50⁰ Brix and acidity of 1.5 percent in all samples initially.

The total soluble solid content in all the six formulations increased significantly during storage. The TSS of squash sample varied with the pulp content used and the initial TSS maintained in the product.

The TSS in formulations from T₁- T₂ increase increased from 45⁰ Brix at 0 days a maximum of 46.20⁰ Brix recorded after 180 days of storage. The corresponding increase in TSS in formulation form T₄- T₆ was from an initial of 50⁰ Brix to a maximum of 51.23⁰ Brix recorded after 180 days of storage. Use of 30 percent pulp in formulations T₃- T₅ contributed to more TSS level during entire period of storage.

There was a significant decrease in pH of squash samples during storage irrespective of the pulp concentrations and TSS maintained initially in the products. Samples of squash maintained at initial TSS of 45⁰ Brix and acidity of 1.5 percent possessed mean pH value of 2.60 at 0 days which lowered to mean value of 2.10 after 180 days of storage. In comparison to this, samples of squash T₄- T₆ containing 1.5 percent acidity and 50⁰ Brix TSS, initial pH of 2.62 dropped to a minimum of 1.96 after 180 days of storage. The squash samples exhibited decrease in pH during storage with the use of additional levels of pulp in the formulations.

There was a significant gradual increase in acidity of squash samples during storage. Initially all the samples were maintained to contain 1.5 percent acidity of the squash formulations with 45⁰ Brix increased to mean value of 1.73 percent after 180 days of storage, where as in the formulations with 50⁰ Brix, acidity increased to the extent of 1.78 percent. Increase in the pulp content in the formulation contributed to more acid content and formulation with 35 percent pulp content possessed 1.64 percent and 1.66

percent acidity in squash samples respectively containing 45⁰ and 50⁰ Brix total soluble solids.

The total and reducing sugars exhibited significant increase during storage in all formulations. Significantly more reducing and total sugars were observed in formulations (T₄- T₆) maintained initially at 50⁰ Brix compared to (T₁ – T₃) treatments maintained at 45⁰ Brix. Maximum reducing and total sugars were recorded at higher levels of pulp i.e 35 percent used in both the sets of formulations.

Squash samples (T₁ – T₃) maintained initially at 45⁰ Brix, acidity 1.5 percent possessed mean reducing sugars 33.64 percent and total sugars 41.11 percent at 0 days of storage and the values recorded after 180 days of storage were 35.23 and 42.90 percent respectively.

Squash samples (T₄- T₆) maintained initially at 50⁰ Brix, acidity 1.5 percent possessed mean reducing sugar content of 35.46 percent and total sugars 36.93 at 0 days of storage. The values recorded after 180 days of storage were 36.93 percent reducing sugars and 47.70 percent sugars.

The initial mean anthocyanin content was maximum 5.70 mg (%) in formulation (T₄- T₆) maintained at 50⁰ Brix, acidity 1.5 percent compared to lower value of 5.53 mg percent in formulations (T₁- T₃) maintained at 45⁰ Brix and acidity 1.5 percent. There was a significant decrease in anthocyanin content due to storage in all formulations. The mean anthocyanin content after 180 days of storage varied from 2.06 – 2.03 mg percent and 4.62 mg

percent during storage in formulations maintained at 45⁰ Brix and 50⁰ Brix respectively.

There was a significant decrease in colour score assigned by the panelists to the squash samples during storage. Formulations maintained to higher TSS i.e 50⁰ Brix (T₄- T₆) had mean colour score 3.54 at 0 days, which decreased to score of 1.40 after 180 days of storage. The formulations T₁ – T₃ (Maintained at 45⁰ Brix, acidity 1.5 percent) had colour score of 3.51 at 0 days of evaluation and a lower value of 1.33 after 180 days of tasting.

Use of 30 percent pulp in both sets of formulations have produced squash of excellent colour attribute and the mean colour score for T₂- T₄ (Containing 30 percent pulp and 45⁰ and 50⁰ Brix total soluble solids) were 2.68 and 2.79 respectively during storage.

The flavour scores of squash samples evaluated at periodical intervals indicated decreasing trend with the storage. The panelists awarded maximum score to the samples containing more pulp i.e 35 percent and TSS 50⁰ Brix on flavour basis. The mean flavour scores for formulations T₁- T₃ (45⁰ Brix TSS, acidity 1.5 percent) was 3.16 at 0 days and the values decreased to score of 1.13 after 180 days of storage. The formulations T₄- T₆ (50⁰ Brix TSS, acidity 1.5 percent) had initialed mean flavour score of 3.30 and it dropped to lowest of 1.35 after 180 days of storage.

The overall acceptability scores were maximum to the formulations maintained at 50⁰ Brix and acidity of 1.5 percent compared to the

formulations T₁- T₃ where in 45⁰ Brix and acidity of 1.5 percent was maintained.

The overall acceptability scores recorded in T₄- T₆ were 3.29 at 0 days of evaluation and the product remained acceptable with OAA score of 1.37 even after 180 days of storage. Squash samples T₁- T₃ formulated to contain TSS 45⁰ Brix acidity 1.5 percent possessed overall acceptability score of 2.93 at 0 days of storage. The products did not show any microbial spoilage during storage except colour determination, which reduced OAA scores significantly.

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SUMMARY AND CONCLUSION

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The pulp yield from strawberries by hot break method was 71.43 per cent. The waste material in the form of calyx was recorded to be 7.31 per cent. The pulp was viscous, reddish in colour with anthocyanin content of 16.96 mg percent. The pulp was characterized with soluble solid content of 8.0 percent, pH 3.60 and acidity 0.70 percent as citric acid and sugar acid ration of 11.4. The total and reducing sugars present in pulp were 6.20 and 3.77 percent respectively.

Quality changes in squash during storage

Six formulations of squash from strawberry were prepared by using hot extracted pulp at 25, 30 or 35 percent levels and maintaining TSS of 45 or 50⁰ Brix and acidity of 1.5 percent in all samples initially.

The total soluble solid content in all the six formulations increased significantly during storage. The TSS of squash sample varied with the pulp content used and the initial TSS maintained in the product.

The TSS in formulations from T₁- T₂ increase increased from 45⁰ Brix at 0 days a maximum of 46.20⁰ Brix recorded after 180 days of storage. The corresponding increase in TSS in formulation form T₄- T₆ was from an initial of 50⁰ Brix to a maximum of 51.23⁰ Brix recorded after 180 days of storage. Use of 30 percent pulp in formulations T₃- T₅ contributed to more TSS level during entire period of storage.

There was a significant decrease in pH of squash samples during storage irrespective of the pulp concentrations and TSS maintained initially in the products. Samples of squash maintained at initial TSS of 45⁰ Brix and acidity of 1.5 percent possessed mean pH value of 2.60 at 0 days which lowered to mean value of 2.10 after 180 days of storage. In comparison to this, samples of squash T₄- T₆ containing 1.5 percent acidity and 50⁰ Brix TSS, initial pH of 2.62 dropped to a minimum of 1.96 after 180 days of storage. The squash samples exhibited decrease in pH during storage with the use of additional levels of pulp in the formulations.

There was a significant gradual increase in acidity of squash samples during storage. Initially all the samples were maintained to contain 1.5 percent acidity of the squash formulations with 45⁰ Brix increased to mean value of 1.73 percent after 180 days of storage, where as in the formulations with 50⁰ Brix, acidity increased to the extent of 1.78 percent. Increase in the pulp content in the formulation contributed to more acid content and formulation with 35 percent pulp content possessed 1.64 percent and 1.66

percent acidity in squash samples respectively containing 45⁰ and 50⁰ Brix total soluble solids.

The total and reducing sugars exhibited significant increase during storage in all formulations. Significantly more reducing and total sugars were observed in formulations (T₄- T₆) maintained initially at 50⁰ Brix compared to (T₁ – T₃) treatments maintained at 45⁰ Brix. Maximum reducing and total sugars were recorded at higher levels of pulp i.e 35 percent used in both the sets of formulations.

Squash samples (T₁ – T₃) maintained initially at 45⁰ Brix, acidity 1.5 percent possessed mean reducing sugars 33.64 percent and total sugars 41.11 percent at 0 days of storage and the values recorded after 180 days of storage were 35.23 and 42.90 percent respectively.

Squash samples (T₄- T₆) maintained initially at 50⁰ Brix, acidity 1.5 percent possessed mean reducing sugar content of 35.46 percent and total sugars 36.93 at 0 days of storage. The values recorded after 180 days of storage were 36.93 percent reducing sugars and 47.70 percent sugars.

The initial mean anthocyanin content was maximum 5.70 mg (%) in formulation (T₄- T₆) maintained at 50⁰ Brix, acidity 1.5 percent compared to lower value of 5.53 mg percent in formulations (T₁- T₃) maintained at 45⁰ Brix and acidity 1.5 percent. There was a significant decrease in anthocyanin content due to storage in all formulations. The mean anthocyanin content after 180 days of storage varied from 2.06 – 2.03 mg percent and 4.62 mg

percent during storage in formulations maintained at 45⁰ Brix and 50⁰ Brix respectively.

There was a significant decrease in colour score assigned by the panelists to the squash samples during storage. Formulations maintained to higher TSS i.e 50⁰ Brix (T₄- T₆) had mean colour score 3.54 at 0 days, which decreased to score of 1.40 after 180 days of storage. The formulations T₁ – T₃ (Maintained at 45⁰ Brix, acidity 1.5 percent) had colour score of 3.51 at 0 days of evaluation and a lower value of 1.33 after 180 days of tasting.

Use of 30 percent pulp in both sets of formulations have produced squash of excellent colour attribute and the mean colour score for T₂- T₄ (Containing 30 percent pulp and 45⁰ and 50⁰ Brix total soluble solids) were 2.68 and 2.79 respectively during storage.

The flavour scores of squash samples evaluated at periodical intervals indicated decreasing trend with the storage. The panelists awarded maximum score to the samples containing more pulp i.e 35 percent and TSS 50⁰ Brix on flavour basis. The mean flavour scores for formulations T₁- T₃ (45⁰ Brix TSS, acidity 1.5 percent) was 3.16 at 0 days and the values decreased to score of 1.13 after 180 days of storage. The formulations T₄- T₆ (50⁰ Brix TSS, acidity 1.5 percent) had initialed mean flavour score of 3.30 and it dropped to lowest of 1.35 after 180 days of storage.

The overall acceptability scores were maximum to the formulations maintained at 50⁰ Brix and acidity of 1.5 percent compared to the

formulations T₁- T₃ where in 45⁰ Brix and acidity of 1.5 percent was maintained.

The overall acceptability scores recorded in T₄- T₆ were 3.29 at 0 days of evaluation and the product remained acceptable with OAA score of 1.37 even after 180 days of storage. Squash samples T₁- T₃ formulated to contain TSS 45⁰ Brix acidity 1.5 percent possessed overall acceptability score of 2.93 at 0 days of storage. The products did not show any microbial spoilage during storage except colour determination, which reduced OAA scores significantly.

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* *Original not seen.*

CERTIFICATE

This is to certify that all the correction and modifications suggested by the External Examiner in the thesis script of Mr. Mohammad Saleem rather (Regd. No. 2000-A-606-M) “ *Development And Evaluation Of Strawberry Squash*” have been taken care of before final binding of the same.

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