PROCESSING OF BITTERGOURD FOR THE PRODUCTION OF DIETETIC BEVERAGES

Thesis

by

TUHIN KUMAR SINGH

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Dr. Y.S.P.U.H.&F., Solan

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2002

Dedicated

to

Maa-Babuji & Vijay Pal

Dr. V.S. Barwal
Associate Professor

Department of Postharvest Technology
Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) – 173 230

CERTIFICATE-I

This is to certify that the thesis entitled "**Processing of bittergourd for the production of dietetic beverages**", submitted in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE** in **HORTICULTURE (Postharvest Technology)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan (H.P.) is a bonafide research work carried out by **Mr. Tuhin Kumar Singh (H-2000-15-M)** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigations have been fully acknowledged.

Place : Nauni, Solan
Dated : 27 September, 2002

(V.S. Barwal)
Chairman
Advisory Committee

CERTIFICATE-II

This is to certify that the thesis entitled **"Processing of bittergourd for the production of dietetic beverages"**, submitted by **Mr. Tuhin Kumar Singh (H-2000-15-M)** to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Solan (H.P.), in partial fulfilment of the requirements for the award of degree of **MASTER OF SCIENCE** in **HORTICULTURE (Postharvest Technology)** has been approved by the Student's Advisory Committee after an oral examination of the same in collaboration with the external examiner.

(V.S. Barwal)
Chairman
Advisory Committee

External Examiner

Professor and Head
Department of Postharvest Technology

Dean
College of Horticulture

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O! All, salutations to You in front and from behind, salutations to You all round; You are of infinite prowess, of immeasurable valour; You pervade everything and so You are everything. His blessing that I learnt,

"The whole manifestation is duality ..... and behind duality is unity" and
"What limits God? His name".

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Errors and omissions are mine.

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Place: Nauni-Solan
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(Tuhin Kumar Singh)

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION

Chapter-1

INTRODUCTION

Bittergourd (*Momordica charantia* L.) or Balsam pear or 'Karela' is a popular vegetable of Indo-Pakistan sub-continent and cultivated throughout India during the warm season. The fruit though bitter, is wholesome and esteemed as vegetable when young. The fruit is of considerable importance because of its many medicinal applications.

Though much of the work is done for preservation of bittergourd by different methods such as steeping preservation (Ramah *et al.*, 1999), processing of bittergourd (Kalra *et al.*, 1983), sun drying and dehydration of bittergourd (Manimegalai and Ramah, 1998), but very little work has been done to prepare beverages from bittergourd juice in India.

Management of diabetes mellitus without any side effect is still a challenge to the medical system. Several laboratories are involved in isolating or synthesizing new oral hypoglycaemic agents. In this field of research, medicinal plants of different systems of medicine such as Indian system, Chinese system and Tibetian system could prove to be of great importance (Chaturvedi, *et al.*, 1995).

Bittergourd; a member of cucurbitaceous family is a popular vegetable among gourds. Due to its peculiar taste and flavour, it may not be liked by most of the persons suffering from diabetes. It has high nutritive value among different gourds (Choudhary, 1996). This crop is grown throughout the country for its small or long green fruit which is commonly used as vegetable beside its use in curry, soup and pickle making. Bittergourd is rich source of ascorbic acid and fair source of protein, minerals and dietary fiber (Kalra *et al.*, 1983).

In India, bittergourd is available in the market from June last to the 1st week of September. During this period, preservation methods such as dehydration, steeping preservation and pickling are adopted to preserve the bittergourd for the off-season.

But, nutritive/medicinal value of bittergourd is affected to great extent (Kalra *et al.*, 1983). Therefore, a processing technique is to be developed to prepare a product which preserve its nutritive value and utilize surplus production during peak season.

Keeping this in view, the present study is therefore proposed for processing of bittergourd for the production of dietetic beverages such as RTS and spiced squash, which shall be available during off season as a refreshing drink with the following objectives:

Objectives:

i) Standardization, preservation and evaluation of juice and dietetic beverages such as RTS and spiced squash from bittergourd juice.

ii) To study the physico-chemical, sensory and microbiological qualities during storage of the processed products.

iii) To work out the economics of the developed products.

REVIEW OF LITERATURE

Chapter-2

REVIEW OF LITERATURE

Bittergourd is reported to be originated in the tropics of the old world and is widely cultivated in China, Malaysia, India and tropical Africa (Choudhary, 1996). Bittergourd is one of the nutritionally and commercially important vegetables. Due to the presence of bitter principle (Triterpenoid), it could be used only for certain type of preparations.

Some of the work done in India and abroad on the physico-chemical composition, medicinal property, preservation of bittergourd, juice extraction and preservation, dietetic products, non-nutritive sweeteners spices and herbs have been reviewed under the following heads:

2.1 Bittergourd fruit: Physico-chemical composition, Medicinal/ Pharmacological properties

2.2 Preservation of bittergourd

2.3 Juice extraction and preservation

2.4 Dietetic products

2.5 Non-nutritive sweeteners

2.6 Safety evaluation

2.7 Spices and herbs: Health Properties and Uses

2.8 Spiced product development

2.9 Storage studies: Changes in Physico-Chemical and Sensory Attributes

2.1 BITTERGOURD FRUIT: PHYSICO-CHEMICAL COMPOSITION AND MEDICINAL/PHARMACOLOGICAL PROPERTIES

2.1.1 Physico-Chemical Composition

The physical characteristics and chemical composition of the bittergourd fruits have been investigated by Kalra *et al.* (1983) and Gopalan *et al.* (1980). The vegetable is considered to be a good source of ascorbic acid, a fair source of protein and poor source of sugar. The tender fruit contain 3.0 to 3.5 per cent reducing sugars and 3.5 to 4.5 per cent total sugars. The bittergourd contains 88 mg/100 g of ascorbic acid in fresh tender large fruit (Choudhary, 1996). Bittergourd is reported to contain 210 I.U. of Beta-carotene as vitamin A and 72 ug/100g thiamine (Anon., 1962). Bittergourd is also a good source of essential amino acids and minerals (Yuwai *et al.*, 1991). The catechol activity which causes enzymic browning is reported to be very low in bittergourd. The fruit of bittergourd yield 150 mg/100g of a hypoglycaemic principle 'Charantin' and alkaloid Momordicin which is said to be responsible for the bitterness of fruit (Kalra *et al.*, 1988).

2.1.2 Medicinal/Pharmalogical Properties

Bittergourd is known to possess many medicinal properties. The fruit is tonic, somachic, stimulant, laxative and is used in rheumatism, gout, disease of spleen and liver and is blood purifier besides controlling diabetes (Kedar and Chakrabarti, 1982). Hypoglycaemic property of bittergourd fruit is reported by Raman and Lau (1996) and Srivastava *et al.* (1993).

Lotlikar and Rao (1966) isolated charantin from bittergourd fruits and observed that it is a non-nitrogenous neutral substance. They further found that charantin lowers blood sugar in fasting rabbits by 42 per cent at 4th hour. The fall being gradual from the 1st to 4th hours and recovering slowly to initial level.

Bhandari and Grover (1998) isolated a steroid glycoside 'charantin' as the active hypoglycaemic principle from *Momordica charantia* plant. They further observed that *M. charantia* containing at least three non steroidal orally active hypoglycaemic principles having pancreatic as well as extra pancreatic mechanism of action. All parts of the plant including leaves, flowers, fruit and seed are extensively used in folk medicines (Sharma and Sharma, 2000). Khan (1999) observed that administration of fresh bittergourd juice in diabetic rabbits caused a fall in blood glucose. The minimal dose required for causing significant effect ($P \leq 0.05$) on blood glucose was 5 ml.

Ali *et al.* (1993) found that pulp juice of bittergourd had a significant hypoglycaemic effect in glucose-fed normal rats when the extract was fed 45 minutes before the oral glucose load. They further concluded that the presence of non-sapogenin hypoglycaemic compound(s) in *M. charantia* fruit pulp is probably mediated either by improving the insulin secretory capacity of the Beta-cells or by improving the action of insulin.

Shah *et al.* (1999) studied the effect of karela powder (*Momordica charantia*) in Qooba (Dermatophytosis) and claimed that karela has the capacity to cure Qooba (Dermatophytosis) upto 48 per cent cases recorded in 30 cases including control group of 10 cases for 40 days application. They further observed that powder is also effective in skin infection by local application.

Majeed and Badmaev (1997) studied the effect of aqueous extract of bittergourd in seven patients with adult onset diabetes in a 7 week open trial and observed significant decrease in the blood sugar level. The baseline mean value of glycosylated haemoglobin was 8.37 mg per cent and after 7 weeks the mean value significantly decreased to 6.95 mg per cent ($P \leq 0.01$).

2.2 PRESERVATION OF BITTERGOURD

The bittergourd is consumed as fresh vegetable. Bittergourd cannot endure long storage after harvest as they are highly perishable at normal atmosphere at ambient temperature. But, it can be successfully preserved by canning, dehydration and pickling.

Kalra *et al.* (1983) screened five cultivars of bittergourd namely ***BG-12, BG-13, BG-14, C-96*** and ***Sel-1*** for their suitability for processing. They found that there was significant loss of ascorbic acid after processing in bittergourd. The cultivar ***BG-14*** was found to be the best for canning followed by ***C-96*** mainly due to their superior colour, texture and flavour. For the purpose of dehydration, the cultivar ***BG-14*** was recommended followed by cultivar ***BG-13***. According to Kalra (1991), the main purpose of blanching before processing is to inactivate the enzymes, to remove raw bitter taste, to stabilize the colour and texture and to reduce the bacterial load.

Manimegalai and Ramah (1998) worked on the effect of pretreatments on quality characteristics of dehydrated bittergourd rings. They found that blanching in 2.0 per cent salt solution had lesser bitter principle and higher retention of chlorophyll. Bittergourd blanched in water (3 min.) and soaked in solution containing 0.3 per cent KMS, 0.1 per cent MgO and 0.1 per cent $NaHCO_3$ for 30 min. were more suitable for preparing dehydrated bittergourd chips with high consumer acceptability. They obtained OD values for the bitter principle (Triterpenoid) in the treated dehydrated bittergourd varieties to differentiate the concentration of bitter principle before and after storage.

Kumar *et al.* (1991) studied the effect of dehydration of bittergourd rings and found that catalase was the most heat resistant enzyme in bittergourds. They observed that blanching 1 cm thick rings for 2 min. in boiling water inactivate all the enzymes present in rings. Among the five treatments tried, blanching rings in 5 per cent NaCl and drying them in a tray drier for 3 hours at 70°C followed by 4 hours drying at 60°C gave dark green, soft textured, slightly salty and less bitter product. Ramah *et al.* (1999) worked on steeping preservation of bittergourd in acidified brine solution. Three varieties of bittergourd were preserved at room temperature by steeping in soak solution containing 2 per cent salt, 0.5 per cent acetic acid and 200 ppm SO_2. They observed significant reduction in ascorbic acid, chlorophyll and bitter principle during the storage period.

Jawahir *et al.* (2001) observed the effect of blanching on pickled bittergourd. They reported that bittergourd fruit slices blanched either in 5 per cent NaCl at 100°C for 3 min. (HTST) or in two stage blanching process in 5 per cent NaCl at 70-80°C for 20 min. (LTLT), followed at 100°C for 3 min. (HTST) was most effective in removing bitterness and maintaining firmness of vinegar pickled products. Effect of blanching was significant ($P \leq 0.05$) on the acceptability of the product. Aggarwal and Kaur (1997) standardized recipe for preparation of bittergourd pickle. Spice recipe having red chillies (4g), Turmeric (4g), Fenugreek (2g), Fennel (2g), Onion seed (2g), acetic acid (1 ml) and salt (20 g) were adjudged best. They observed that pickles from fresh unfried sample attained the same shape and texture even after six months storage.

Rekha *et al.* (1995) worked on preparation of quick cooking bittergourd curry mix and found that soaking of bittergourd pieces in 5 per cent brine for 15 min. followed by blanching and sulphiting before dehydration improved rehydration qualities. Both spice mix.and dried bittergourd remained stable below 0.56 water activity and equilibrated to 10.3 and 12.5 per cent moisture on dry weight basis. Bag-in-bag packaging with bittergourd in Polypropylene (50 micron) and spice mix in metallised Polyester/Polyethylene (0.12 micron/37 LDPE) bags were found to give a shelf life of about 3 months under ambient storage conditions (27°C and 65% RH).

2.3 PULP/JUICE: EXTRACTION AND PRESERVATION

2.3.1 Extraction

Mehta and Bajaj (1983) obtained Kinnow juice through the Screw type juice extractor. Chahal and Saini (1999) recovered watermelon juice by halving the fruits and pressing it against revolving burr of Burrying machine. Bawa and Saini (1987) extracted carrot juice through Screw type juice extractor and obtained 37.1 per cent juice yield.

Shrestha and Bhatia (1982) obtain 74.25 per cent to 85.20 per cent juice yield from different cultivars of apple by pectinase treatment (0.5%) in hydraulic press. Chakraborty *et al.* (1993) recorded 30 per cent juice yield from watermelon fruit when pressed through basket press. Pineapple fruits were pressed after grating yielded 50 per cent juice (Sandhu and Bhatia, 1985).

2.3.2 Preservation

Mehta and Bajaj (1983) preserved juices of three varieties of citrus with pasteurization, sulphur dioxide (700 ppm) and sodium benzoate (0.05%) and found that colour retention during storage was better in samples preserved with sulphur dioxide in comparison with the other two methods of preservation. There was a notable loss of (23.27 to 60.52%) ascorbic acid during 8 months storage interval. Masoodi *et al.* (1992) preserved grape juice by (a) pasteurization at 88°C for 2 minutes and (b) preserved chemically using 350, 450, 550 and 600 ppm of sulphur dioxide as potassium metabisulphite (KMS).

Bawa and Saini (1987) preserved carrot juice with 600 ppm sodium benzoate over a period of six months without adversely affecting the composition and consumer acceptability. Watermelon juice was acidified with citric acid (0.35%) and preserved with sodium benzoate @ 500 ppm (Chakraborty *et al.*, 1993).

Khurdiya (1995) emphasized that benzoic acid is more effective against yeast than moulds and sulphur dioxide is more effective against moulds than yeasts. SO_2 can be used in controlling enzymatic and non-enzymatic browning, preventing oxidation and modifying protein texture.

2.4 DIETETIC PRODUCTS

Schiffman *et al.* (1985) evaluated lemon-lime and cola flavoured beverages sweetened with six sweeteners organoleptically from forty persons of 18 to 34 years old on similarity and adjective scales. Sucrose and aspartame were found statistically equivalent to adjective scale whereas acesulfame and sodium saccharin were most different from sucrose. Wiseman and McDaniel (1991) reported intense fruit flavour in orange and cherry beverages when sweetened with aspartame than with sucrose. However, they found no significant differences between aspartame or sucrose sweetened strawberry flavoured beverages.

Pandey and Nigam (1987) emphasized the importance of non-nutritive sweeteners in food systems for (a) expand food and beverage choice for those who must or want to control caloric carbohydrates or sugar intakes, (b) assist weight control or reduction for consumers concerning about obesity, (c) aid in management of diabetes or sucrose intolerance, (d) assist in control of dental caries and (e) enhance the usage of pharmaceuticals.

Pelgroms (1987) discussed the idea of including a combination of sugars and artificial sweeteners in low energy foods in the preparation for total elimination of the sugar component. Tomar *et al.* (1988) standardize a process for preparation of diabetic jelly and found that treatment having papaya extract and guava extract (50% each) + Sorbitol (30%) + citric acid (0.3%) was adjudged best. Kosmark (1992) prepared low calorie hard candy with (a) sucrose and corn syrup, (b) polydextrose, and (c) polydextrose and isomalt which have calorie content of approximately 288, 194 and 117 K cal, respectively. Saccharin is used as a substitute for sucrose in soft drinks; processed foods like jams, jellies, juices, chewing gums, cosmetics like tooth pastes, mouthwash, lipsticks, pharmaceutical coatings of tablets in tobacco products and more recently in pan masala. It is also used in carbonated drinks (Polasa, 1995).

Barwal (1995) obtained calories reduction in jam up to 28 per cent per serving by the use of non-nutritive sweeteners viz. saccharin, aspartame and cyclamate with similar overall quality and sensory attributes. Pastor *et al.* (1996) prepared low sugar peach nectar with high fruit content (60%), 0.082 to 0.922 g/l aspartame and 0 to 4.0 g/l guar gum. They further found that experimental low calorie sample showed calorie content ranged between 15.1 to 18.9 K cal/100 g compared to 55.15 K cal/100 g in control samples. Barwal and Kalia (1997) prepared low sugar apple jellies by using non-nutritive sweeteners with sweetness proportion (sucrose equivalent) of 25, 50 and 75 per cent along with sugar. They attained 23 per cent reduction in calories per serving without compromising quality.

Sharma (1999) prepared dietetic plum appetizer and found considerable decrease in energy value when sweetened with saccharin (18.16 K cal/100 g) and cyclamate (18.28 K cal/10 g) compared to sucrose (129.71 K cal/100 g). Barwal *et al.* (2002) developed dietetic apricot squash using non-nutritive sweeteners with sweetness proportion (sucrose equivalent) of 25, 50, 75 and 100 per cent along with sugar. Overall acceptability mean score of dietetic squash sweetened with cyclamate at 25 per cent was higher and statistically on a par with standard, indicating that cyclamate can be an appropriate sweeteners for the preparation of dietetic apricot squash. The calories reduction could be achieved upto 25 per cent per serving, without compromising quality.

2.5 NON-NUTRITIVE SWEETENERS

2.5.1 Saccharin

Saccharin is commercially available as acid saccharin, sodium saccharin and calcium saccharin. It is used as a substitute for sucrose in soft drinks and processed foods (Grenby, 1991). The joint committee of FAO/WHO has fixed the acceptable daily intake of saccharin as 2.5 mg/kg of body weight.

2.5.2 Sorbitol

Sorbitol is available in crystalline form and as 70 per cent solution. Sorbitol is generally recognized as safe (GRAS) for use in special dietary foods, breath mints, cough syrup, hard and soft candies and chewing gums. It is 0.5-0.7 times as sweet as sucrose, depending upon the concentration and temperature (BeMiller, 1992).

Small amount of polyol (Sorbitol) added to beverage cause an improvement in mouthfeel. Best results are often achieved by a mixture of sorbitol and sugar. The hydroxyl groups of the sorbitol are less reactive than the aldehyde and ketone group of the sugars. This makes them stable to heat, and they melt without decomposition. They do not undergo Millard reaction and hence browning is minimal on heating. Sorbitol is very little absorbed in the intestine. This represents a calorific value of 2K cal per 100 g. Sorbitol does not give rise to elevated blood sugar levels when eaten (Dias, 1999). Kachhi *et al.* (1988) reviewed the legal status of using polyols in U.S.A. and other countries and observed that sorbitol is included in the list of permitted emulsifying and stabilizing agent (Rule 60). They further found that sorbitol is included in the list of permitted sweetening agents for sugar boiled confectionery (A. 25.01).

Thin layer chromatography (TLC) offers the greatest potential for a rapid and specific method for identification of sorbitol. This method is based on the thin layer chromatographic separation of sorbitol from its potential contaminants, using silica gel G treated with boric acid as the stationary phase and distilled water as the mobile solvent. The sorbitol is detected with an alkaline potassium permanganate spray reagent and its R_f values is compared with that of a sorbitol standard. The average R_f value for sorbitol was found to be 0.66 (Coles and Upton, 1972).

2.6 SAFETY EVALUATION

DuBois (1992) identified five key areas of sweetener performance. Those five area are safety and regulatory status, taste, solubility and cost. Safety and the proper use of sweeteners as well as other food additives are of major concern. In the United States, sweeteners are regulated by the 1958 Food Additives Amendment to the Food, Drug and Cosmetic Act. Under terms of this amendment, there are two ways for a sweetener or food ingredient to be generally recognized as safe (GRAS). The basis to achieve GRAS status may be either i) Scientific procedure or ii) in the case of substances used in food prior to January 1, 1958, through experience based on common use in food (CRF, 1992). The other method of approval is the food additive petition (DuBois, 1992). The pattern require a battery of comprehensive safety tests such as metabolism, pharmacology, toxicity and mutagenicity test. These tests are used to establish safety and an acceptable daily intake (ADI). Taste, solubility, stability and cost are other criteria for choosing an alternative sweetener (DuBois, 1992). Sweetener used outside the United States is regulated by the appropriate organization with each country. However, in an attempt to standardize international regulation of food additives, Food and Agriculture Organization (FAO) of the United Nations and World Health Organization (WHO) established the joint FAO/WHO Expert Committee on Food Additive (JECFA).

2.7 SPICES AND HERBS: HEALTH PROPERTIES AND USES

Herbs and spices have been valued for ages not only for their culinary uses but also for their medicinal properties. These provided the materials used in various systems of alternate medicine such as Ayurveda, Siddha, Unani, Chinese, Tibetan, Neuropathy, Aromapathy, Homeopathy and Flower remedies. Spices and herbs have antibiotic properties and used as drugs for resistant pathogens like those of Malaria, TB or AIDS, as also for treating late onset age-related chronic diseases like arthritis, Perkinson and Aljheimer's diseases, diseases of heart and lung and even cancer (Mandal, 2001).

Griffin (1992) reported that the use of spices in foods is primarily for their consistency of flavour, aroma, sterility, stability in storage and components like essential oils, pigments and natural anti-oxidants contribute health benefits.

Daswani and Bohra (2001) found that aqueous and acetone extracts of *Amomum aromaticum* (Bari Elaichi) of peel and seeds and *Cinnamomum zeylanicum*

(Bark) have shown total inhibition against *Staphylococcus aureus*. Only aqueous extract of seeds of *Foeniculum vulgare* (Saunf), *Myristica fragrans* (Jaiphal) and *Trigonella foenum-graceum* have shown inhibition against *Staphylococcus aureus* bacteria. Shelf (1983) reviewed the antimicrobial properties of spices, spice oils and spice extract in foods. Moleyar and Narsimham (1992) observed that essential oils from ginger and mint inhibited the growth of the food borne microorganisms like *Staphylococcus* spp., *Micrococcus* spp., *Bacillus* spp. and *Enterobacter* spp. Sambaith (1993) reported that active principles of spices e.g. cumin, cinnamon, ginger and mustard reduced cholesterol levels in animals. Meena and Sethi (1994) reported antimicrobial activities of ajowain, mustard, basil, coriander, cumin, clove, ginger and eugenol. Among these, highest antimicrobial activity were recorded by mustard, eugenol and oils from ajowain and clove. Giese (1995) reported anticarcinogenic properties of garlic, ginger mints, various herbs and spices. Patnaik *et al.* (1995) observed antibiotic activity of essential oil from mentha against *Bacillus subtilis* and *Escherichia* coli (*E.coli*). The antimicrobial activity of clove, cinnamon, mustard, ajowain, cumin and coriander were found effective for checking the growth of micro-organisms and found effective against *S. cerevisae, Mycoderma* sp., *B. cereus* and *L. acidophilus* (Meena and Sethi, 1998).

2.8 SPICED PRODUCT DEVELOPMENT

According to Woodroof and Luh (1986) plum fruits were utilized to a limited extent for beverage preparation such as squashes and appetizers. Sethi (1990) developed a nutritious and colourful beverage from fermented black carrot with 3 per cent salt, 1.0 per cent mustard + 0.015 per cent benzoic acid and 0.01 per cent KMS which retained good colour, flavour and taste upto six months at ambient conditions. Sharma *et al.* (1991) developed recipe and processing technology for unfermented plum beverage by the addition of mint extract and aromatic spices and found organoleptically acceptable by the panelists including children than squash without spices. Joshi *et al.* (1993) prepared plum appetizer with various proportion of spices viz. mint extract (0.04%), ginger extract (0.05%), salt (1.3%), black salt (0.7%), cumin (0.25%), cardamom (0.25%), black pepper (0.1%) and citric acid (0.5%) and was adjudged best over those without spices, especially with respect to taste and flavour. Deka and Sethi (2001) standardized spiced lime aonla (95:5%) RTS beverage with common salt (0.5%) + black salt (0.5%), cumin (0.25%), cardamom (0.25%), black pepper (0.1%) ginger extract (2%) and mint (0.4%). They further reported that mango-pineapple (85:15) with cardamom spice drops (0.006%) was best among the RTS beverages prepared from commercial spice drops.

Sharma *et al.* (2002) developed and evaluated spiced plum squash with various combination of spices which had appealing colour, body, taste and sugar:acid blend. The developed squash was analyzed for various physico-chemical and sensory characteristics during storage period of 180 days.

2.9 STORAGE STUDIES: CHANGES IN PHYSICO-CHEMICAL AND SENSORY ATTRIBUTES

Palaniswamy and Muthukrishnan (1974) observed a slight increase of TSS in the case of lemon juice after a storage of seven months. Mehta and Bajaj (1983) obtained similar results in different citrus cultivars after a storage period of eight months. Kumar and Singh (1996) observed increase in TSS, decrease in acidity, pH and ascorbic acid content in tomato juice stored for six months at ambient conditions.

Jain *et al.* (1996) reported that TSS, acidity and viscosity remained unchanged in mango nectar and RTS during storage, but ascorbic acid content was reduced significantly. Similar results were reported in mango nectar by Sahni and Khurdiya (1989).

Pandey *et al.* (1995) reported that spiced raw mango beverage (pana) processed for 10-15 minutes had nominal variation in acidity and salt content after 9 months of storage, while total sugars and ascorbic acid contents decreased significantly. Organoleptic evaluation showed that beverage prepared without sugar was adjudged best after 9 months of storage.

Sahni and Kumar (1998) reported the cause of both enzymatic and non-enzymatic reactions results in organoleptic defects and deterioration of foods during processing and storage. Enzyme polyphenol oxidase (PPO-EC.1.14.18.1) is responsible for browning in fruits and vegetables including fruit juices.

Saini and Pal (1997) while working on the storage stability of Kinnow juice reported that there was negligible change in TSS, TS, pH, ash and viscosity whereas, ascorbic acid content decline significantly under room temperature. Reducing sugar during the storage period of 6 months found to be increased significantly.

Chauhan and Sharma (1996) reported slight increase in acidity and decrease in protein content and vitamin C in apricot-soy fortified beverage. Ranote *et al.* (1993) while evaluating thermal process and shelf life of Kinnow juice observed marginal decline in TSS, pH, acidity and total sugars, but significant increase in reducing sugars. There was decrease in ascorbic acid content during storage period of six months. Chahal and Saini (1999) noticed no change in TSS, specific gravity, viscosity and ash content in hybrid variety of watermelon juices during six month of storage period. There was increase in acidity with considerable loss of ascorbic acid.

Bawa and Saini (1987) observed significant increase in reducing sugars, whereas soluble solids, pH and acidity remained almost constant in carrot juice during six months of storage interval irrespective of temperature. Total sugars decreased significantly. The changes in reducing sugars were found to be considerable in RTS drink prepared from different combination of Dashehari and Banganpalli mangoes as reported by Srivastava (1998).

Shrestha and Bhatia (1982) reported no change in TSS whereas, acidity, reducing sugars and non-enzymatic browning increased during four months of storage interval. Jain *et al.* (1984) observed increase in reducing sugars, TSS, but gradual loss in ascorbic acid content of orange, lemon and bale squashes during 12 months storage period. Chakraborty *et al.* (1993) observed no changes in chemical characteristics of watermelon juice during storage period of four months, but observed reduction in reducing sugars content in watermelon RTS beverage stored at room temperature for four months.

Non-significant changes were noticed in total acids, acid insoluble ash and total ash, but highly significant changes were noticed in reducing sugars, non-reducing sugars, non-enzymatic browning and ascorbic acid during storage of papaya nectar for 9 months (Aruna *et al.*, 1997). Thakur and Barwal (1998) reported slight decrease in total sugars content and acidity in Kiwifruit squash during storage of 150 days and observed slight increase of TSS in Allison cultivar upto 60 days of storage period.

Sharma *et al.* (2001) observed slight increase in TSS and reducing sugars, but slight decrease of moisture and acid content while working on the effect of storage temperature and folds of concentration on quality characteristics of galgal juice concentrates. Krishnaveni *et al.* (2001) studied the storage stability of Jack fruit RTS beverage and showed that there was increasing trend in the acidity and reducing sugars and decreasing trend in pH, total sugars and ascorbic acid content during storage. Sharma *et al.* (2002) recorded non-significant increase in TSS, but significant increase in reducing sugars during six months of storage interval. The spiced squash had appealing colour, body, taste and sugar:acid blend.

Sensory evaluation after 40 weeks storage at different temperature revealed non-significant variation in cola beverages sweetened with sucrose, aspartame and saccharin (Homler, 1984). Ragab (1987) reported increase in total sugars in apricot jam sweetened with saccharin and xylitol during storage. The increase was apparently due to hydrolysis of starch and conversion of non-reducing sugars into reducing sugars. Barwal (1995) observed an increase in reducing sugars and total solid contents and decrease in moisture and total sugar contents in dietetic apple preserves. Despite the changes observed in various attributes, an overview of quality parameters at different storage intervals were statistically non-significant and the preserve(s) remained quite acceptable. Barwal *et al.* (2002) recorded continuous decrease in TSS as the share of non-nutritive sweeteners increased due to non-addition of TSS by alternative sweeteners. Slight decrease in total sugars and increase in reducing sugars were recorded in dietetic apricot squash during 240 days of storage interval.

MATERIALS AND METHODS

Chapter-3

MATERIALS AND METHODS

The present investigation entitled "Processing of bittergourd for the production of dietetic beverages", was carried out in the Department of Postharvest Technology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan during 2000-2002. The objectives of the study were to develop techniques for the extraction and preservation of bittergourd juice; and preparation and evaluation of dietetic bittergourd RTS and spiced squash for the masses in general and health conscious, obese and diabetic subjects in particular. To achieve the objectives, different experiments were laid down and standardized in sequence. The best results obtained from first experiment were incorporated in the next experiment of the investigation.

3.1 PROCUREMENT OF RAW MATERIALS

3.1.1 Bittergourd

Mature and green fruit of bittergourd cultivar 'Solan Hara' were procured from the local market, Solan (H.P.). Fruits were sorted, graded and washed thoroughly in water to remove adherent foreign materials.

3.1.2 Spices and herbs

Various spices and herbs viz. cardamom, cumin, black pepper, common salt, black salt and mentha were purchased from local market, Solan (H.P.). Fresh ginger purchased from local market was washed thoroughly, peeled manually and passed through Screw type juice extractor to extract juice. Ginger extract was stored for further use under refrigerated conditions. Fresh mint leaves were washed, crushed in a blender and squeezed through muslin cloth to get extract. Mint extract was also stored under refrigerated conditions for further use.

Cardamom, cumin and black pepper were dried in an oven at 60°C for 24 hrs and ground in the super mixer grinder MX-1155. Ground spices were packed in air tight capped glass jars for the preparation of bittergourd spiced squash.

3.1.3 Non-nutritive sweeteners

Non-nutritive sweeteners viz. saccharin and sorbitol were purchased from M/S Devinder Cottage Industries, Chandigarh.

3.2 PRODUCT DEVELOPMENT

3.2.1 Experiment-I: Standardization of juice extraction from bittergourd fruits

3.2.1.1 Spiral pressing

Bittergourd fruits were cut horizontally into 4-6 pieces and passed through Spiral press and juice was collected.

3.2.1.2 Carrot juice extractor

4 to 8 pieces (depending on size) of bittergourd fruits were put into Carrot juice extractor and superfluous juice was collected.

3.2.1.3 Basket pressing

Fruits of bittergourd were passed through the grater and grated material was pressed by Basket press. Extracted juice was collected.

3.2.2 Experiment-II: Standardization of methods for preservation of bittergourd juice

The method standardized in experiment-I was used for further extraction of bittergourd juice. Extracted juice from the bittergourd fruit was acidified with 0.5 per cent citric acid, divided into three lots and preserved immediately by the following methods.

i) First lot was filled in glass jars (10 litre capacity) and preserved by the addition of sulphur dioxide @ 1000 ppm from KMS (1000 ppm SO_2 + 0.5% CA).

ii) Second lot also filled in glass jars (10 litre capacity) and preserved by the addition of sodium benzoate @ 750 ppm (750 ppm sodium benzoate + 0.5 % CA).

iii) Third lot was filled in 600 ml bottles and pasteurized (pasteurization + 0.5% CA).

Preserved juice was stored at ambient conditions (Annexure-I) and analysed for physico-chemical and microbial characteristics at 0, 2, 4 and 6 months of storage intervals.

3.2.3 Experiment-III: Standardization of bittergourd RTS

RTS were prepared using three combinations of bittergourd juice with different levels of total soluble solids (TSS) as per details mentioned in Table 1.

Table 1. Ingredients used for preparation and development of bittergourd RTS

Treatments	TSS (°Brix)	Juice (%)
T_1	10.00	10.00
T_2	10.00	15.00
T_3	10.00	20.00
T_4	12.50	10.00
T_5	12.50	15.00
T_6	12.50	20.00
T_7	15.00	10.00
T_8	15.00	15.00
T_9	15.00	20.00

RTS were prepared from the freshly extracted bittergourd juice. Sugar syrup was prepared separately, strained through muslin cloth, cooled and added to the calculated quantity of bittergourd juice. Pre-standardized amount of colour and flavour were added and RTS was filled into pre-cleaned sterilized dried bottles of 200 ml capacity, crown corked and processed for 30 minutes in boiling water. The bottles were cooled, labelled and analysed for various sensory characteristics. Unit operations used for the preparation of RTS is given in Fig-1.

3.2.4 Experiment-IV: Development of dietetic bittergourd RTS

RTS prepared in Experiment-III were evaluated for sensory characteristics by a panel of 10 judges. The recipe of best rated treatment from experiment-III was selected for the development of dietetic RTS. Sugar (sucrose) sweetness was replaced with equi-sweetness of saccharin and sorbitol at different proportions 25, 50, 75 and 100 per cent as mentioned in Table 2.

Table 2. Experimental details for the development of dietetic bittergourd RTS

Treatments	Per cent sweetness equivalent used		
	Sucrose	+	Non-nutritive sweeteners
T_1	100	+	0 (Standard)
T_2	75	+	25 (Saccharin)
T_3	75	+	25 (Sorbitol)
T_4	50	+	50 (Saccharin)
T_5	50	+	50 (Sorbitol)
T_6	25	+	75 (Saccharin)
T_7	25	+	75 (Sorbitol)
T_8	0	+	100 (Saccharin)
T_9	0	+	100 (Sorbitol)

Sugar syrup was prepared by boiling the calculated amount of sugar and water, cooled to room temperature and mixed with the juice. Saccharin was dissolved in small quantity of water and added to the mixture. Sorbitol was added as such and mixed well. Colour and flavour were first diluted and added to the product which was hot filled in pre-cleaned, sterilized dried bottles of 200 ml capacity. After sealing and labelling, bottles were stored at ambient conditions (Annexure-I) and analysed on preparation day and after 2, 4 and 6 months of storage intervals.

3.2.5 Experiment-V: Standardization of bittergourd spiced squash

Three combinations each of juice (25, 30 & 35%), total soluble solids (40, 45 & 50°B) and spice recipes (S_1, S_2 & S_3) were taken to develop bittergourd spiced squash as per detail mentioned in Table 3.

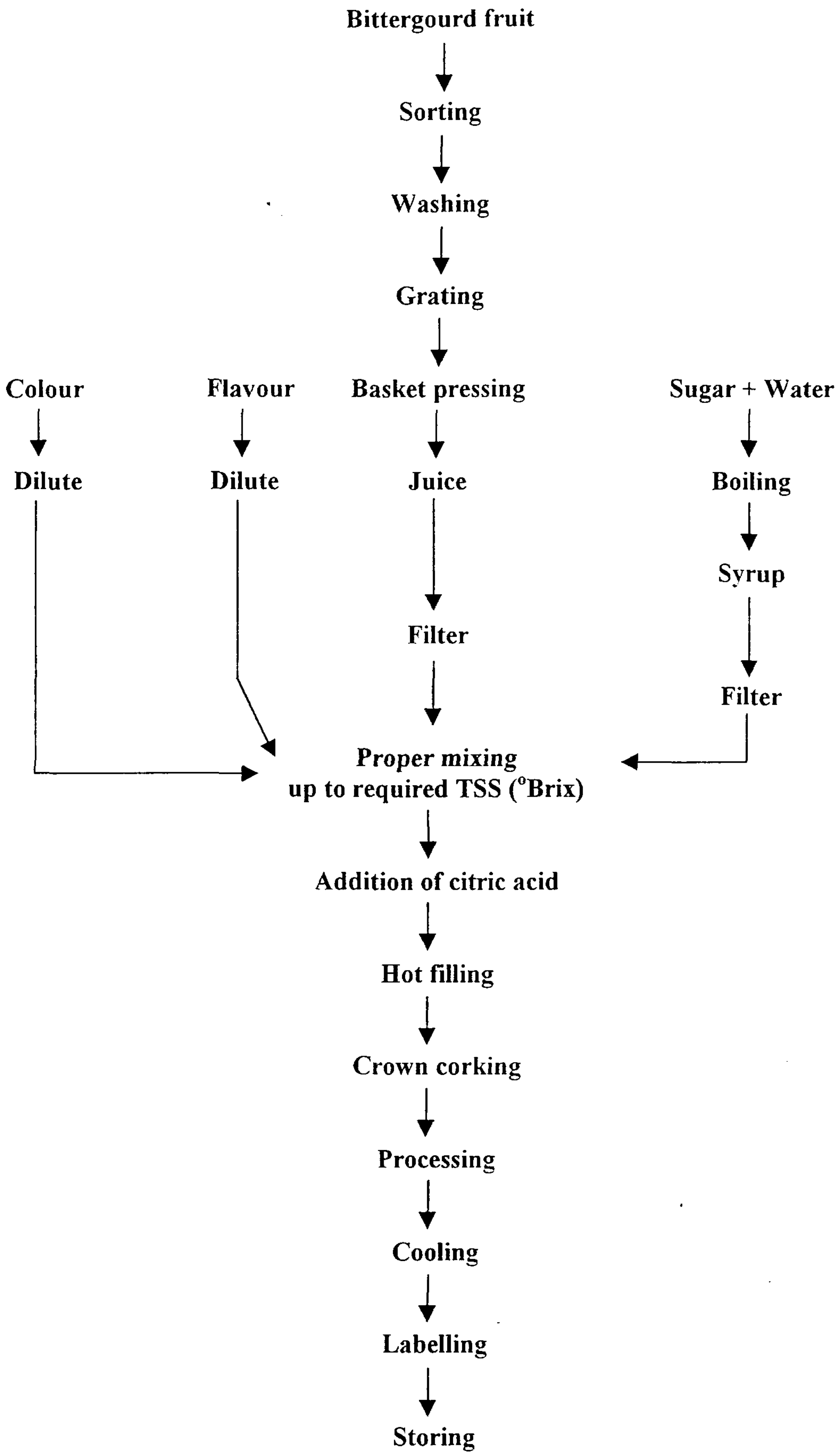

Fig. 1. Flow diagram for preparation of bittergourd RTS

Spiced squashes were prepared from fresh juice. Sugar syrup was prepared separately, strained through muslin cloth, cooled and added to the calculated quantity of juice. Pre-determined quantities of cardamom, cumin, black pepper, common salt and black salt as per recipes in Table-4 were boiled in 200 ml water, strained through muslin cloth and added to mixture of juice and sugar syrup. Then, mint and ginger extracts were added as per recipe (Table 4). Citric acid @ 1.00 per cent and SO_2 @ 350 ppm along with colour and flavour were added to the product and mixed well. The prepared squash was filled in the pre-cleaned, sterilized dried bottles of 200 ml capacity, crown corked, labelled and analysed for sensory characteristics. Unit operations used for the preparation of bittergourd spiced squash is given in Fig. 2.

Table 3. Ingredients used for preparation and development of bittergourd spiced squash

Treatments	TSS (°Brix)	Juice (%)	Spice recipe
T_1	40	25	S_1
T_2	40	25	S_2
T_3	40	25	S_3
T_4	40	30	S_1
T_5	40	30	S_2
T_6	40	30	S_3
T_7	40	35	S_1
T_8	40	35	S_2
T_9	40	35	S_3
T_{10}	45	25	S_1
T_{11}	45	25	S_2
T_{12}	45	25	S_3
T_{13}	45	30	S_1
T_{14}	45	30	S_2
T_{15}	45	30	S_3
T_{16}	45	35	S_1
T_{17}	45	35	S_2
T_{18}	45	35	S_3
T_{19}	50	25	S_1
T_{20}	50	25	S_2
T_{21}	50	25	S_3
T_{22}	50	30	S_1
T_{23}	50	30	S_2
T_{24}	50	30	S_3
T_{25}	50	35	S_1
T_{26}	50	35	S_2
T_{27}	50	35	S_3

Table 4. Proportion of spices and herbs used for the preparation of 100 ml bittergourd spiced squash

Particulars	Spice recipes		
	S_1	S_2	S_3
Mint extract (ml)	0.50	1.00	1.50
Ginger extract (ml)	1.00	1.50	2.00
Common salt (g)	0.50	1.00	1.50
Black salt (g)	0.50	1.00	1.50
Cumin (g)	0.25	0.50	0.75
Cardamom (g)	0.10	0.20	0.30
Black pepper (g)	0.25	0.50	0.75

3.2.6 Experiment-VI: Development of dietetic bittergourd spiced squash

Spiced squashes prepared in Experiment-V were evaluated for sensory characteristics by a panel of 10 judges. The recipe of best rated treatment from experiment-V was selected for the preparation of dietetic bittergourd spiced squash. Sugar (sucrose) sweetness was replaced with equi-sweetness of saccharin and sorbitol at different proportions (25, 50, 75 and 100 per cent) as mentioned in Table 5 for the preparation of dietetic bittergourd spiced squash.

Table 5. Experimental details for the development of dietetic bittergourd spiced squash

Treatments	Per cent sweetness equivalent used		
	Sucrose	+	Non-nutritive sweeteners
T_1	100	+	0 (Standard)
T_2	75	+	25 (Saccharin)
T_3	75	+	25 (Sorbitol)
T_4	50	+	50 (Saccharin)
T_5	50	+	50 (Sorbitol)
T_6	25	+	75 (Saccharin)
T_7	25	+	75 (Sorbitol)
T_8	0	+	100 (Saccharin)
T_9	0	+	100 (Sorbitol)

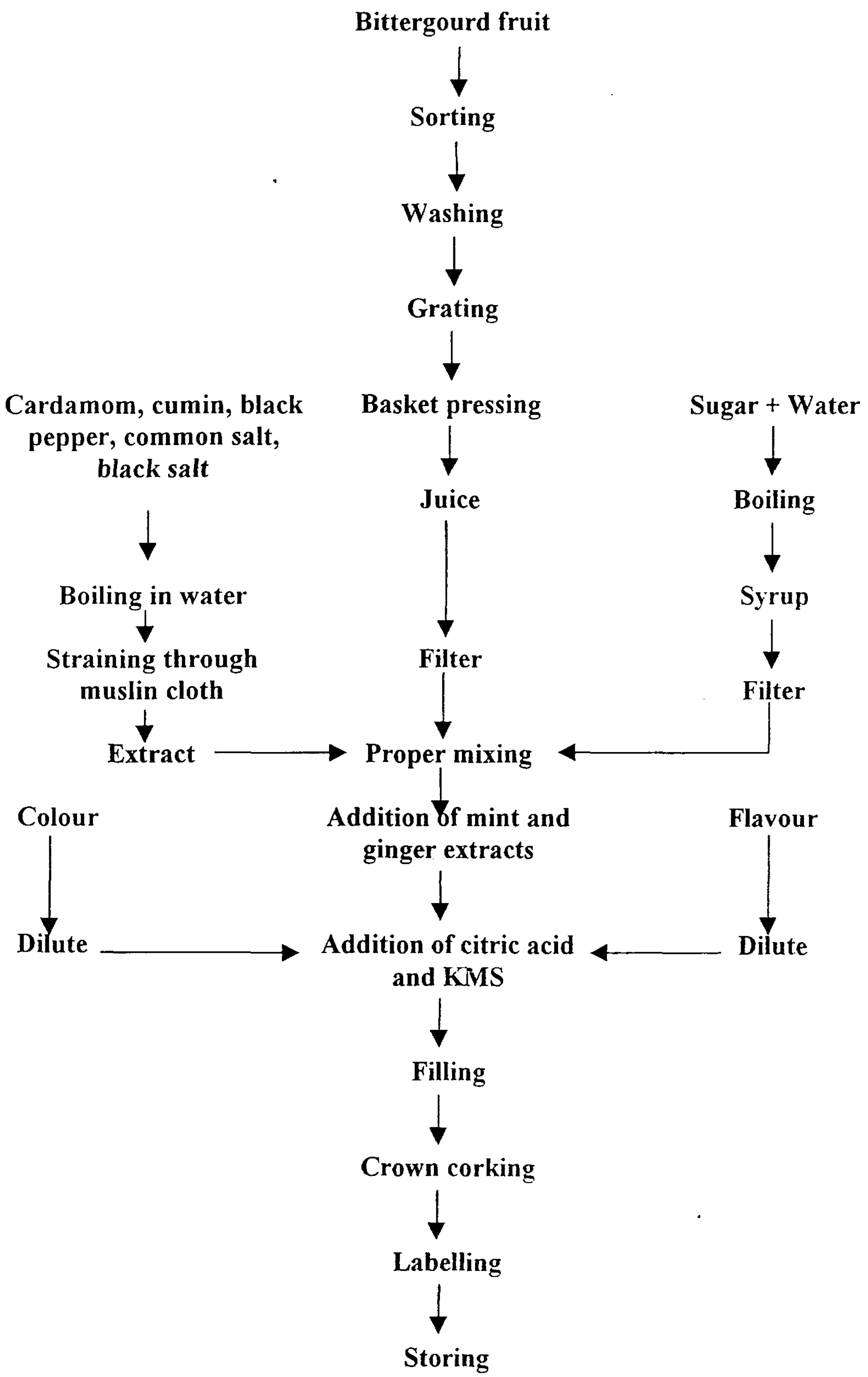

Fig. 2. Flow diagram for preparation of bittergourd spiced squash

Sugar syrup was prepared by boiling the calculated amount of sugar and water, cooled at room temperature and mixed with the juice. Calculated quantity of saccharin for each treatments were dissolved in water and mixed with the juice. Sorbitol was added as such. Extracts of spices and herbs were added along with the calculated amount of non-nutritive sweeteners to the mixture. Citric acid @ 1.00 per cent and SO_2 @ 350 ppm along with colour and flavour were added. Prepared product was filled in pre-cleaned, sterilized dried bottles of 700 ml capacity. After sealing and labelling, bottles were stored at ambient conditions (Annexure-I) and analysed on preparation day and after 60, 120 and 180 days of storage intervals.

3.3 METHODS OF ANALYSIS

Fruit size

To know fruit size, length and diameter were taken into consideration and measured with the help of Vernier Calliper. Ten fruits were selected at random and the average fruit size (length and diameter) was calculated and expressed in centimeters (cm).

Fruit weight

Ten fruits were selected at random and weighed on Top Pan Balance individually and average fruit weight was calculated and expressed in g/fruit

Juice recovery

Juice yield was measured from 10 kg fruit, extracted through Spiral press, Carrot grater and Basket pressing after grating

$$\text{Per cent juice} = \frac{\text{Juice yield (litre)}}{\text{Fruit taken (10 kg)}} \times 100$$

Relative Viscosity

Relative viscosity was determined according to method and procedure reported by Ranganna (1986).

$$\text{Relative viscosity} = \frac{\text{Time required by product to pass through capillary (seconds)}}{\text{Time required by water to pass through same capillary (seconds)}}$$

Total soluble solids (TSS)

Total soluble solids were measured by Hand refractometers (Erma) of 0-32°B and 28-62°B range. The results were expressed as degree Brix (°B). Correction factor was applied as given by Lal *et al.* (1986).

Titratable acidity

Titratable acidity was estimated by titrating a known volume of sample against 0.1 N NaOH solution using phenolphthalein as an indicator (AOAC, 1980). The titratable acidity was calculated and expressed as per cent citric acid (% CA).

$$\text{Per cent acidity (as CA)} = \frac{\text{Titre value x 0.1 N NaOH x 64 x Volume made x 100}}{\text{Weight/Volume taken x Aliquot taken x 1000}}$$

Sugars

Sugars were estimated according to Lane and Eynon's Volumetric method (Ranganna, 1986) by titrating the sample against Fehling solutions and expressed in percentage.

a) $$\text{Per cent reducing sugars} = \frac{\text{Factor x Dilution x 100}}{\text{Titre value x Weight or volume of sample}}$$

b) Per cent total sugars (as invert sugars) = Calculated as in (a) making use of titre value obtained in the determination of total sugars after inversion.

c) Non-reducing sugars = (Total sugars as invert sugars - Reducing sugars) x 0.95

d) Per cent total sugars = Per cent reducing sugars + Per cent non-reducing sugars

Ascorbic acid

Ascorbic acid content was determined as per AOAC (1980) using 2, 6-dichlorophenol-indophenol dye. The sample was extracted in 3 per cent HPO_3 solution and titrated with the dye to pink end point. The results were expressed as mg/100 g of sample.

Salt

Salt as sodium chloride (NaCl) was measured by Mohr's direct titration method. An aliquot of sample was titrated with 0.1 N silver nitrate solution using 5.0 per cent potassium chromate as indicator to a red brown end point (Ranganna, 1986).

$$\text{Per cent salt (as NaCl)} = \frac{\text{(Sample titre - Blank titre) x 0.1N of } AgNO_3 \text{ x Volume made x 58.45 x 100}}{\text{Aliquot taken x Weight of sample x 1000}}$$

Saccharin

Sample containing saccharin was extracted in the separating funnel by diethyl ether. Ether was evaporated on water bath and left over residue was dissolved in 5 ml acetone and 4 ml distilled water and titrated with 0.05 N NaOH solution using bromothymol blue as an indicator (Ranganna, 1986).

1 ml of 0.05 N NaOH = 0.00916 g of saccharin

Sorbitol

Sample containing sorbitol was identified by thin layer chromatographic separation method using silica gel G treated with boric acid as stationary phase and distilled water as the mobile solvent. The sorbitol was detected with an alkaline permanganate spray reagent and its R_f value is compared with that of sorbitol standard (Coles and Upton, 1972).

KMS (SO_2)

The sulphur dioxide (ppm) was measured by using the modified Ripper titration method as described by Ranganna (1986).

1 ml of 0.02 N Iodine = 0.64 mg of SO_2

$$SO_2 \text{ (ppm)} = \frac{\text{Titre x 0.64 x 1000}}{\text{Weight of sample}}$$

Energy value

Energy value of the bittergourd RTS and spiced squash was calculated by taking into account the amount of carbohydrates, proteins, fats and sorbitol present in the RTS and spiced squash. The contents of each nutrient were multiplied by a conversion factor as reported by Holland (1992) and Kalia and Sood (1996) and expressed in K cal/100 g of bittergourd RTS and spiced squash.

3.4 MICROBIAL STUDIES

Total plate count of microorganisms were taken according to the method given by Harrigan and McCance (1966). Nutrient agar media was prepared as per composition:

3.4.1 Composition of nutrient agar media*

Peptone	:	5.0 g
Beef extract	:	3.0 g
Agar	:	20.0 g
Water	:	1000 ml
pH	:	7.0

*Sterilization in autoclave at 15 lbs per sq. inch pressure for 20 minutes

Petriplates were inoculated @ 1 ml with 10^{-2} dilution of RTS and spiced squash and incubated at $30 \pm 2^{\circ}C$ temperature for 48-72 hrs. Number of colonies formed were counted. The microbial population was expressed as cfu x 10^{2}/ml of RTS and spiced squash.

3.5 SENSORY EVALUATION

The sensory evaluation of the products were conducted by a panel of 10 judges. Each judge was provided with a glass of fresh water to rinse the mouth before evaluating the next sample. Each sample was evaluated for various quality attributes viz. colour, taste, flavour, body and overall acceptability on 9 points hedonic scale signifying:

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

Judges were asked to rate the samples on a prescribed sensory evaluation performa (Annexure-II & III).

3.6 STATISTICAL ANALYSIS

The data of quantitative estimation of various physico-chemical characteristics of different products were analysed by Complete Randomized Design (CRD), while the data of sensory evaluation were analyzed by Randomized Block Design (RBD) as described by *Panse and Sukhatme (1967).*

RESULTS AND DISCUSSION

Chapter-4

RESULTS AND DISCUSSION

The present investigation entitled, "Processing of bittergourd for the production of dietetic beverages" was conducted in the Department of Postharvest Technology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.). The results are presented and discussed in this chapter under the following heads:

4.1 Physico-chemical characteristics of bittergourd (cv. Solan Hara)

4.2 Standardization of juice extraction from bittergourd fruit

4.3 Standardization of methods for preservation of bittergourd juice

4.4 Standardization of recipe for the development of bittergourd RTS on the basis of sensory characteristics

4.5 Physico-chemical characteristics of organoleptically best rated (standard) bittergourd RTS

4.6 Standardization of recipe for the development of bittergourd spiced squash on the basis of sensory characteristics

4.7 Physico-chemical characteristics of organoleptically best rated (standard) bittergourd spiced squash

4.8 Storage studies in relation to different physico-chemical, microbial and sensory attributes of dietetic bittergourd RTS and spiced squash

4.9 Cost of production

4.1 PHYSICO-CHEMICAL CHARACTERISTICS OF BITTERGOURD (CV. SOLAN HARA) FRUIT

The data presented in Table 6 on physico-chemical characteristics of bittergourd (cv. Solan Hara) fruit revealed that average weight per fruit was 51.50$\pm$2.27 g. The fruit length and diameter were 11.48$\pm$1.57 cm and 2.63$\pm$0.33 cm, respectively. Kalra *et al.* (1988) studied physical characters of bittergourd and found considerable variations among the cultivars.

Table 6. **Physico-chemical composition of fresh bittergourd (cv. *Solan Hara*) fruit**

Characteristics	Fruit (Mean±SD)
A. Physical*	
Fruit weight (g)	51.50±2.27
Fruit size:	
a) Fruit length (cm)	11.48±1.57
b) Fruit diameter (cm)	2.63±0.33
B. Chemical	
TSS (°Brix)	3.00±0.04
Titratable acidity (% CA)	0.056±0.002
Ascorbic acid (mg/100 g)	88.40±0.09
Reducing sugars (%)	2.50±0.11
Total sugars (%)	2.80±0.18

* Mean of 10 fruits

The total soluble solids (TSS) in fruit was 3.00±0.04° Brix. Titratable acidity was 0.056±0.002 per cent. The bittergourd fruit contained 88.40±0.09 mg/100 g as ascorbic acid. It shows that the fruit were good source of vitamin-C which has nutritional importance. Total sugars (2.80±0.18%) and reducing sugars (2.50±0.11%) were recorded in fruit. Similar values were reported for various physico-chemical characteristics of bittergourd by Kalra *et al.* (1988) and Manimegalai and Ramah (1998). Variation from the earlier studies for different parameters observed may be attributed to different cultivars and agro-climatic factors which prevailed during the growing season.

4.2 STANDARDIZATION OF JUICE EXTRACTION FROM BITTER-GOURD FRUIT

Bittergourd (cv. Solan Hara) fruits were procured in two lots from the local market, Solan (H.P.) and brought to the canning unit of the Department of Postharvest Technology. 10 kg of fruits were taken for each extraction process. Bittergourd juice was extracted by Spiral pressing, Carrot grater and Basket pressing after grating. The highest juice recovery was obtained in case of Basket pressing after grating (50%)

followed by Spiral pressing (30%) and the lowest yield observed was 10 per cent in case of Carrot grater (Table 7). Similar findings of the juice yield were reported by Shrestha and Bhatia (1982), Sandhu and Bhatia (1985) and Chakraborty *et al.* (1993).

Therefore, Basket-pressing after grating was chosen for extraction of juice from bittergourd fruit for further studies

Table 7. Standardization of juice extraction from bittergourd fruit

Extraction process*	Juice recovery (%)
1 Spiral pressing	30.00
2 Carrot Grater	10.00
3 Basket pressing after grating	50.00

* 10 Kg of fruits were taken for each juice extraction

4.3 STANDARDIZATION OF METHODS FOR PRESERVATION OF BITTERGOURD JUICE

A method was standardized for the preservation of bittergourd juice for 180 days (6 months) of storage The juice was preserved with sulphur dioxide @ 1000 ppm + 0.5 per cent citric acid, sodium benzoate @ 750 ppm + 0.5 per cent citric acid and pasteurized in presence of 0.5 per cent citric acid. Physico-chemical and microbiological characteristics of bittergourd juice at different storage intervals are presented in Table 8.

TSS remained non-significant for all the methods during 180 days of storage period. A slight increase was observed in TSS at 120 days of storage interval but remained statistically non-significant (Table 8). Similar increase in TSS was recorded by Kumar and Singh (1996) in tomato juice during storage. Palaniswamy and Muthukrishnan (1974) found slight increase of TSS in lemon juice after 7 months of storage

From Table 8, it is discernible that ascorbic acid content of bittergourd juice ranged from 88.40 to 53.04 mg/100 g. Maximum ascorbic acid content (88.40 mg/100 g) was observed in sulphur dioxide preserved juice while minimum (53.04 mg/100 g) was observed in pasteurized juice. It is due to the fact that heat treatment during pasteurization might have degraded the ascorbic acid. Sharma *et al.* (2001) also reported the loss of ascorbic acid during the concentration of galgal juice. There was significant decrease of ascorbic acid during storage period of 180 days (Table 8). The ascorbic acid decreased rapidly during first 60 days of storage, thereafter, decrease was slow but remained statistically significant at 120 and 180 days of storage. Lowest ascorbic acid content (26.05 mg/100 g) was observed after 180 days of storage period in pasteurized bittergourd juice. Ranote *et al.* (1993) and Kumar and Singh (1996) observed a significant decrease of ascorbic acid in kinnow and tomato juice at room temperature during 160 and 180 days of storage, respectively.

The perusal of data in Table 8 indicates that reducing sugars ranged between 2.50 and 2.60 per cent. Highest reducing sugars (2.60%) were recorded in pasteurized juice, while the juice preserved with sulphur dioxide and sodium benzoate had 2.50 per cent reducing sugars. An increase in reducing sugars was observed with the advancement of storage period upto 6 months. The increase might be due to the hydrolysis of non-reducing sugars into reducing sugars. Bawa and Saini (1987) also observed an increase in reducing sugars of carrot juice during 6 months of storage. Chahal and Saini (1999) obtained similar results on storability of watermelon juice.

Data presented in Table 8 further show that highest percentage of total sugars (2.80%) was recorded in the juice preserved with sulphur dioxide and sodium benzoate. Slight decrease in total sugars was observed in the pasteurized juice during storage. It was further found that with the advancement of storage period, total sugars decreased but remained statistically non-significant with each other. After 6 months of storage, total sugars were found to be 2.70 per cent in all the methods of preservation. Chakraborty *et al.* (1993) also observed non-significant decrease in total sugars of RTS sweetened juice during storage of 150 days. Bawa and Saini (1987) observed similar results on the storage quality of carrot juice.

No microbial count was detected in the juice on preservation day in all the three methods (Table 8). However, the total microbial count after 60 days of storage was 67 cfu/g and 69 cfu/g in juice preserved with sulphur dioxide and pasteurization respectively. Full plate growth of microbial flora, mostly fungi was observed in sodium benzoate preserved juice after 60 days of storage. Sodium benzoate is least

Table 8. Physico-chemical and microbial characteristics of bittergourd juice at different storage intervals

Methods	Days after storage																							
	0						60						120						180					
	TSS	AA	RS	TS	MC	CO	TSS	AA	RS	TS	MC	CO	TSS	AA	RS	TS	MC	CO	TSS	AA	RS	TS	MC	CO
Sulphur dioxide (1000 ppm + 0.5 CA)	3.00	88.40	2.50	2.80	-	Colour remain green	3.00	84.80	2.50	2.80	0.67	Colour bleached to pale green	3.02	80.00	2.60	2.70	0.68	Fully bleached to whitish green	3.02	76.70	2.60	2.70	0.69	Whitish green
Sodium benzoate (750ppm + 0.5% CA)	3.00	88.20	2.50	2.80	-	Colour remain green	3.00	83.50	2.50	2.80	Full plate growth	Colour change to brown	3.02	79.05	2.60	2.70	Full plate growth	Dark brown	3.02	76.01	2.60	2.70	Full plate growth	Dark brown with off odour
Pasteurization (0.5% CA)	3.00	53.04	2.60	2.70	-	Colour changes to pale green	3.00	40.85	2.60	2.70	0.69	Colour remain dull green	3.02	32.68	2.70	2.70	0.70	Dull green	3.02	26.05	2.70	2.70	0.72	Dull green
$CD_{0.05}$	NS	0.33	0.003	0.009			NS	0.47	0.002	0.001			NS	0.28	0.005	NS			NS	0.52	0.001	0.008		

Abbreviations:

TSS: Total soluble solids (° Brix)
AA: Ascorbic acid (mg/100 g)
RS: Reducing sugars (%)
TS: Total sugars (%)
MC: Microbial count cfu$\times 10^2$/ml
CO: Comment

Plate 1. Full plate growth of fungi from juice preserved by sodium benzoate after 60 days of storage

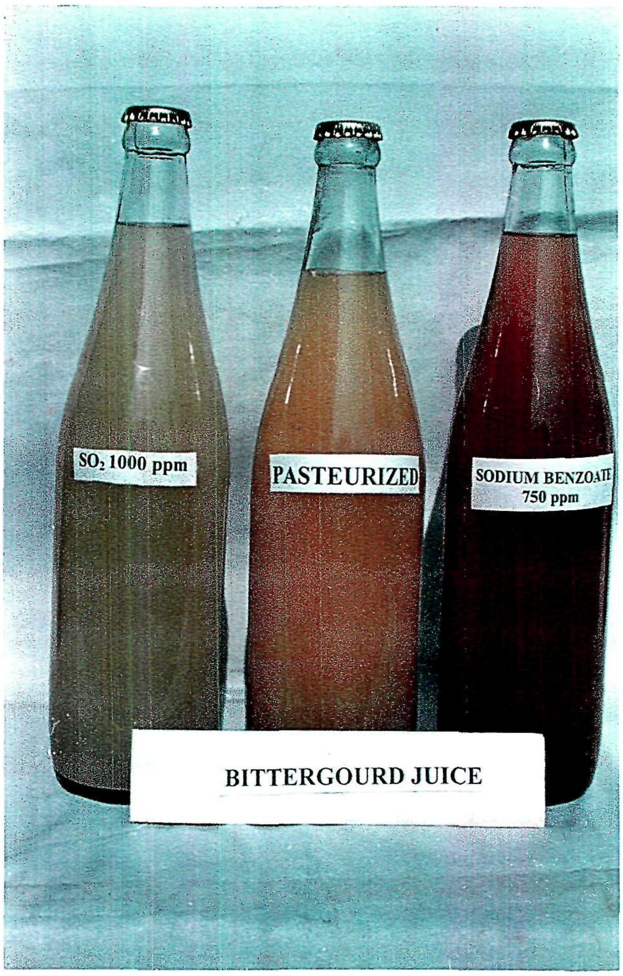

Plate 2. Preservation of bittergourd juice by SO_2, sodium benzoate and pasteurization

effective against fungi than yeast (Khurdiya, 1995). Juice preserved with sulphur dioxide and pasteurization remained stable at 120 and 180 days of storage intervals. Full plate growth of microbial population was observed in sodium benzoate preserved juice after 60 days and onward storage intervals, which rendered it unfit for consumption.

Immediately after preservation treatments, colour of the juice remained green (natural) with sulphur dioxide and sodium benzoate whereas, it changed to pale green in pasteurized juice. After 60 days of storage, the colour bleached to pale green of juice preserved by sulphur dioxide. The colour of the pasteurized juice remained dull green (Table 8). Juice colour of sodium benzoate preserved juice was changed to brown after 60 days of storage. At 120 days of storage interval, sulphur dioxide preserved juice was fully bleached to whitish green. It might be due to the bleaching action of sulphur dioxide (Khurdiya, 1995). However, pasteurized juice colour remained dull green after 120 days of storage. Further browning of colour was observed in sodium benzoate preserved juice which might be due to polyphenol oxidase (Sahni and Kumar, 1998). After 180 days of storage, the juice colour observed was whitish green with sulphur dioxide and dark brown having off odour (spoiled) with sodium benzoate. Colour remained dull green in pasteurized juice after 180 days of storage interval.

It is evident from Table 8 that there was significant decrease of ascorbic acid by pasteurization. Moreover, the juice preserved with sodium benzoate was microbiologically unstable. In both these preservation methods, juice colour was found unacceptable visually and lacked in appeal for further product development. However, the juice preserved with sulphur dioxide containing 0.5 per cent citric acid was rated physico-chemically and microbiologically good/stable during 6 months of storage period.

4.4 STANDARDIZATION OF RECIPE FOR THE DEVELOPMENT OF BITTERGOURD RTS ON THE BASIS OF SENSORY CHARACTERISTICS

Data in Table 9 depict the sensory evaluation scores for different quality parameters of bittergourd RTS prepared by using different ingredients (Table 1).

Table 9. Effect of different treatments on sensory characteristics* of bittergourd RTS

Treatments	Colour	Flavour	Taste	Body	Overall acceptability
T_1	7.60	7.74	7.59	7.417	7.59
T_2	7.35	7.57	7.13	7.418	7.36
T_3	6.01	5.13	4.51	7.418	5.78
T_4	7.67	7.85	7.76	7.418	7.68
T_5	7.20	7.41	7.07	7.416	7.27
T_6	6.00	5.15	5.54	7.416	5.78
T_7	7.61	7.64	7.36	7.418	7.50
T_8	7.29	7.38	6.97	7.419	7.26
T_9	6.00	5.12	4.52	7.418	5.70
$CD_{0.05}$	0.16	0.21	0.18	NS	0.06

* Rating on 9-point Hedonic scale

9 = Like extremely
1 = Dislike extremely

Colour

The colour score (7.67) was highest for T_4 and lowest (6.00) for T_9 and T_6 (Table 9). T_4 was found statistically non-significant with T_1 and T_7 and differed significantly with rest of the treatments. It was observed that with the increase in the juice content, sensory colour score decreased significantly. The colour score of 15 per cent juice RTS (T_2, T_5 and T_8) were statistically non-significant with each other but differed significantly with 10 per cent juice RTS (T_1, T_4 and T_7) and 20 per cent juice RTS (T_3, T_6 and T_9). Joshi *et al.* (1993) also observed decrease in colour units with the increase in juice content while working on the preparation of plum beverages.

Flavour

It is evident from the data tabulated in Table 9 that flavour score for different treatments varied from 5.12 (T_9) to 7.85 (T_4). T_4 was statistically non-significant with T_1 and T_7 and differed significantly with rest of the treatments. Decrease in flavour score with the increase in juice concentration might be due to increase in raw and characteristic bittergourd flavour which was disliked by the panelists. Therefore, 15 per cent juice RTS (T_2, T_5 and T_8) and 20 per cent juice RTS (T_3, T_6 and T_9) had obtained proportionately lower sensory flavour score.

Taste

Taste score of bittergourd RTS varied between 4.51 and 7.76 (Table 9). T_1 and T_4 were statistically non-significant and differed significantly with rest of the treatments. T_2, T_5 and T_8 contained 15 per cent juice were statistically non-significant but differed significantly with rest of the treatments. It can be concluded that products with high juice contents had higher bitter principles which lowered the acceptability for taste. Kalra *et al.* (1988) reported that the bitterness in bittergourd is due to the presence of momordicin.

Body

The data pertaining to body/consistency of bittergourd RTS, presented in Table 9 indicate that T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8 and T_9 were statistically insignificant with each other. Maximum body score 7.419 was recorded in T_8 and minimum (7.416) was scored by T_5 and T_6 treatments.

Overall acceptability

The data for overall acceptability of bittergourd RTS (Table 9) show that highest score (7.68) was obtained by T_4 and lowest (5.70) by T_9. Treatment T_4 differed significantly with rest of the treatments. T_3 and T_6 were found statistically non-significant with each other. Treatments T_5 and T_8 were found on a par with each other and differed significantly from rest of the treatments. T_4 treatment was adjudged best (Fig. 3) by the panelists due to its acceptable sugar/juice blend. T_4 treatment was also rated best by a panel of judges for colour, flavour, taste and overall acceptability. Hence, recipe used for the preparation of T_4 was used for the development of dietetic RTS in further studies.

4.5 PHYSICO-CHEMICAL CHARACTERISTICS OF OGANOLEPTICALLY BEST RATED (STANDARD) BITTERGOURD RTS

Organoleptically rated best bittergourd RTS (T_4) was analysed for various physico-chemical characteristics.

A perusal of data given in Table 10 show that total soluble solids (TSS) of T_4 (best rated RTS) treatment was recorded 12.50±0.01°B. The said RTS meets the FPO specification (FPO, 1955). The acidity was recorded 0.40±0.03 per cent. Reducing sugars (4.09±0.13%) and total sugars (9.98±0.26%) were recorded in the developed bittergourd RTS (Table 10). Ascorbic acid content was 8.84±0.02 mg/100 g.

Table 10. Physico-chemical characteristics of developed/ standardized bittergourd RTS

Characteristics	Mean±SD
1. TSS (°Brix)	12.50±0.01
2. Titratable acidity (% CA)	0.40±0.03
3. Reducing sugars (%)	4.09±0.13
4. Total sugars (%)	9.98±0.26
5. Ascorbic acid (mg/100 g)	8.84±0.02

4.6 STANDARDIZATION OF RECIPE FOR THE DEVELOPMENT OF BITTERGOURD SPICED SQUASH ON THE BASIS OF SENSORY CHARACTERISTICS

Sensory evaluation scores for different characteristics of bittergourd spiced squash prepared by combination of different ingredients (Table 3) were as follows:

Colour

Data in Table 11(a) pertain to the sensory colour score of bittergourd spiced squash. The highest sensory score (7.96) was obtained by treatment having 25 per cent juice with S_1 spice recipe at 40° Brix, which remained on a par with S_2 having similar juice content and TSS but differed significantly with rest of the combinations. Lowest colour score (5.49) was observed in combination having 35 per cent juice with S_3 *spice recipe at 50° Brix. It is evident from the Table 11(b) that mean colour score*

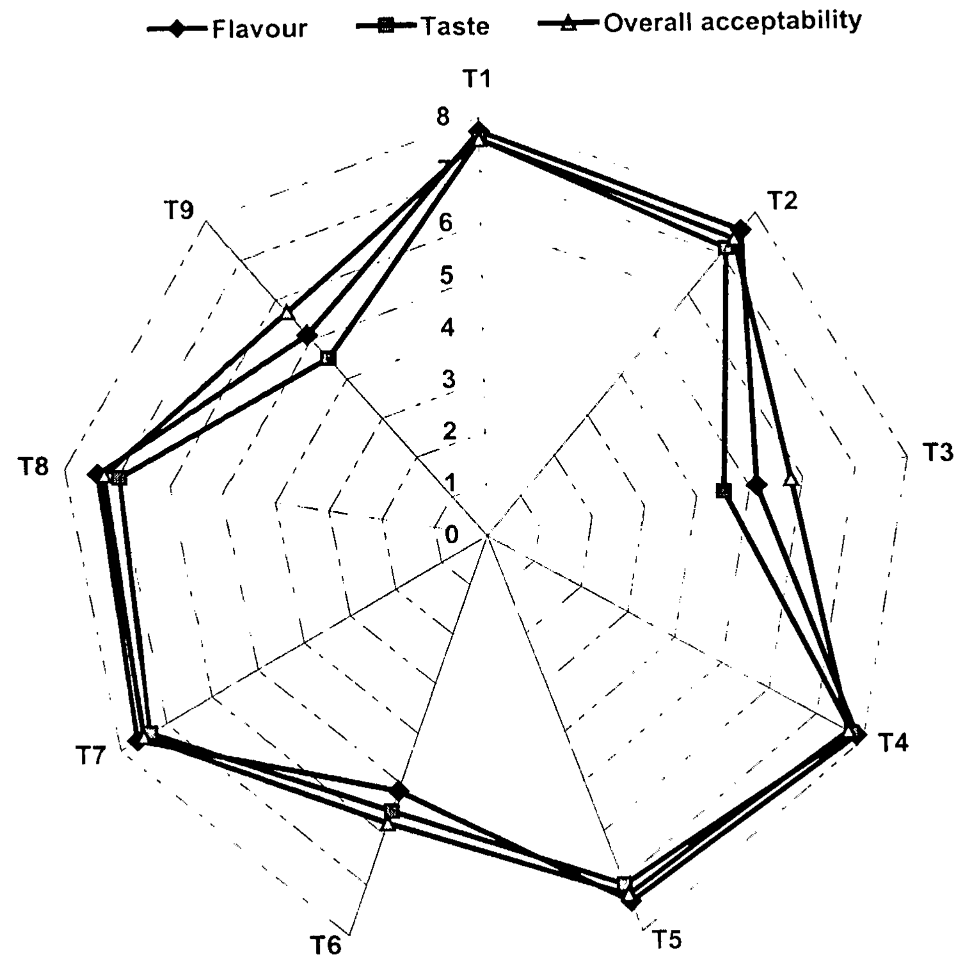

Fig. 3. Effect of different treatments on sensory characteristics of bittergourd RTS

Plate 3. Standard bittergourd RTS prepared with 10 per cent juice at 12.5° Brix (TSS)

Table 11(a). Effect of different ingredients on sensory colour* of bittergourd spiced squash

TSS (°Brix)	Juice (25%)			Juice (30%)			Juice (35%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
40	7.96	7.95	7.76	7.69	7.67	7.61	7.53	7.51	7.50
45	7.80	7.80	7.75	7.53	7.53	7.49	5.58	5.57	5.55
50	7.80	7.79	7.60	7.51	7.50	7.49	5.53	5.50	5.49

Table 11(b). Mean of TSS, juice and spice (%)

Treatment	TSS (°Brix)			Juice (%)			Spice (%)		
	40	**45**	**50**	**25**	**30**	**35**	S_1	S_2	S_3
Mean	7.67	6.95	6.93	7.80	7.56	6.20	7.21	7.20	7.14

Spice recipe: S_1, S_2, S_3

Table 11(c). Mean of TxJ

TSS (°Birx)	Juice percentage		
	25	30	35
40	7.84	7.66	7.52
45	7.78	7.52	5.56
50	7.78	7.50	5.50

Table 11(d). Mean of TxS

TSS (°Birx)	Spice percentage		
	S_1	S_2	S_3
40	7.72	7.72	7.58
45	6.97	6.96	6.93
50	6.94	6.93	6.86

Table 11(e). Mean of JxS

Juice (%)	Spice percentage		
	S_1	S_2	S_3
25	7.85	7.85	7.70
30	7.57	7.57	7.53
35	6.20	6.20	6.19

Effect	$\mathbf{CD_{0.05}}$
TSS (T)	NS
Juice (J)	NS
Spice (S)	0.003
TxJ	NS
TxS	0.019
JxS	0.007
TxJxS	0.050

* Rating on 9-point Hedonic scale: 9=Like extremely, 1=Dislike extremely

decreased with increase in TSS, juice per cent and spice recipes. Highest mean colour score (7.84) was recorded in the combination having 25 per cent juice at 40° Brix, but increased TSS (40, 45 and 50°B) with increased juice per cent (25, 30 and 35%) produced non-significant result for the colour score [Table 11(c)]. Mean of T x S having S_1 and S_2 spice recipe at 40, 45 and 50° Brix remained on a par with each other but differed significantly with rest of the combinations [Table 11(d)]. Highest mean score (7.72) for TSS and spice interaction were found in the combinations having 40° Brix with S_1 and S_2 spice recipe which remained statistically significant with rest of the combinations [Table 11(d)]. Interaction between juice and spice was found to be significant. Highest mean colour score (7.85) was obtained by the combinations having 25 per cent juice and spice recipes S_1 and S_2 which remained statistically significant with rest of the combinations. Mean of J x S for colour score having S_1 and S_2 spice recipe at 25, 30 and 35 per cent juice remained on a par with each other but differed significantly with rest of the combinations [Table 11(e)]. The decrease in colour score with proportionate increase in spices might be due to the fact that extract of spices darkened the colour of the squash. Interaction between TSS, juice and spice recipe was found statistically significant.

Flavour

Table 12(a) reveals that sensory flavour score was highest (7.94) in the treatment having 40° Brix with S_2 spice recipe containing 25 per cent juice, which differed significantly with rest of the treatments (Fig. 4). Lowest sensory score (4.13) for flavour was recorded in the treatment having 50° Brix, 35 per cent juice and S_1 spice recipe. Mean flavour score for TSS was found non-significant [Table 12(b)]. It is evident from the Table 12(b) that as the juice content increased in treatments, a marked effect on the sensory flavour score of bittergourd spiced squash was noticed. Mean flavour score for 25 per cent juice was found highest (7.31) which remained statistically significant with 30 and 35 per cent juice content. The decrease in flavour score with the per cent increase in juice content might be due to characteristic raw bittergourd flavour which was not liked by the panelist. Mean flavour score for spices was highest (6.20) for S_2 spice recipe which remained statistically significant from S_1 and S_3 recipe. Spice recipe S_3 got higher flavour score than S_1. Higher sensory score for S_2 recipe might be due to proper blend of different spices which imparted an excellent flavour to the product.

Highest flavour mean score (7.56) for TSS and juice interaction was found in the treatment having 25 per cent juice at 40° Brix which remained statistically significant with rest of the treatments [Table 12(c)]. Lowest flavour score (4.24) was recorded in the treatment having 35 per cent juice at 50° Brix. Interaction between the juice and spices was found highly significant [Table 12(e)]. Interactions between TSS and spice recipe were found significant. Lowest flavour score (5.71) for TSS and spice interaction was recorded in the treatments having 50° Brix and S_1 spice recipe [Table 12(d)]. Treatments having 25 per cent juice and S_2 spice recipe got the highest flavour score (7.52) which remained statistically significant with rest of the treatments. Lowest flavour score (4.17) was recorded in the treatment having 35 per cent juice with S_1 spice recipe. Interaction between TxJxS was found significant.

Taste

Data in Table 13(a) show sensory taste score of different bittergourd spiced squashes. Highest sensory score (8.00) was recorded in combination having 40° Brix with S_2 spice recipe and 25 per cent juice content which remained statistically significant with rest of the treatments. Lowest score (3.50) was recorded in the treatment having 35 per cent juice at 50° Brix and S_1 spice recipe. It is evident from the Table 13(a) that taste scores decreases with the per cent increase in juice. Mean taste scores decreases with an increase in TSS, which remained statistically significant with each other [Table 13(b)]. Sensory score decreased with increase in juice content. Highest mean score (7.54) was obtained with 25 per cent juice. Among spices, highest mean taste score (6.12) was found in the treatments having S_2 spice recipe which differed significantly with rest of the treatments [Table 13(b)]. Interaction between TSS and juice was found significant. Highest mean score (7.68) was recorded in the treatment containing 40° Brix and 25 per cent juice. The sensory score for taste decreased as the TSS (°Brix) and per cent juice increased. Lowest taste score (3.53) was recorded in the treatment having 50° Brix and 35 per cent juice content [Table 13(c)]. Highest mean taste score (6.31) for TSS and spice interaction was obtained by

Table 12(a). **Effect of different ingredients on sensory flavour* of bittergourd spiced squash**

TSS (°Brix)	Juice (25%)			Juice (30%)			Juice (35%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
40	7.38	7.94	7.37	7.19	7.26	7.20	4.22	4.55	4.32
45	7.19	7.48	7.21	6.43	6.59	6.51	4.17	4.39	4.32
50	7.00	7.15	7.08	6.00	6.16	6.10	4.13	4.31	4.29

Table 12(b). **Mean of TSS, juice and spice (%)**

Treatment	TSS (°Brix)			Juice (%)			Spice (%)		
	40	45	50	25	30	35	S_1	S_2	S_3
Mean	6.38	6.03	5.80	7.31	6.60	4.30	5.97	6.20	6.04

Spice recipe: S_1, S_2, S_3

Table 12(c). **Mean of TxJ**

TSS (°Birx)	Juice percentage		
	25	30	35
40	7.56	7.22	4.36
45	7.29	6.51	4.29
50	7.08	6.09	4.24

Table 12(d). **Mean of TxS**

TSS (°Birx)	Spice percentage		
	S_1	S_2	S_3
40	6.26	6.58	6.30
45	5.93	6.15	6.01
50	5.71	5.87	5.82

Table 12(e). **Mean of JxS**

Juice (%)	Spice percentage		
	S_1	S_2	S_3
25	7.19	7.52	7.22
30	6.54	6.67	6.60
35	4.17	4.42	4.31

Effect	**$CD_{0.05}$**
TSS (T)	NS
Juice (J)	0.030
Spice (S)	0.030
TxJ	0.060
TxS	0.050
JxS	0.030
TxJxS	0.002

* Rating on 9-point Hedonic scale: 9=Like extremely, 1=Dislike extremely

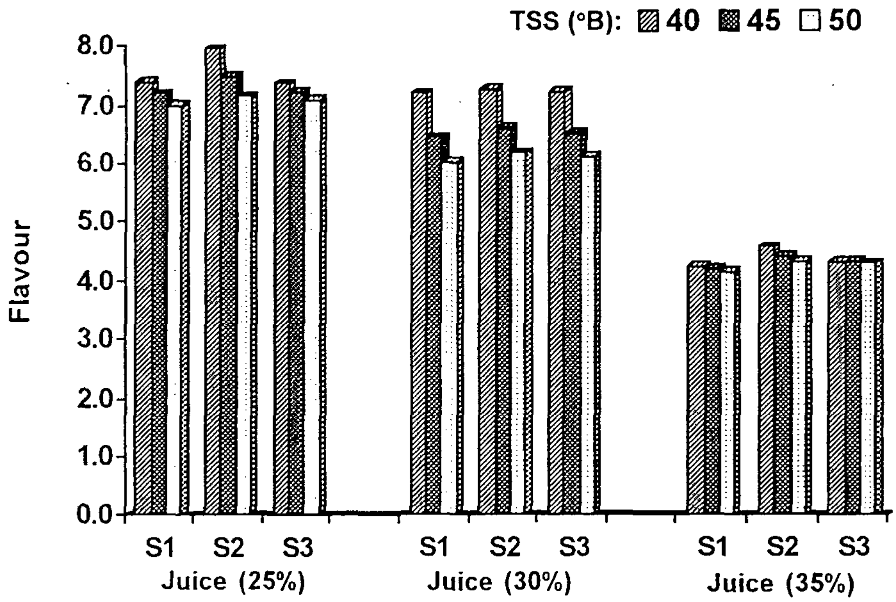

Fig. 4. Effect of different ingredients on sensory flavour score of bittergourd spiced squash

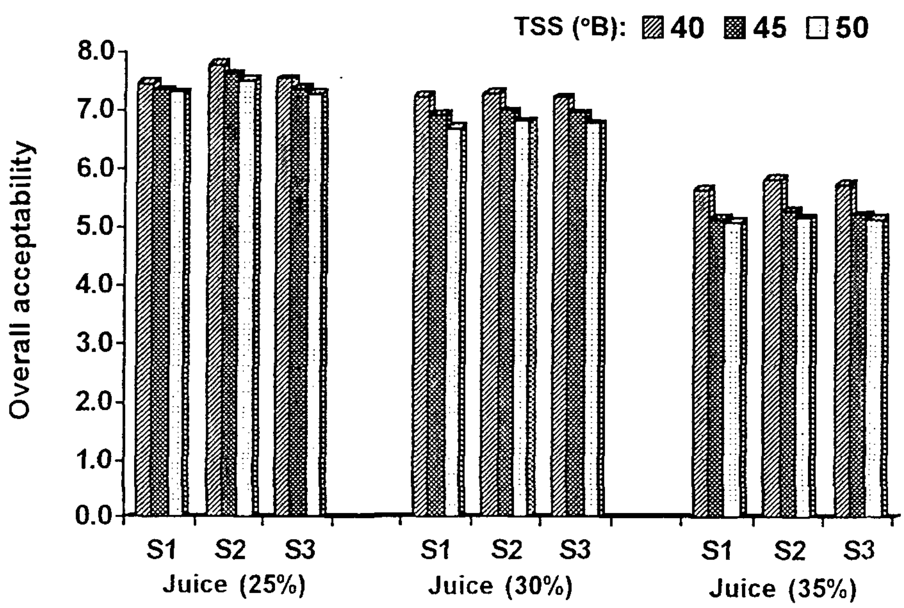

Fig. 5. Effect of different ingredients on sensory overall acceptability score of bittergourd spiced squash

Table 13(a). Effect of different ingredients on sensory taste* of bittergourd spiced squash

TSS (°Brix)	Juice (25%)			Juice (30%)			Juice (35%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
40	7.30	8.00	7.75	6.78	6.98	6.84	3.61	3.94	3.82
45	7.26	7.99	7.29	6.41	6.54	6.48	3.52	3.89	3.73
50	7.18	7.86	7.22	6.04	6.29	6.17	3.50	3.57	3.53

Table 13(b). Mean of TSS, juice and spice (%)

Treatment	TSS (°Brix)			Juice (%)			Spice (%)		
	40	45	50	25	30	35	S_1	S_2	S_3
Mean	6.11	5.90	5.71	7.54	6.50	3.68	5.73	6.12	5.87

Spice recipe: S_1, S_2, S_3

Table 13(c). Mean of TxJ

TSS (°Birx)	Juice percentage		
	25	30	35
40	7.68	6.87	3.79
45	7.51	6.48	3.71
50	7.42	6.17	3.53

Table 13(d). Mean of TxS

TSS (°Birx)	Spice percentage		
	S_1	S_2	S_3
40	5.90	6.31	6.14
45	5.73	6.14	5.83
50	5.57	5.91	5.64

Table 13(e). Mean of JxS

Juice (%)	Spice percentage		
	S_1	S_2	S_3
25	7.25	7.95	7.42
30	6.41	6.60	6.50
35	3.54	3.80	3.69

Effect	$CD_{0.05}$
TSS (T)	0.010
Juice (J)	0.002
Spice (S)	0.009
TxJ	0.020
TxS	0.020
JxS	0.010
TxJxS	0.003

* Rating on 9-point Hedonic scale: 9=Like extremely, 1=Dislike extremely

the combination having 40° Brix and S_2 spice recipe Table 13(d). Lowest score (5.57) was recorded in the combination having S_1 spice recipe and 50° Brix. It is evident from Table 13(d) that with increased TSS, taste score decreased significantly. Spice recipe S_2 obtained highest score with different combinations of TSS which might be due to appropriate blend of different spices; added characteristic aroma and flavour to the squash. Sharma *et al.* (2002) observed similar results while working on preparation and evaluation of spiced plum squash. Highest mean score (7.95) for juice and spice interaction was recorded in the treatment having 25 per cent juice and S_2 spice recipe. As per cent juice in spiced squash was increased, a significant decrease in taste score was recorded. S_1 spice recipe recorded lowest taste score (3.54) with 35 per cent juice content (Table 13(e)].

Perusal of data further reveals that combined effect of spices and herbs by S_2 spice recipe improved the taste in the final product. Taste/flavour of the treatment having 40° Brix + 25 per cent juice and S_2 spice recipe was adjudged best due to balanced sugar/acid ratio and juice-spice blend in the squash. Similar results were observed by Sharma *et al.* (2002) and Lal *et al.* (1999), while working on spiced plum squash and apple-ginger based squash, respectively.

Body

Table 14(a) illustrates that highest body score (7.27) in the treatment having 40° Brix + 25 per cent juice and S_1 spice recipe, remained statistically non-significant with rest of the treatments. Mean body scores for TSS, juice and spice recipe were found statistically non-significant [Table 14(b)]. Interactions between TSS and juice, TSS and spices and juice and spices were also remained non-significant [Table 14(c), 14(d), 14(e)]. No significant effect was observed on sensory scores of body with per cent increase in TSS, juice and spices on the body of the squash.

Overall acceptability

Table 15(a) depicts the sensory scores for overall acceptability of bittergourd spiced squash obtained by different treatments. Highest score (7.79) was obtained by the treatment having 40° Brix + 25 per cent juice and S_2 spice recipe which remained statistically significant with rest of the treatments (Fig. 5). Lowest sensory score

(5.10) was obtained by treatment having 50° Brix + 35 per cent juice and S_1 spice recipe. Highest sensory mean score for TSS was recorded in the treatment having 40° Brix which remained highly significant with rest of the treatments in respective combinations [Table 15(b)]. Mean sensory score for juice decreased with per cent increase in juice content. Highest mean sensory score (7.48) for juice was found in the treatments having 25 per cent juice [Table 15(b)]. Among spice recipes highest overall acceptability score (6.70) was recorded in the treatments having S_2 spice recipe which remained statistically significant with rest of the treatments. Lowest mean score in respect of spices mixture was recorded in the treatments having S_1 spice recipe. Sensory scores for overall acceptability was highest for the combination having 25 per cent juice and S_2 spice recipe. It might be due to the optimum blend of different spices which added pleasing flavour and aroma to the product. Sharma (1999) also obtained the similar results while working on spiced plum beverage.

Highest mean sensory score (7.60) for TSS and juice interaction was found in the treatments having 40° Brix and 25 per cent juice content which remained statistically significant with rest of the treatments [Table 15(c)]. Sensory scores for overall acceptability decreased as per cent juice and TSS increased. Lowest sensory score (5.13) was recorded in the treatment having 50° Brix and 35 per cent juice content [Table 15(c)]. Highest mean score (6.97) for TSS and spice interaction was obtained by the treatment having 40° Brix and S_2 spice recipe which differed significantly with rest of the treatments [Table 15(d)]. Sensory score decreased with increase in TSS. It is evident from Table 15(e) that mean sensory score for juice and spice interaction was found highest (7.64) in the combination having 25 per cent juice and S_2 spice recipe. Sensory score decreased with the per cent increase in juice content having S_1 spice recipe. Spice recipe S_1 got the lowest sensory score (5.29) with 35 per cent juice content. Lowest sensory score in JxS interaction was recorded in the combinations having 35 per cent juice, irrespective of spice recipe.

It can be concluded from the Table 15(a) that treatments having 40° Brix + 25 per cent juice and S_2 spice recipe were adjudged best by the panelists due to its acceptable sugar/acid blend. Addition of spices, herbs and salt might have influenced

Table 14(a). Effect of different ingredients on sensory body* of bittergourd spiced squash

TSS (°Brix)	Juice (25%)			Juice (30%)			Juice (35%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
40	7.27	7.25	7.25	7.26	7.26	7.25	7.25	7.26	7.26
45	7.25	7.26	7.26	7.25	7.26	7.26	7.26	7.26	7.25
50	7.25	7.25	7.25	7.26	7.25	7.26	7.25	7.25	7.24

Table 14(b). Mean of TSS, juice and spice (%)

Treatment	TSS (°Brix)			Juice (%)			Spice (%)		
	40	45	50	25	30	35	S_1	S_2	S_3
Mean	7.26	7.26	7.26	7.26	7.26	7.26	7.26	7.26	7.26

Spice recipe: S_1, S_2, S_3

Table 14(c). Mean of TxJ

TSS (°Birx)	Juice percentage		
	25	30	35
40	7.25	7.26	7.26
45	7.26	7.26	7.26
50	7.26	7.26	7.25

Table 14(d). Mean of TxS

TSS (°Birx)	Spice percentage		
	S_1	S_2	S_3
40	7.26	7.26	7.25
45	7.25	7.26	7.26
50	7.27	7.25	7.25

Table 14(e). Mean of JxS

Juice (%)	Spice percentage		
	S_1	S_2	S_3
25	7.27	7.25	7.26
30	7.26	7.26	7.26
35	7.26	7.26	7.25

Effect	$CD_{0.05}$
TSS (T)	NS
Juice (J)	NS
Spice (S)	NS
TxJ	NS
TxS	NS
JxS	NS
TxJxS	NS

* Rating on 9-point Hedonic scale: 9=Like extremely, 1=Dislike extremely

Table 15(a). Effect of different ingredients on sensory overall acceptability* of bittergourd spiced squash

TSS (°Brix)	Juice (25%)			Juice (30%)			Juice (35%)		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
40	7.48	7.79	7.53	7.23	7.29	7.22	5.65	5.82	5.73
45	7.36	7.63	7.38	6.91	6.98	6.94	5.13	5.28	5.21
50	7.31	7.51	7.29	6.70	6.80	6.76	5.10	5.16	5.14

Table 15(b). Mean of TSS, juice and spice (%)

Treatment	TSS (°Brix)			Juice (%)			Spice (%)		
	40	45	50	25	30	35	S_1	S_2	S_3
Mean	6.86	6.54	6.42	7.48	6.98	5.36	6.54	6.70	6.58

Spice recipe: S_1, S_2, S_3

Table 15(c). Mean of TxJ

TSS (°Birx)	Juice percentage		
	25	30	35
40	7.60	7.25	5.73
45	7.46	6.94	5.21
50	7.37	6.75	5.13

Table 15(d). Mean of TxS

TSS (°Birx)	Spice percentage		
	S_1	S_2	S_3
40	6.79	6.97	6.83
45	6.47	6.63	6.51
50	6.37	6.49	6.40

Table 15(e). Mean of JxS

Juice (%)	Spice percentage		
	S_1	S_2	S_3
25	7.38	7.64	7.40
30	6.95	6.99	6.97
35	5.29	5.42	5.36

Effect	$CD_{0.05}$
TSS (T)	0.007
Juice (J)	0.004
Spice (S)	0.005
TxJ	0.012
TxS	0.016
JxS	0.011
TxJxS	0.021

* Rating on 9-point Hedonic scale: 9=Like extremely, 1=Dislike extremely

the taste perception of judges. Similar results were also obtained by Sharma *et al.* (2002), Sharma (1999) and Lal *et al.* (1999).

4.7 PHYSICO-CHEMICAL CHARACTERISTICS OF ORGANOLEPTICALLY BEST RATED (STANDARD) BITTERGOURD SPICED SQUASH

Table 16 shows that total soluble solids (TSS) of standard bittergourd spiced squash (25% juice + 40° Brix + S_2 spice recipe) was recorded 40.00±0.04°B. TSS fulfills FPO specifications (FPO, 1955). The titratable acidity was recorded 1.00±0.03 per cent. Reducing sugars were 17.68±0.29 per cent and total sugars were recorded 32.31±0.42 in the developed product. Ascorbic acid 20.09±0.10 mg/100 g was recorded in the standard spiced bittergourd squash (Table 16). Salt as sodium chloride was found to be 1.56±0.18 per cent in the standard product.

Table 16. Physico-chemical characteristics of developed/standardized spiced bittergourd squash

Characteristics	Mean±SD
1. TSS (°Brix)	40.00±0.04
2. Titratable acidity (% CA)	1.00±0.03
3. Reducing sugars (%)	17.68±0.29
4. Total sugars (%)	32.31±0.42
5. Ascorbic acid (mg/100 g)	20.09±0.10
6. Salt as NaCl (%)	1.56±0.18

4.8 STORAGE STUDIES IN RELATION TO DIFFERENT PHYSICO-CHEMICAL, MICROBIAL AND SENSORY ATTRIBUTES OF DIETETIC BITTERGOURD RTS AND SPICED SQUASH

4.8.1 Physico-chemical attributes

Total soluble solids (TSS)

It is evident from Table 17 that total soluble solids (TSS) of bittergourd RTS recorded at different storage intervals ranged between 0.32 to 20.07°B. On preparation day, maximum TSS (20°B) was observed in T_9 (100% sorbitol sweetened) and minimum (0.32°B) in T_8 (100% saccharin sweetened) RTS which increased to 20.07°B and 0.34°B, respectively after 180 days of storage. Similar results were obtained in bittergourd spiced squash (Table 17). Maximum TSS (52.37°B) was observed in T_9 (100% sorbitol sweetened) and minimum (0.78°B) in T_8 (100% saccharin sweetened) spiced squash which increased to 52.49°B and 1.03°B, respectively after 180 days of storage period. The mean values for TSS of different treatments differed significantly with each other. The TSS increased during different storage intervals but increase was found to be statistically non-significant in all the treatments. The interaction between treatment and storage was also found non-significant. Slight increase in TSS during storage might be due to the hydrolysis of polysaccharides into monosaccharides and soluble disaccharide (Gould, 1983) and solubilization of juice constituents during storage. Our results are in conformity with the findings of Mayer (1960), Mehta and Bajaj (1983), Attri (1989) and Sharma (1997).

Titratable acidity

The data in Table 18 pertaining to titratable acidity revealed that titratable acidity in bittergourd RTS and spiced squash at different intervals during storage ranged between 0.38-0.42 per cent and 0.90-1.04 per cent, respectively. At 0 day storage, highest value of RTS (0.42%) and spiced squash (1.04%) were recorded in T_2 & T_7 ; and T_6, respectively. Titratable acidity remained non-significant with the mean values obtained by different treatments. Titratable acidity decreased during storage intervals but mean values remained non-significant upto 180 days of storage period. Similar decrease in acidity was recorded by Pandey *et al.* (1995). The interaction between the treatment and storage period was also found non-significant. The decrease in titratable acidity during storage might be due to co-polymerization of organic acids with sugars and amino-acids and loss of volatile acids during storage (Reynolds, 1965; Bauman, 1979; Sandhu *et al.*, 1985; Saini and Pal, 1997 and Krishnaveni *et al.*, 2001).

Reducing sugars

Data of different bittergourd RTS and spiced squashes presented in Table 19 show that reducing sugars increased significantly during storage period. On preparation day, the highest reducing sugars were recorded in T_1 (standard) and lowest

Plate 4. Standard bittergourd spiced squash prepared with 25 per cent juice, S_2 spice recipe at 40° Brix (TSS)

Table 17. Effect of different proportions of non-nutritive sweeteners on TSS (°Brix) of bittergourd RTS and spiced squash

Treatments	TSS (°Brix)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	12.51	12.52	12.52	12.53	12.52	40.02	40.06	40.11	40.14	40.08
T_2	9.20	9.20	9.21	9.22	9.21	30.40	30.47	30.49	30.52	30.47
T_3	12.60	12.62	12.62	12.63	12.62	42.86	42.95	43.01	43.07	42.97
T_4	6.02	6.07	6.11	6.15	6.09	20.32	20.39	20.47	20.52	20.43
T_5	14.91	14.94	14.97	14.98	14.95	45.06	45.14	45.23	45.31	45.19
T_6	4.06	4.07	4.08	4.10	4.08	10.26	10.34	10.41	10.46	10.37
T_7	17.62	17.63	17.65	17.68	17.65	49.03	49.11	49.19	49.25	49.15
T_8	0.32	0.32	0.34	0.34	0.33	0.78	0.83	0.89	1.03	0.88
T_9	20.00	20.02	20.05	20.07	20.04	52.37	52.40	52.44	52.49	52.43
Mean	10.80	10.82	10.84	10.86		32.34	32.41	32.47	32.53	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.71	0.08
Storage (S)	NS	NS
T x S	NS	NS

Table 18. Effect of different proportions of non-nutritive sweeteners on titratable acidity of bittergourd RTS and spiced squash

Treatments	Titratable acidity (% CA)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	0.41	0.40	0.40	0.39	0.40	1.02	0.99	0.92	0.90	0.96
T_2	0.42	0.41	0.40	0.39	0.41	1.01	0.96	0.93	0.91	0.95
T_3	0.41	0.41	0.40	0.39	0.40	1.02	0.96	0.92	0.91	0.95
T_4	0.40	0.39	0.39	0.38	0.39	1.03	0.98	0.95	0.92	0.97
T_5	0.41	0.40	0.39	0.39	0.40	1.03	0.99	0.96	0.94	0.98
T_6	0.40	0.39	0.39	0.38	0.39	1.04	0.99	0.95	0.93	0.98
T_7	0.42	0.41	0.40	0.40	0.41	1.01	0.96	0.92	0.90	0.95
T_8	0.41	0.40	0.39	0.39	0.40	1.02	0.96	0.93	0.91	0.96
T_9	0.40	0.39	0.39	0.38	0.39	1.03	0.97	0.94	0.92	0.97
Mean	0.41	0.40	0.39	0.39		1.02	0.97	0.94	0.92	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	NS	NS
Storage (S)	NS	NS
T x S	NS	NS

Table 19. Effect of different proportions of non-nutritive sweeteners on reducing sugars of bittergourd RTS and spiced squash

Treatments	Reducing sugars (%)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	4.09	4.29	4.38	4.47	4.31	17.68	18.76	19.13	19.32	18.72
T_2	3.06	3.25	3.42	3.51	3.31	13.96	14.42	15.09	15.24	14.68
T_3	3.07	3.27	3.44	3.53	3.33	13.92	14.40	15.07	15.21	14.65
T_4	2.04	2.21	2.35	2.42	2.26	9.67	11.00	11.40	11.47	10.89
T_5	2.03	2.23	2.37	2.43	2.27	9.69	11.06	11.43	11.49	10.92
T_6	1.02	1.12	1.23	1.29	1.17	5.15	5.34	5.57	5.74	5.45
T_7	1.03	1.14	1.24	1.31	1.18	5.13	5.36	5.59	5.77	5.46
T_8	0.25	0.25	0.26	0.26	0.26	0.61	0.61	0.62	0.63	0.62
T_9	0.25	0.25	0.26	0.26	0.26	0.61	0.62	0.62	0.63	0.62
Mean	1.87	2.00	2.11	2.16		8.49	9.06	9.39	9.50	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.07	0.08
Storage (S)	0.02	0.07
T x S	0.03	0.001

in T_8 and T_9 (100% sorbitol and saccharin sweetened) samples in both RTS and spiced squash, respectively. T_2 and T_3; T_4 and T_5; T_6 and T_7; and T_8 and T_9 remained statistically non-significant with each other during all storage intervals in both RTS and spiced squash but differed significantly with rest of the treatments.

The increase in reducing sugars during storage might be due to hydrolysis or inversion of non-reducing sugars to reducing sugars. A significant increase in reducing sugars during storage was reported by Aruna *et al.* (1997) in papaya nectar and Srivastava (1998) in mango RTS drinks. Similar increase in reducing sugar was observed in orange and lemon squashes by Jain *et al.* (1984).

Total sugars

Data in Table 20 show that total sugars of bittergourd RTS varied from 0.26 per cent to 9.98 per cent. At 0 day storage, maximum total sugars (9.98%) were recorded in T_1 (standard) which differed significantly with rest of the treatments. T_2 and T_3; T_4 and T_5; T_6 and T_7; and T_8 and T_9 were statistically on a par with each other at all storage intervals and differed significantly with rest of the treatments. Similarly, maximum total sugars (32.31%) were obtained by T_1 (standard) and minimum (0.76%) by T_8 in spiced squash (Table 20). The respective values of each treatment decreased significantly at different storage intervals except for T_8 and T_9 where non-significant change was observed during 180 days of storage. Interaction between treatment and storage period was found to be significant.

The reaction of sugars with amino acids, a process known as Millard reaction, other chemical reactions of sugars in presence of acids (Khurana and Anand, 1980; Shreshtha and Bhatia, 1982) and co-polymerization of sugars with organic acids particularly at high temperature (Saini and Grewal, 1995 and Thakur and Barwal, 1998) are attributed to the loss of total sugars during storage.

Ascorbic acid

It is revealed from Table 21 that ascorbic acid content of bittergourd RTS and spiced squash at different storage intervals ranged from 7.62 to 8.84 mg/100 g and

12.75 to 20.09 mg/100 g, respectively. In bittergourd RTS, maximum ascorbic acid content (8.84 mg/100 g) was recorded in T_1 on preparation day which significantly decreased to 8.48 mg after 60 days, 8.08 mg after 120 days and 7.67 mg per 100 g after 180 days of storage. Ascorbic acid contents in all the treatments remained on a par with each other but differed significantly at different storage intervals. In bittergourd spiced squash, maximum ascorbic acid (20.09 mg/100 g) was obtained by T_1 (standard) on the preparation day which significantly decreased to 12.81 mg/100 g after 180 days of storage. Ascorbic acid decreased significantly in all the storage intervals (Table 21). Interaction between treatment and storage period was found to be non-significant.

The decrease in ascorbic acid during storage may be attributed to its degradation into dehydro ascorbic acid or furfural or hydroxy methyl furfural during storage in the products. Similar decline in ascorbic acid content has also been reported in carbonated apple juice (Bright and Potter, 1979), guava nectar (Murari and Verma, 1989), raw mango beverage (Pandey *et al.*, 1995), apricot-soy nectar (Chauhan and Sharma, 1996) and spiced plum squash (Sharma, *et al.*, 2002).

Relative viscosity

The data presented in Table 22 indicate that relative viscosity of dietetic bittergourd RTS and spiced squash ranged between 1.02 to 1.57 and 1.09 to 5.10, respectively. Relative viscosity significantly decreased with increase of saccharin sweetness (T_2, T_4, T_6 and T_8) [Fig. 6] whereas, it increased with increased sorbitol sweetness (T_3, T_5, T_7 and T_9) [Fig. 7]. Highest relative viscosity was observed in T_9 (100% sorbitol sweetened) RTS (1.57) and spiced squash (5.10) and minimum relative viscosity was observed in T_8 (100% saccharin sweetened) RTS and spiced squash, respectively. There was non-significant decrease of relative viscosity during 180 days of storage in RTS and spiced squash. Treatments produced highly significant results for relative viscosity. The interaction between treatment and storage was found non-significant.

Decrease in relative viscosity during storage intervals might be due to polymerization and co-polymerization processes; pectin degradation and precipitation of colloidal particles resulting in the formation of haze (Wilson and Burns, 1983).

Table 20. Effect of different proportions of non-nutritive sweeteners on total sugars of bittergourd RTS and spiced squash

Treatments	Total sugars (%)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	9.98	9.82	9.66	9.61	9.77	32.31	31.84	31.30	31.13	31.65
T_2	7.56	7.34	7.20	7.17	7.32	26.28	25.72	25.25	24.93	25.55
T_3	7.58	7.35	7.22	7.17	7.33	26.31	25.76	25.30	24.97	25.59
T_4	5.04	4.79	4.60	4.58	4.75	16.80	16.43	16.09	15.99	16.33
T_5	5.03	4.80	4.61	4.59	4.76	16.73	16.39	16.00	15.93	16.26
T_6	2.72	2.57	2.48	2.43	2.55	8.39	8.14	8.02	7.98	8.13
T_7	2.74	2.58	2.49	2.44	2.56	8.41	8.17	8.10	7.99	8.17
T_8	0.28	0.28	0.27	0.27	0.26	0.76	0.75	0.71	0.70	0.73
T_9	0.28	0.28	0.27	0.26	0.27	0.77	0.75	0.73	0.71	0.74
Mean	4.58	4.42	4.31	4.28		15.20	14.88	14.61	14.48	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.20	0.51
Storage (S)	0.02	0.13
T x S	0.15	0.24

Table 21. Effect of different proportions of non-nutritive sweeteners on ascorbic acid of bittergourd RTS and spiced squash

Treatments	Ascorbic acid (mg/100 g)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	8.84	8.48	8.08	7.67	8.27	20.09	16.70	14.57	12.81	16.04
T_2	8.82	8.42	8.03	7.69	8.24	20.06	16.68	14.50	12.77	16.00
T_3	8.82	8.46	8.05	7.62	8.24	20.08	16.65	14.53	12.75	16.00
T_4	8.83	8.50	8.07	7.65	8.26	20.05	16.69	14.56	12.77	16.02
T_5	8.83	8.48	8.05	7.67	8.26	20.05	16.65	14.56	12.76	16.01
T_6	8.82	8.45	8.01	7.63	8.23	20.08	16.68	14.58	12.80	16.04
T_7	8.83	8.47	8.04	7.62	8.24	20.06	16.67	14.56	12.77	16.02
T_8	8.83	8.49	8.03	7.65	8.25	20.06	16.68	14.57	12.81	16.03
T_9	8.81	8.43	8.01	7.62	8.22	20.07	16.65	14.55	12.78	16.01
Mean	8.83	8.46	8.04	7.65		20.07	16.67	14.55	12.78	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	NS	NS
Storage (S)	0.06	0.25
T x S	NS	NS

Table 22. Effect of different proportions of non-nutritive sweeteners on relative viscosity of bittergourd RTS and spiced squash

Treatments	Relative viscosity									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	1.36	1.35	1.35	1.34	1.35	2.70	2.66	2.57	2.53	2.62
T_2	1.25	1.24	1.23	1.23	1.24	2.39	2.34	2.26	2.10	2.27
T_3	1.47	1.46	1.44	1.43	1.45	4.41	3.68	4.22	4.11	4.11
T_4	1.16	1.15	1.15	1.13	1.15	1.43	1.39	1.34	1.30	1.37
T_5	1.50	1.49	1.48	1.48	1.49	4.59	4.50	4.40	4.28	4.44
T_6	1.14	1.13	1.12	1.12	1.13	1.30	1.21	1.17	1.16	1.21
T_7	1.54	1.53	1.52	1.52	1.53	5.02	4.59	4.60	4.44	4.66
T_8	1.07	1.05	1.03	1.02	1.04	1.19	1.14	1.11	1.09	1.13
T_9	1.57	1.55	1.55	1.54	1.55	5.10	4.89	4.80	4.78	4.89
Mean	1.34	1.33	1.32	1.31		3.13	2.93	2.93	2.87	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.003	0.04
Storage (S)	NS	NS
T x S	NS	NS

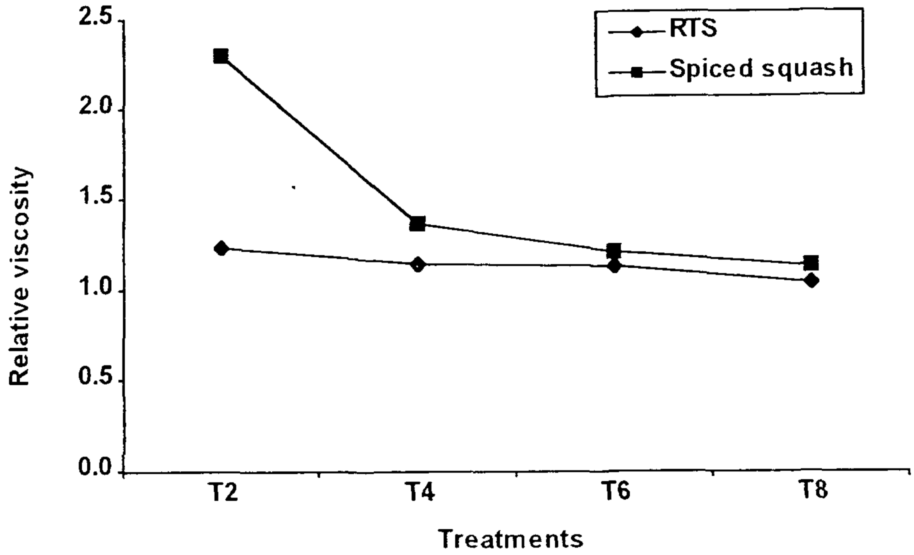

Fig. 6. Effect of different proportions of saccharin on relative viscosity of bittergourd RTS and spiced squash

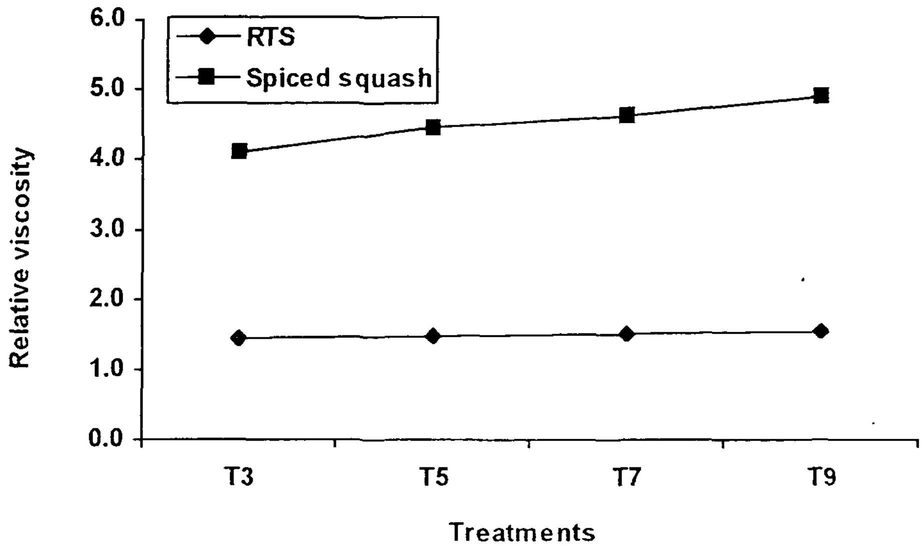

Fig. 7. Effect of different proportions of *sorbitol on* relative viscosity of bittergourd RTS and spiced squash

Saccharin

Table 23 shows the storage stability of saccharin in bittergourd RTS and spiced squash. It is clear from the data that no significant degradation of saccharin was observed during 180 days of storage. As the proportion of sucrose sweetness decreased (Table 5), the amount of saccharin (non-nutritive sweetener) increased (Table 23). In bittergourd RTS and spiced squash, the highest saccharin content was obtained in T_8 (0.024/100 g) and (0.078/100 g), respectively. The treatments produced significant results for saccharin content in RTS and spiced squash. The interaction between treatment and storage was found to be non-significant.

Table 23. Effect of different proportions of non-nutritive sweeteners on saccharin contents of bittergourd RTS and spiced squash

Treatments	Saccharin (g/100 g)									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	-	-	-	-	-	-	-	-	-	-
T_2	0.0057	0.0054	0.0049	0.0043	0.0051	0.0180	0.0170	0.0170	0.0160	0.0170
T_3	-	-	-	-	-	-	-	-	-	-
T_4	0.0120	0.0119	0.0117	0.0117	0.0118	0.0380	0.0370	0.0360	0.0360	0.0370
T_5	-	-	-	-	-	-	-	-	-	-
T_6	0.0170	0.0160	0.0160	0.0150	0.0162	0.0540	0.0540	0.0540	0.0530	0.0540
T_7	-	-	-	-	-	-	-	-	-	-
T_8	0.0240	0.0230	0.0230	0.0220	0.0230	0.0780	0.0780	0.0770	0.0760	0.0770
T_9	-	-	-	-	-	-	-	-	-	-
Mean	0.0150	0.0140	0.0140	0.0130		0.0470	0.0470	0.0460	0.0450	0.0460

Effect	$CD_{0.05}$	Effect	$CD_{0.05}$
Treatment (T)	0.004	Treatment (T)	0.013
Storage (S)	NS	Storage (S)	NS
T x S	NS	T x S	NS

Diezak (1986) reported the use of saccharin in canned fruits and preserved products and observed heat and storage stability of saccharin during processing.

Sorbitol

The data in Table 24 revealed the identification of sorbitol component in bittergourd RTS and spiced squash. The average R_f value obtained by 100 per cent sorbitol sweetened RTS and spiced squash was 0.66. Treatments T_3 and T_5 had average R_f value of 0.65 while treatments T_7 and T_9 had average R_f value of 0.66 which showed the presence of sorbitol at 25, 50, 75 and 100 per cent sweetness level in RTS and spiced squash during different storage intervals upto 180 days. Similar R_f values were obtained and observed by Coles and Upton (1972).

Table 24. Identification of sorbitol component in bittergourd RTS and spiced squash

Treatments	RTS						Spiced squash			
	Storage period (days)						Storage period (days)			
	Rf	Standard	0	60	120	180	0	60	120	180
T_1	-	-	-	-	-	-	-	-	-	-
T_2	-	-	-	-	-	-	-	-	-	-
T_3	0.65	0.66	+	+	+	+	+	+	+	+
T_4	-	-	-	-	-	-	-	-	-	-
T_5	0.65	0.66	+	+	+	+	+	+	+	+
T_6	-	-	-	-	-	-	-	-	-	-
T_7	0.66	0.66	+	+	+	+	+	+	+	+
T_8	-	-	-	-	-	-	-	-	-	-
T_9	0.66	0.66	+	+	+	+	+	+	+	+

Sodium chloride and Sulphur dioxide

Table 25 shows the effect of different proportions of non-nutritive sweeteners on sodium chloride and sulphur dioxide in bittergourd spiced squash. On preparation day, highest value (1.61%) was recorded in T_2 and lowest (1.53%) in T_3 which decreased to 1.60 and 1.52 per cent, respectively after 180 days of storage. Sodium chloride contents remained non-significant in all the treatments. Storage mean values remained on a par at different storage intervals upto 180 days. The interaction between treatment and storage period was found non-significant..A slight decrease in sodium chloride contents during storage might be due to precipitation or chemical/human error during analysis which cannot be avoided.

Table 25 shows total SO_2 contents in bittergourd spiced squash at different storage intervals. SO_2 ranged between 320 to 330 ppm. On preparation day, highest value (330 ppm) was recorded in T_1 and T_8 and lowest (328 ppm) in T_2, T_4, T_5 and T_9 treatments. Non-significant difference of sulphur dioxide was recorded in all the

Table 25. Effect of different proportions of non-nutritive sweeteners on sodium chloride and sulphur dioxide on bittergourd spiced squash

Treatments	Spiced squash									
	Sodium chloride (%)					Sulphur dioxide (ppm)				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	1.56	1.59	1.59	1.58	1.58	330	326	325	322	326
T_2	1.61	1.60	1.61	1.60	1.61	328	327	324	320	325
T_3	1.53	1.53	1.52	1.52	1.53	329	327	325	322	326
T_4	1.57	1.56	1.55	1.56	1.56	328	326	324	323	325
T_5	1.54	1.55	1.53	1.54	1.54	328	325	323	321	324
T_6	1.56	1.55	1.57	1.56	1.56	329	326	324	321	325
T_7	1.56	1.58	1.56	1.56	1.57	329	327	325	320	325
T_8	1.55	1.55	1.54	1.55	1.55	330	326	324	322	326
T_9	1.60	1.61	1.60	1.60	1.60	328	325	323	320	324
Mean	1.56	1.57	1.56	1.56		329	326	324	321	

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	NS	NS
Storage (S)	NS	NS
T x S	NS	NS

treatments on preparation day, which decreased insignificantly upto 180 days of storage. The interaction between treatment and storage was found non-significant. It might be due to the fact that the glass bottles were sealed hermatically which did not allow the gas to escape from the bottle during entire storage period. Sharma *et al.* (2001) also found decrease in sulphur dioxide content during storage of six months in galgal juice concentrates.

Energy value

The data presented in Table 26 pertaining to energy value of bittergourd RTS and spiced squash. Energy value of bittergourd RTS and spiced squash ranged from 1.08 K cal/100 g to 61.12 k cal/ 100g and 2.80 k cal/100g to 191.48 k cal/100 g, respectively. On preparation day, maximum energy value 61.12 k cal/100g (RTS) and 191.48 k cal/100 g (spiced squash) was recorded in T_9 (100% sorbitol sweetened) and

Table 26. Effect of different proportions of non-nutritive sweeteners on the energy value of bittergourd RTS and spiced squash

Treatments	Energy value (K cal/100 g)			
	RTS		Spiced squash	
	0	180	0	180
T_1	39.92	38.44	129.24	124.52
T_2	30.24	28.64	105.12	99.72
T_3	45.32	43.64	152.34	146.98
T_4	20.16	18.32	67.20	63.96
T_5	50.12	48.36	161.12	157.92
T_6	10.88	9.72	33.56	31.92
T_7	55.96	54.76	174.94	173.26
T_8	1.12	1.08	3.04	2.80
T_9	61.12	61.04	191.48	191.24

minimum 1.12 k cal/100 g (RTS) and 3.04 k cal/100 g (spiced squash) was obtained by T_8 which decreased to 61.04 k cal/100g (RTS) and 191.24 k cal/100 g, respectively after 180 days of storage. The decrease in energy value during storage may be attributed to decrease in the total sugars. Though sorbitol have high energy value but does not give rise to elevated blood sugar levels when taken. Very little is absorbed by

the small intestine and what reaches the colon is fermented by the microflora to give volatile fatty acids (Dias, 1999).

Similar decrease in energy value per serving in products was observed by Kosmark (1992), Barwal (1995), Barwal and Kalia (1997), Sharma (1999) and Barwal (2002) while developing fruit products with the use of non-nutritive sweeteners.

4.8.2 Microbial studies

On the preparation day and after 60, 120 and 180 days of storage intervals, bittergourd RTS and spiced squash were analysed for microbial growth. The data in Table 27 pertain to microbiological evaluation of different treatments for bacteria, mould and yeast. Table 27 shows that highest total plate count (TPC) was recorded in T_8 (100% saccharin sweetened) bittergourd RTS and spiced squash. On preparation day, microbial growth in bittergourd RTS and spiced squash was absent. Treatments T_1, T_2, T_3, T_5, T_7 and T_9, both in RTS and spiced squash were found free of bacteria upto 180 days of storage. However, $T_6$and T_8 showed very low growth of bacteria after 120 days in RTS. After 180 days of storage, growth of bacteria were recorded in T_4, T_6 and T_8 in RTS. Low growth of yeast could be seen in T_1, T_2 and T_3 after 180 days of storage (Table 27). Low to moderate growth of moulds was observed in T_6 and T_8 after 180 days of storage.

In bittergourd spiced squash, relatively less number of microorganisms were developed on the nutrient agar plate. This might be due to antimicrobial properties of species (Shelf, 1983; Meena and Sethi, 1994; Meena and Sethi, 1998); Daswani and Bohra, 2001). Highest count of bacteria and mould were developed in T_4, T_6 and T_8 while presence of yeast was visualized only in T_1, T_2 and T_3 after 180 days of storage period. Less microbial count in T_1 (Standard), T_3, T_5, T_7 and T_9 treatments might be due to high soluble solids contents which kept a_w very low by binding free water into bound form, thereby decreased the availability of water to microorganisms and inhibited their growth. Similar findings were observed by Srivastava (1983), Kumar (1992), Barwal (1995) and Sharma (1999).

Table 27. Effect of different proportions of non-nutritive sweeteners on microbial population of bittergourd RTS and spiced squash

Treatments	Microbial population																							
	RTS												Spiced squash											
	Bacteria				Yeast				Mould				Bacteria				Yeast				Mould			
	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180	0	60	120	180
T_1	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
T_2	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
T_3	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_4	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+
T_5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_6	-	-	+	++	-	-	-	-	-	-	+	++	-	-	-	+	-	-	-	-	-	-	+	++
T_7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_8	-	-	+	+++	-	-	-	-	-	-	+++	+++	-	-	-	++	-	-	-	-	-	-	++	++
T_9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

4.8.3 Sensory evaluation of dietetic bittergourd RTS and spiced squash

Colour

Data presented in Table 28 show the sensory scores of colour/appearance for dietetic RTS and spiced squash. Sensory scores pertaining to colour of bittergourd RTS and spiced squash ranged from 5.35 to 6.30 and 6.28 to 7.40, respectively. On preparation day, the highest colour score was 6.30 for bittergourd RTS and 7.40 for bittergourd spiced squash in T_1 (Standard) and lowest 5.43 (RTS) and 6.50 (spiced squash), in T_8 (100% Saccharin sweetened) treatment. After 180 days of storage interval, the respective values decreased to 6.25 and 5.35 for bittergourd RTS and 7.14 and 6.28 for bittergourd spiced squash (Table 28). T_3 & T_5 for RTS and T_5 & T_7 for spiced squash remained non-significant but differed significantly with rest of the treatments. Storage mean values for colour at different storage intervals upto 180 days remained on a par with each other. The interaction between treatment and storage was also found to be non-significant. The decrease in colour score in storage might be due to co-polymerization of organic acids with the products, caused browning which was found undesirable by the panelists. Similar decrease in colour score was also reported by Cornwell and Wrolstad (1981) while working on causes of browning in pear juice concentrate during storage and Babsky *et al.* (1986) while working on the influence of storage on the composition of clarified apple juice concentrate. Sharma *et al.* (2002) obtained similar results during preparation and evaluation of spiced plum beverage.

It was further observed that with the increase in sweetness proportion of saccharin in RTS, the colour profile of samples decreased significantly during storage. It might be due to the bleaching effect of saccharin at higher concentrations (Sharma, 1999). Colour profile of sorbitol sweetened RTS and spiced squash remained higher (Table 28) than that of saccharin during storage due to its heat and storage stability, resistant to thermal and non-enzymatic browning (BeMiller, 1992; Giese, 1993 and Dias, 1999).

Flavour

Data tabulated in Table 29 reveal that sensory flavour score varied from 5.24 to 6.25 for RTS and 6.30 to 7.35 for bittergourd spiced squash. On preparation day, flavour score was maximum for both RTS (6.25) and spiced squash (7.35) which was obtained by T_1 (standard). During storage, flavour score decreased slightly but remained non-significant at different intervals. T_3, T_5, T_7 and T_9 were statistically non-significant with each other and differed significantly with rest of the treatments. Storage mean values for flavour after 60, 120 and 180 days of storage intervals were found non-significant. Decrease in flavour score could be possibly due to loss of volatile aromatic substances in storage at ambient conditions as reported by Thakur and Barwal (1998). It was also observed that sorbitol sweetened samples (T_5, T_7 and T_9) got more flavour scores than saccharin sweetened (T_4, T_6 and T_8) RTS and spiced squash at higher concentrations (Table 29). It might be due to low tendency of sorbitol to undergo fermentation with the production of acids which influence the flavour of the finished product (BeMiller, 1992). Our findings for saccharin is in conformity with the observations recorded by Schiffman *et al.* (1985) while evaluating lemon-lime and cola flavoured beverages.

Taste

Sensory taste scores for bittergourd RTS and spiced squash varied from 5.31 to 6.52 and 6.13 to 7.30, respectively (Table 30). On preparation day, maximum score 6.30 for RTS and 7.10 for spiced squash were obtained by T_1 (standard) and minimum 5.31 (RTS) and 6.13 (spiced squash) were recorded in T_8 (100% saccharin sweetened). Treatments T_1, T_3, T_5, T_7 and T_9 (Sorbitol sweetened) remained non-significant from each other but differed significantly from rest of the treatments. Taste score decreased significantly as the concentration of saccharin increased (Fig. 8), but it remained non-significant with increased concentration of sorbitol (Fig. 9). It might be due to bitter metallic after taste of saccharin which become evident with increasing sweetness proportion of 25 (T_2), 50 (T_4), 75 (T_6) and 100 (T_8) per cent in both RTS and spiced squash. Similar observations were also noticed by Schiffman *et al.* (1985), Sharma (1999) and Barwal *et al.* (2002).

Storage mean scores remained statistically non-significant for 60 & 120 days; and 120 & 180 days storage intervals in RTS and 0, 60 and 120 days storage intervals for spiced squash. The taste score increased during storage in both RTS and seasoned squash. The increase in sensory taste score might be due to the degradation of bitter

Table 28. Effect of different proportions of non-nutritive sweeteners on colour* of bittergourd RTS and spiced squash

Treatments	Colour									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	6.30	6.28	6.27	6.25	6.28	7.40	7.32	7.22	7.14	7.27
T_2	6.22	6.20	6.19	6.17	6.20	7.30	7.21	7.11	.6.98	7.15
T_3	6.18	6.16	6.14	6.13	6.15	7.39	7.31	7.21	7.13	7.26
T_4	5.93	5.90	5.87	5.86	5.89	6.93	6.86	6.78	6.64	6.80
T_5	6.17	6.16	6.14	6.11	6.15	7.37	7.31	7.20	6.99	7.22
T_6	5.68	5.67	5.64	5.61	5.65	6.78	6.59	6.41	6.33	6.53
T_7	6.10	6.08	6.05	6.02	6.06	7.37	7.31	7.20	6.98	7.22
T_8	5.43	5.41	5.38	5.35	5.39	6.50	6.43	6.35	6.28	6.39
T_9	6.00	5.97	5.92	5.89	5.95	7.39	7.33	7.24	7.17	7.28
Mean	6.00	5.98	5.96	5.93		7.16	7.07	6.97	6.85	

*Rating on 9-point Hedonic scale

9 = Liked extremely

1 = Dislike extremely

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.003	0.004
Storage (S)	NS	NS
T x S	NS	NS

Table 29. **Effect of different proportions of non-nutritive sweeteners on flavour* of bittergourd RTS and spiced squash**

Treatments	Flavour									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	6.25	6.23	6.21	6.20	6.22	7.35	7.33	7.29	7.21	7.30
T_2	6.15	6.13	6.11	6.09	6.12	7.25	7.19	7.14	7.04	7.16
T_3	6.24	6.22	6.20	6.18	6.21	7.25	7.22	7.15	7.14	7.19
T_4	5.74	5.72	5.69	5.66	5.70	6.84	6.79	6.71	6.63	6.74
T_5	6.24	6.23	6.20	6.18	6.21	7.28	7.22	7.16	7.12	7.19
T_6	5.51	5.49	5.47	5.45	5.48	6.61	6.56	6.52	6.45	6.54
T_7	6.24	6.23	6.20	6.18	6.21	7.26	7.20	7.18	7.13	7.19
T_8	5.32	5.29	5.27	5.24	5.28	6.52	6.46	6.41	6.30	6.42
T_9	6.23	6.21	6.18	6.17	6.20	7.24	7.21	7.18	7.13	7.19
Mean	5.99	5.97	5.95	5.93		7.07	7.02	6.97	6.91	

*Rating on 9-point Hedonic scale

9 = Liked extremely

1 = Dislike extremely

Effect	**$CD_{0.05}$**	**$CD_{0.05}$**
Treatment (T)	0.01	0.02
Storage (S)	NS	NS
T x S	NS	NS

Table 30. Effect of different proportions of non-nutritive sweeteners on taste* of bittergourd RTS and spiced squash

Treatments	Taste									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	6.30	6.39	6.45	6.52	6.42	7.10	7.21	7.25	7.30	7.22
T_2	6.01	6.12	6.19	6.27	6.15	6.89	7.01	7.10	7.15	7.04
T_3	6.24	6.33	6.38	6.44	6.35	7.08	7.19	7.24	7.28	7.20
T_4	5.90	5.97	6.03	6.11	6.00	6.77	6.83	6.95	7.00	6.90
T_5	6.29	6.38	6.44	6.51	6.41	7.09	7.18	7.25	7.29	7.20
T_6	5.47	5.52	5.59	6.04	5.66	6.36	6.45	6.53	6.65	6.50
T_7	6.24	6.34	6.37	6.42	6.34	7.08	7.17	7.22	7.29	7.19
T_8	5.31	5.46	5.52	5.58	5.47	6.13	6.25	6.32	6.41	6.28
T_9	6.25	6.32	6.38	6.43	6.34	7.09	7.18	7.23	7.28	7.20
Mean	6.00	6.09	6.15	6.26		6.84	6.94	7.01	7.07	

*Rating on 9-point Hedonic scale

9 = Liked extremely

1 = Dislike extremely

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.14	0.03
Storage (S)	0.13	0.17
T x S	0.04	0.007

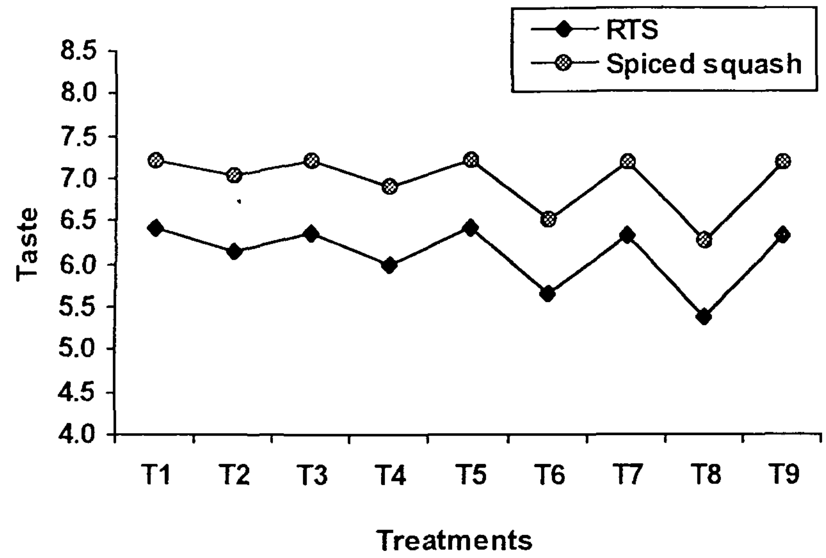

Fig. 8. Effect of different proportions of non-nutritive sweeteners on sensory taste score of bittergourd RTS and spiced squash

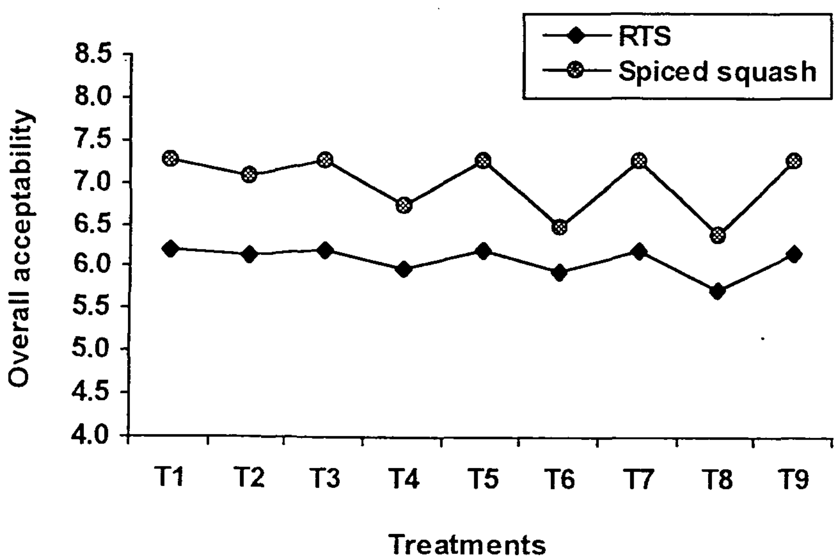

Fig. 9. Effect of different proportions of non-nutritive sweeteners on sensory overall acceptability score of bittergourd RTS and spiced squash

principle during storage. Manimegalai and Ramah (1998) obtained OD values for the bitter principle (Triterpenoid) in the treated dehydrated bittergourd and found low /less bitter principle during storage. Ramah *et al.* (1999) also observed similar decrease in bitter principle while working on steeping preservation of bittergourd.

Body

A perusal of data in Table 31 reveals that highest sensory mean body scores 6.65 for RTS and 7.06 for spiced squash was obtained by T_5 (50% sugar and 50 % sorbitol sweetened) which remained statistically significant with rest of the treatments. Treatment mean of different storage intervals of T_1 and T_3 remained statistically on a par with each other and differed significantly with rest of the treatments for both RTS and spiced squash. Among non-nutritive sweeteners, saccharin at low level (25%) and sorbitol at 50 per cent level obtained higher score than other combinations. With the increased concentration of saccharin (25, 50, 75 and 100%), sensory body score decreased significantly. It might be due to the fact that saccharin at higher levels could have degraded the colloidal nature of finished product considerably (Sharma, 1999). It can also be concluded from the Table 31 that body profile was higher for sorbitol sweetened bittergourd RTS and spiced squash than saccharin sweetened treatments. Sorbitol is an excellent bodying agent as reported by Beereboom (1979), Giese (1993) and Dias (1999). No attempts have been made so far by earlier workers to study body/consistency profile of dietetic bittergourd RTS and spiced squash by using non-nutritive sweeteners.

Overall acceptability

Table 32 illustrates the sensory mean scores for overall acceptability of different treatments. Highest mean value 6.20 for RTS and 7.29 for spiced squash were obtained by T_1 (standard) which remained statistically non-significant with the mean values obtained by T_3, T_5, T_7 and T_9 but differed significantly for overall acceptability with rest of the treatments. Overall acceptability decreased during storage in all the treatments. Storage mean values for overall acceptability differed significantly at different storage intervals for bittergourd RTS and spiced squash. Interaction between treatment and storage was found to be non-significant. Sharma *et* *al.* (2002) observed similar results while working on spiced plum beverage. Overall acceptability scores decreased with the increased sweetness share of saccharin (Table 32) and increased with the increased per cent share of sorbitol sweetness. It might be due to the fact that saccharin at higher concentration (T_4, T_6 and T_8) attributed to poor overall acceptability with persistent sweetness and a metallic after taste (Diezak, 1986; BeMiller, 1992; Giese, 1993 and Barwal *et al.*, 2002).

4.9 COST OF PRODUCTION

Cost incurred in preparation of bittergourd RTS and spiced squash was calculated by taking into consideration the cost of all the inputs used. The comparative cost of production of standard, 100 per cent saccharin sweetened and 100 per cent sorbitol sweetened RTS and spiced squash were given in Table-33 and Table-34, respectively. The cost was calculated on the basis of current market prices of ingredients, nominal processing charges and reasonable profit margins.

The cost per unit was found lowest (Rs. 4.47/200 ml bottle) for RTS sweetened by saccharin (100% sweetness level) followed by Rs 5.05/200 ml bottle) of standard bittergourd RTS. Cost of sorbitol sweetened (100% sweetness level) RTS was highest (Rs. 8.12/200 ml bottle) due to the fact that sorbitol has less sweetness potential (0.5%) than sucrose (Table 33).

The cost per unit for bittergourd spiced squash was found lowest (Rs. 16.29/700 ml bottle) in saccharin sweetened (100% sweetness level) followed by sugar sweetened Rs. 22.48/700 ml bottle. The highest production cost was recorded Rs. 55.58/700 ml bottle in sorbitol sweetened (100% sweetness level) due to the above mentioned reason and almost double amount was used for the preparation of equi-sweetness spiced squash which increased its cost of production (Table 34).

Plate 5. Dietetic bittergourd RTS sweetened with saccharin at 100, 75, 50, 25 and 0 per cent sweetness level

Plate 6. Dietetic bittergourd RTS sweetened with sorbitol at 100, 75, 50, 25 and 0 per cent sweetness level

Plate 7. Dietetic bittergourd spiced squash sweetened with saccharin at 0, 25, 50, 75 and 100 per cent sweetness levels

Plate 8. Dietetic bittergourd spiced squash sweetened with sorbitol at 0, 25, 50, 75 and 100 per cent sweetness levels

Table 31. Effect of different proportions of non-nutritive sweeteners on body* of bittergourd RTS and spiced squash

Treatments	Body									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	6.30	6.29	6.27	6.25	6.28	7.05	6.97	6.76	6.69	6.87
T_2	6.15	6.12	6.09	6.08	6.11	7.01	6.85	6.73	6.61	6.80
T_3	6.29	6.28	6.28	6.27	6.28	7.05	6.96	6.79	6.68	6.87
T_4	6.05	6.00	5.99	5.98	6.00	6.73	6.64	6.51	6.40	6.57
T_5	6.65	6.63	6.62	6.61	6.63	7.06	6.96	6.83	6.75	6.90
T_6	5.90	5.89	5.87	5.86	5.88	6.62	6.57	6.42	6.35	6.49
T_7	6.13	6.11	6.09	6.07	6.10	6.98	6.85	6.77	6.65	6.81
T_8	5.65	5.64	5.61	5.59	5.62	6.43	6.38	6.24	6.18	6.31
T_9	6.00	5.99	5.97	5.95	5.98	6.90	6.81	6.74	6.65	6.78
Mean	6.12	6.11	6.09	6.07		6.87	6.78	6.64	6.55	

*Rating on 9-point Hedonic scale

9 = Liked extremely
1 = Dislike extremely

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.01	0.005
Storage (S)	NS	NS
T x S	NS	NS

Table 32. Effect of different proportions of non-nutritive sweeteners on overall acceptability* of bittergourd RTS and spiced squash

Treatments	Overall acceptability									
	RTS					Spiced squash				
	Storage period (days)					Storage period (days)				
	0	60	120	180	Mean	0	60	120	180	Mean
T_1	6.25	6.20	6.18	6.15	6.20	7.41	7.34	7.25	7.15	7.29
T_2	6.18	6.15	6.11	6.07	6.13	7.20	7.13	7.04	6.93	7.08
T_3	6.24	6.20	6.17	6.15	6.19	7.40	7.34	7.23	7.13	7.28
T_4	6.02	5.98	5.95	5.91	5.97	6.84	6.77	6.72	6.64	6.74
T_5	6.23	6.21	6.18	6.14	6.19	7.40	7.33	7.25	7.14	7.28
T_6	5.96	5.95	5.93	5.91	5.94	6.60	6.53	6.46	6.38	6.49
T_7	6.24	6.21	6.17	6.14	6.19	7.39	7.31	7.24	7.16	7.28
T_8	5.76	5.73	5.71	5.68	5.72	6.52	6.44	6.37	6.26	6.40
T_9	6.25	6.19	6.16	6.15	6.19	7.39	7.34	7.25	7.14	7.28
Mean	6.13	6.09	6.06	6.03		7.13	7.06	6.98	6.88	

*Rating on 9-point Hedonic scale

9 = Liked extremely

1 = Dislike extremely

Effect	$CD_{0.05}$	$CD_{0.05}$
Treatment (T)	0.05	0.03
Storage (S)	0.02	0.05
T x S	NS	NS

Table 33. Cost of production of bittergourd RTS

Ingredients	Rate (Rs.)	Standard RTS (100 %)		Saccharin RTS (100%)		Sorbitol RTS (100%)	
		Quantity	Amount (Rs.)	Quantity	Amount (Rs.)	Quantity	Amount (Rs.)
Juice	16 /lit	1 lit.	16.00	1 lit.	16.00	1 Lit.	16.00
Sugar	18 /kg	1250 g	22.50	-	-	-	-
Sorbitol	50/lit	-	-	-	-	2500 ml	125.00
Saccharin	0.40 /g	-	-	8.33 g	3.33	-	-
Citric acid	120 /kg	40.00 g	4.80	40.00 g	4.80	40.00 g	4.80
Bottles (200 ml)	1.5/bottle	50	75.00	50	75.00	50	75.00
Crown cork	0.50/cap	50	25.00	50	25.00	50	25.00
Label	0.50/label	50	25.00	50	25.00	50	25.00
Total cost of ingredients			168.30		149.13		270.80
Processing cost	@20%		33.66		29.826		54.16
Total preparation cost			201.96		178.96		324.96
Profit	@20%		40.39		35.79		64.99
Breakage cost	@5%		10.09		8.95		16.25
Net cost			252.41		223.70		406.20
Total yield	10 liters (50 bottles)						
Sale price per bottle			5.05		4.47		8.12

Table 34. Cost of production of bittergourd spiced squash

Ingredients	Rate (Rs.)	Standard spiced squash (100%)		Saccharin spiced squash (100%)		Sorbitol spiced squash (100%)	
		Quantity	Amount (Rs.)	Quantity	Amount (Rs.)	Quantity	Amount (Rs.)
Juice	16/lit	2.5 lit.	40.00	2.5 lit.	40.00	2.5 Lit.	40.00
Sugar	18/kg	3.925/kg	70.65	-	-	-	-
Mint extract	12/lit	100 ml	1.20	100 ml	1.20	100 ml	1.20
Ginger extract	100/lit	150 ml	15.00	150 ml	15.00	150 ml	15.00
Common salt	8/kg	100 g	0.80	100 g	0.80	100 g	0.80
Black salt	10/kg	100 g	1.00	100 g	1.00	100 g	1.00
Cumin	100/kg	50 g	5.00	50 g	5.00	50 g	5.00
Cardamom	120/kg	20 g	2.40	20 g	2.40	20 g	2.40
Black pepper	270/kg	50 g	13.50	50 g	13.50	50 g	13.50
Sorbitol	50/lit	-	-	-	-	7.85 lt.	392.50
Saccharin	0.40/g	-	-	26.16 g	10.46	-	-
Citric acid	120 /kg	95 g	11.40	95 g	11.40	95 g	11.40
KMS	0.35/g	10 mg	0.035	10 mg	0.035	10 mg	0.035
Bottles (200 ml)	3.0/bottle	14	42.00	14	42.00	14	42.00
PP cap	0.61/cap	14	8.54	14	8.54	14	8.54
Label	0.50/label	14	7.00	14	7.00	14	7.00
Total cost of ingredients			218.525		158.335		540.375
Processing cost	@20%		43.705		31.667		108.075
Total preparation cost			262.23		190.002		648.45
Profit	@20%		52.446		38.000		129.69
Net cost			314.676		228.002		778.140
Total yield	10 liters (14 bottles)						
Sale price per bottle			22.48		16.29		55.58

SUMMARY AND CONCLUSIONS

Chapter-5

SUMMARY AND CONCLUSIONS

Bittergourd is an important vegetable crop of tropical and subtropical country including India. The fruit is wholesome and esteemed as vegetable when young though bitter. It has many medicinal applications. The present investigation, "Processing of bittergourd for the production of dietetic beverages" was carried out in the Department of Postharvest Technology, College of Horticulture, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni-Solan. Bittergourd fruits were procured from local market and juice was extracted by three methods viz., Spiral pressing, Carrot grater and Basket pressing after grating. Extracted juice was preserved by sulphur dioxide, sodium benzoate and pasteurization. Different combinations of juice with TSS were carried out for the standardization of RTS from bittergourd. Trials were laid down for the development of palatable spiced squash by different combination of spice recipes (S_1, S_2 & S_3), juice content (25, 30 & 35%) and TSS (40, 45 & 50°B). Dietetic RTS and spiced squash were prepared by using non-nutritive sweeteners viz., saccharin and sorbitol with sweetness proportion (sucrose equivalent) of 25, 50, 75 and 100 per cent along with sugar. Physico-chemical, sensory and microbial observations were recorded on the preparation day and subsequently after 60, 120 and 180 days of storage period. The results obtained are summarised as follows:

1. Average weight, length and diameter of procured bittergourd fruit of Solan Hara cultivar were 51.50±2.27(g), 11.48±1.57 (cm) and 2.63±0.33(cm), respectively.

2. Bittergourd juice extracted by Basket press after grating gave highest yield (50 %).

3. Bittergourd juice was successfully preserved with SO_2 @ 1000 ppm for 180 days in glass bottles. Physico-chemical and microbiological characteristics remained stable during storage.

4. Acceptable and palatable bittergourd RTS was developed with 10% juice at 12.50 °Brix on the basis of sensory scores.

5. Bittergourd spiced squash was prepared with 25% juice at 40° Brix with S_2 spice recipe, scored highest sensory attributes than those prepared from other combinations.

6. Sensory profile of sorbitol sweetened RTS and spiced squash with increased sweetness concentration remained higher than saccharin sweetened RTS and spiced squash.

7. Sensory scores of bittergourd spiced squash were found higher than RTS.

8. During storage, there was an increase in total soluble solids, reducing sugars and decrease in titratable acidity, total sugars and ascorbic acid. Despite the changes observed in various attributes, the overview of quality parameters of RTS and spiced squash remained acceptable.

9. The RTS and spiced squash were microbiologically stable and could be stored successfully for a period of 6 months (180 days) without deterioration of quality.

10. Sorbitol sweetened spiced squash at 25, 50, 75 and 100 per cent sweetness level remained organoleptically acceptable and on a par with standard spiced squash at different storage intervals.

11. Saccharin sweetened RTS and spiced squash at 25 per cent got 6.13 and 7.07 sensory score for overall acceptability, respectively but differed significantly from standard products.

12. Cost of production of standard bittergourd RTS was Rs. 5.05/200 ml bottle while cost of production of standard bittergourd spiced squash was Rs. 22.48/700 ml bottle.

13. Cost of production of dietetic bittergourd RTS and spiced squash having 100% sweetness level of saccharin and sorbitol were Rs.4.47 and Rs.8.12 per 200 ml bottles and Rs.16.29 and 55.58 per 700 ml bottles, respectively.

From the present investigation, it can be concluded that bittergourd fruit which otherwise processed to a limited extent, can be successfully used for the preparation of RTS, spiced squash and dietetic products. An acceptable and palatable bittergourd RTS and spiced squash can be prepared by using 10 per cent and 25 per cent juice of Solan Hara cultivar at 12.50 and 40° Brix total soluble solids (TSS), respectively. On the basis of sensory evaluation, sorbitol sweetened (25%, 50%, 75% and 100%) were found pretty close and statistically non-significant for different quality attributes with the standard dietetic RTS and spiced squash. Saccharin sweetened RTS and spiced squash were slightly acceptable by the panel of judges at different storage intervals. The developed dietetic bittergourd RTS and spiced squash will be beneficial to health conscious, obese and diabetic people.

REFERENCES

REFERENCES

Aggarwal, P. and Kaur, B. 1997. Studies on bittergourd pickle. *Beverage Food World*, 24(3): 31-32

Ali, L.; Khan, A.K.A.; Mamun, M.I.R.; Mosihuzzaman, M.; Nahar, N.; Alam, M.N. and Rokeya, B. 1993. Studies on hypoglycaemic effects of fruit, pulp, seed and whole plant of *Momordica charantia* on normal and diabetic model rats. *Planta Med.*, 59(5): 408-412

Anon. 1962. Raw materials: The Wealth of India. *CSIR*, New Delhi. Vol. VI: 408-411

AOAC. 1980. Official methods of analysis. *Association of Official Analytical Chemists*, ed. W. Hortwitz, 13th ed. Washington, D.C., U.S.A.

Aruna, K.; Vimla, V.; Giridhar, N. and Rao, D.G. 1997. Studies on preparation and storage of nectar prepared from papaya (*Carica papaya* L.). *Beverage Food World*, 24(1): 29-32,38

Attri, B.L. 1989. Processing of sand pear(*Pyrus pyrifolia* L.) for juice, alcoholic beverage and their evaluation. *M.Sc. Thesis*, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.)

Babsky, N.E.; Toribio, J.L. and Lozano, J.E. 1986. Influence of storage on the composition of clarified apple juice concentrate. *J. Food Sci*, 51(3): 564-567

Barwal, V.S. 1995. Use of sugar substitutes for the development of dietetic apple preserves. *Ph.D. Thesis*, HPKV, Palampur (H.P.)

Barwal, V.S. and Kalia, M. 1997. Studies on development of reduced sugar apple jelly. *Acta Alimentaria*, 26(2): 107-115

Barwal, V.S.; Lal, B.B. and Attri, S. 2002. Studies on the development of dietetic apricot squash. *Beverage Food World*, 29(3): 21-22

* Bauman, I.G. 1979. Changes in acid concentration in fruit juice concentrates. *Industrielle Obst.* Und Gemiisever-Wentung, 68: 205

Bawa, A.S. and Saini, S.P.S. 1987. Effect of method of preservation on the storage quality of carrot juice. *Indian Food Packer*, 41(1): 42-46

* Beereboom, J.J. 1979. Low calorie bulking agents. *CRC Critical Rev. Food Sci. Nutr.*, 16(5): 401-413

BeMiller, J.N. 1992. Sweeteners, nutritive. **In**: *Encyclopedia of Food Science and Technology*, ed. Y.H. Hui. pp. 2487-2490. John Wiley and Sons, Inc., New York

Bhandari, U. and Grover, J.K. 1998. A reappraisal of clinical studies on the comparative influence of three indigenous plant drugs in diabetes mellitus. *Hamdard Medicus*, 41(2): 9-15

* Bright, R.A. and Potter, N.N. 1979. Acceptability and properties of carbonated apple juice. *Food Prod. Develop.*, 13(4): 34-37

Chahal, G.S. and Saini, S.P.S. 1999. Storability of juice from new hybrid watermelon variety. *Indian Food Packer*, 53(5): 12-16

Chakraborty, S.; Agrawal, M.D. and Shukla, F.C. 1993. Studies on preparation of ready-to-serve beverage from watermelon (*Citrullus vulgaris*) juice. *Beverage Food World*, 20(1): 30-32

Chaturvedi, P.; Shukla, S.; Tripathi, P.; Chaurasia, S.; Singh, S.K. and Tripathi, Y.B. 1995. Comperative study of *Inula racemosa* and *Saussurea lappa* on the glucose level in albino rats. *Ancient Science of Life*, XV(1): 62-70

Chauhan, S.K. and Sharma, R.C. 1996. Effect of supplementation of soy-milk with appricot for beverage preparation. *Beverage Food World*, 23(5): 37-38

Choudhary, B. 1996. Vegetables. National Book Trust, New Delhi, India. pp. 163-167

Coles, Z.A. and Upton, R.P. 1972. Thin layer chromatographic identification test for sorbitol solution. *J. A.O.A.C. methods of analysis*, 55: 1004

Cornwell, C.J. and Wrolstad, R.E. 1981. Causes of browning in pear juice concentrate during storage. *J. Food Sci.*, 46: 515

* CRF, 1992. Eligibility for classification as generally recognized as safe (GRAS). *Code of Fed. Regs.*, Title 21, Sect. 570.30.45. Gast. Print. Office, Washington, D.C.

Daswani, L. and Bohra, A. 2001. Antimicrobial efficacy of extracts of various spices: a study in vitro. *Science and Culture*, 68(1-4): 99-100

Deka, B.C. and Sethi, V. 2001. Preparation of mixed fruit juice spiced RTS beverages. *Indian Food Packer*, 55(3): 58-61

Dias, F.F. 1999. Sorbitol and other sugar alcohols in the food industry. *Indian Food Ind.* 18(4): 229-237

Diezak, D. 1986. Sweeteners-Alternatives to cane and beet sugars. *Food Technol.*, 40(1): 116-123

DuBois, G.E. 1992. Sweeteners, non-nutritive.**In:** *Encyclopedia of Food Science and Technology*, ed. Y.H. Hui, pp. 2470-2487. John Wiley and Sons, Inc., New York

FPO. 1955. *Ministry of Food Processing Industries Government of India.* Printed by the All India Soft Drink Manufacturers Association, New Delhi (June, 1991)

Giese, J. 1995. Development in beverage additives. *Food Technol.*, 49(9): 64-72

Giese, J.H. 1993. Alternative sweeteners and bulking agents. *Food Technol.*, 47(1): 114-126

Gopalan, C.; Ramasastri, B.V. and Balasubramanian, S.C. 1980. Nutritional Value of Indian Foods. National Institute of Medical Research, Hyderabad, India

Gould, W.A. 1983. Tomato production processing and quality evaluation. 2nd ed. AVI Publishing Co. Inc., Westport, CT

Grenby, T.H. 1991. Intense sweeteners for the food industry- An overview. *Trends in Food Sci. Technol.*, 2(1): 2-6

Griffin, J. 1992. Spicing up food profits. *Food Industries*, 45(11): 3,5,7,21

Harrigan, H.F. and McCance, E.M. 1966. *Laboratory methods in microbiology*. Academic Press, New York

Holland, B.; Unwin, I.D. and Buss, D.H. 1992. *Fruits and Nuts*. The Composition of Foods, 5th ed. Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food, Cambridge, U.K.

Homler, B.E. 1984. Properties and stability of Aspartame. *Food Technol.* 38(7): 50-55

Jain, S.P.; Tripathi, V.K.; Ram, H.B. and Singh, S. 1984. Effect of storage conditions on the keeping quality of fruit squashes. *Indian Food Packer*, 38(5): 33-39

Jain, V.; Tiwari, B.L.; Sharma, H.G. and Saxena, R.R. 1996. Evaluation of late maturing mango varieties for the preparation of beverages as nectar and RTS. *Indian Food Packer*, 50(3): 9-14

Jawahir, K.; Badrie, N. and Donawa, A. 2001. Effect of blanching on pickled bittergourd (*Momordica charantia*). *J. Food Sci. Technol.*, 38(2): 105-110

Joshi, V.K.; Chauhan, S.K. and Lal, B.B. 1993. Evaluation of enzymatically extracted plum juice for preparation of plum beverages. *J. Food Sci. Technol.*, 30: 208-210

* Joslyn, M.A. 1956. Role of amino acids in the browning of orange juice. *Adv. Food Res.*, 22: 1

Kachhi, A.I.; Mehta, D. and Tekchandani, H.K. 1988. Sorbitol and other starch derived polyhydric alcohols in the food industry. Saket Food Processing Handbook, ed. J. Narayan and G. Shah, Saket Projects Ltd. India

Kalia, M. and Sood, S. 1996. Energy. **In:** Food preservation and processing. Kalyani Publishers, New Delhi, pp. 66-75

Kalra, C.L. 1991. Effect of blanching in vegetable processing. *Indian Food Packer*, 44(5): 3-16

Kalra, C.L.; Berry, S.K. and Kulkarni, S.G. 1988. The bittergourd-A unique vegetable. *Indian Food Packer*, 42(2): 35-45

Kalra, C.L.; Pruthi, J.S.; Teotia, M.S. and Raina, B.L. 1983. Influence of variety on the quality of processed bittergourd (Karela). *Indian Food Packer*, 37(4): 71-77

Kedar, P. and Chakrabarti, C.H. 1982. Effect of bittergourd (*Momordica charantia*) seed and Glibenclamide in streptozotocin induced diabetes mellitus. *Indian J. Experimental Biology*, 20(3): 232-235

Khan, R.A. 1999. A study of karela (*M. charantia*) on blood glucose. *Hamdard Medicus*, 42(2): 56-61

Khurana, D.S. and Anand, J.C. 1980. Changes in chemical constituents and organoleptic quality for heat processed phalsa beverage during storage in glass bottles. *J. Food Sci.*,18: 160-161

Khurdiya, D.S. 1995. Non-thermal methods for preservation of fruits and vegetables: A critical appraisal. *J. Food Sci. Technol.*, 32(6): 441-452

Kosmark, R. 1992. Personal communication. Pfizer Specialty Chemical Technical Service, Groton, Conn.

Krishnaveni, A.; Manimegalai, G. and Saravanakumar, R. 2001. Storage stability of jack fruit (*Artocarpus heterophyllus*) RTS beverage. *J. Food Sci. Technol.*, 38(6): 601-602

Kumar, D. and Singh, S.P. 1996. Evaluation of tomato cultivars for juice preparation. *Indian Food Packer*, 50(5): 11-15

Kumar, N. 1992. Apple pomace-utilization for edible products. *M.Sc. Thesis*, DR. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.)

Kumar, S.S.; Kalra, R. and Nath, N. 1991. Dehydration of bittergourd (*Momordica charantia* L.) rings. *J. Food Sci. Technol.*, 28(1): 52-53

Lal, B.B.; Joshi, V.K.; Sharma, R.C. and Sharma, R. 1999. Preparation and evaluation of apple and ginger based squash. *J. Sci. Ind. Res.*, 58(7): 530-532

Lal, G; Siddappa, G.S. and Tondon, G.L. 1986. Preservation of fruits and vegetables. *ICAR*, New Delhi, pp. 47-50

Lotlikar, M.M. and Rao, M.R.R. 1966. Pharmacology of a hypoglycaemic principle isolated from the fruits of *Momordica charantia* L. *Indian J. Pharmacy*, 28(5): 129-133

Majeed, M. and Badmaev, V. 1997. Ayurveda and Indo-Tibetan material medica : alternative medicine goes mainstream for better health care delivery. *Proceedings of Indian Pharmaceutical Congress on Ayurveda*, : 1-14

Mandal, R.K. 2001. Herbs and spices: resources for mellennium drugs. *Science and Culture*, 67: 1-2

Manimegalai, G. and Ramah, S. 1998. Effect of pretreatments on the quality characteristics of dehydrated bittergourd rings. *Indian Food Packer*, 52(4): 7-14

Masoodi, F.A.; Bhupinder, K. and Harinder, K. 1992. Perlette grape juice: effect of extraction method, SO_2-concentration and storage on the physico-chemical composition. *Indian Food Packer*, 46(6): 5-13

Mayer, L.H. 1960. Food Chemistry, 3rd ed. AVI Publication Co. Westport, CT

Meena, M.R. and Sethi, V. 1994. Antimicrobial activity of essential oils from spices. *J. Food Sci. Technol.*, 31(1): 68-70

Meena, M.R. and Sethi, V. 1998. Antimicrobial activity of some common spices. *Beverage Food World*, 25(1): 42-43

Mehta, U. and Bajaj, S. 1983. Effect of storage and methods of preservation on the physico-chemical characteristics of citrus juices. *Indian Food Packer*, 37(4): 42-51

* Moleyar, V. and Narsimham, P. 1992. Antibacterial activity of essential oil components. *Int. J. Food Microbiol.*, 16(4): 337-342

Murari, K. and Verma, R.A. 1989. Studies on the effect of varieties and pulp extraction methods on the quality of guava nectar. *Indian Food Packer*, 43(5): 11-15

Palaniswamy, K.P. and Muthukrishnan, C.R. 1974. Studies on the physico-chemical characters of lemon juices and squashes during storage. *Indian Food Packer*, 28(4): 37-41

Pandey, A. and Nigam, P. 1987. Non-nutritive sweeteners in food systems. *Indian Food Industry*, 6(4): 157-165

Pandey, D.C.; Tomar, M.C. and Singh, U.B. 1995. Preparation, processing and storage studies on raw mango pana. *Indian Food Packer*, 49(6): 5-9

Panse, U.G. and Sukhatme, P.V. 1967. *Statistical methods for agricultural workers*. ICAR, New Delhi

Pastor, M.V.; Costell, E.; Lzquierdo, L. and Duran, L. 1996. Optimizing acceptability of a high fruit-low sugar peach nectar using aspartame and guar-gum. *J. Food Sci.*, 61(4):852-855.

* Patnaik, S.; Subramanyan, V.R. and Rath, C.C. 1995. Effects of essential oils on the viability and morphology of *Escherichia coli*. *Microbiol.*, 84: 195-199

* Pelgroms, J. 1987. The combination of sugars with intense sweeteners. *Belgian J. Food Chemistry Biotechnology*, 42(1):3-9

Polasa, K. 1995. Current status of saccharin-An appraisal. *J. Food Sci. Technol.*, 32(4): 267-277

Ragab, M. 1987. Characteristics of apricot jam sweetened with saccharin and xylitol. *Food Chem.*, 23: 55-64

Ramah, S.; Manimegalai, G. and Vennila, P. 1999. Studies on steeping preservation of bittergourd in acidified brine solution. *J. Food Sci. Technol.*, 36(1): 78-80

* Raman, A. and Lau, C. 1996. Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). *Phytomedicine*, 2(4): 349-362

Ranganna, S. 1986. *Handbook of Analysis and Control for Fruit and Vegetable Products*. Tata McGraw Hill Pub. Co. Ltd., Delhi

Ranote, P.S.; Saini, S.P.S. and Bawa, A.S. 1993. Evaluation of thermal process and shelf life of kinnow juice. *J. Food Sci. Technol.*, 30(2): 88-91

Rekha, M.N.; Ramteke, R.S.; Indiramma, A.R. and Eipeson, W.E. 1995. Studies on preparation of quick cooking bittergourd curry mix. *Indian Food Packer*, 49(6): 53-56

* Reynolds, T.H. 1965. Chemistry of non-enzymatic browning II. *Adv. Food Res.*, 14: 167

Sahni, C.K. and Khurdiya, D.S. 1989. Effect of ripening and storage temperature on the quality of mango nectar. *Indian Food Packer*, 43(6): 5-11

Sahni, C.K. and Kumar, S. 1998. Browning reaction in foods-recent approaches to control browning-an overview. *Indian Food Packer*, 52(4): 40-47

Saini, S.P.S. and Grewal, V.S. 1995. Physico-chemical changes during manufacture and storage of sand pear (*Pyrus pyrifolia*) juice concentrate. *Indian Food Packer*, 49(3): 5-14

Saini, S.P.S. and Pal, D. 1997. Storage stability of kinnow juice. *Beverage Food World*, 24(1): 25-26,28

* Sambaith, K. 1993. Effect of cumin, ginger, mustard and tamarind in induced hypercholesteroleanic rats. *Nahrung*, 35(1): 47-51

Sandhu, K.S. and Bhatia, B.S. 1985. Physico-chemical changes during preparation of fruit juice concentrate. *J. Food Sci. Technol.*, 22(3): 202-206

Sandhu, K.S.; Bhatia, B.S. and Shukla, F.C. 1985. Physico-chemical changes during storage of kinnow, mandarin, orange and pineapple juice concentrates. *J. Food Sci. Technol.*, 22(5): 342-345

* Schiffman, S.S.; Crofton, U.A. and Shukla, F.C. 1985. Sensory evaluation of soft drinks with various sweeteners. *Physiology and Behaviour*, 34(3): 369-377

Sethi, V. 1990. Lactic fermention of black carrot juice for spiced beverage. *Indian Food Packer*, 44(3): 7-11

Shah, S.H.; Siddiqui, M.M.H. and Siddiqui, M.Y. 1999. Effect of Karela (*Momordica charantia*) powder in Qooba (Dermatophytosis). *Hamdard*, XLIV(2): 19-21

Sharma, M. 1997. Studies on the preparation and evaluation of Plum-soya products. *M.Sc. Thesis*, Dr.Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.)

Sharma, R. 1999. Studies on preparation and evaluation of low calorie plum appetizer. *M.Sc. Thesis,* Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.)

Sharma, R. and Sharma, A.K. 2000. An indigenous drug management of Madhumeha. *Proceedings of International Congress on Ayurveda*, 84: 28-30

Sharma, R.; Barwal, V.S. and Lal, B.B. 2002. Preparation and evaluation of spiced plum squash. *Beverage Food World*, 29(3): 23-26

Sharma, R.C.; Chauhan, S.K.; Chopra, S.K. and Dhar, R.P. 1991. Processing of stone fruits with special reference to plums. *Beverage Food World*, 18(3): 18-20

Sharma, S.K.; Sharma, P.C. and Lal, B.B. 2001. Effect of storage temperature and folds of concentration on quality characteristics of galgal (*Citrus pseudolimon* Tan.) juice concentrates. *J. Food Sci. Technol.*, 38(6): 553-556

* Shelf, L.A. 1983. Antimicrobial effect of spices. *J. Food Safety*, 6: 29

Shrestha, M.K. and Bhatia, B.S. 1982. Apple juice: Physico-chemical characteristics and storage studies. *Indian Food Packer*, 36(3): 53-60

Srivastava, J.S. 1998. Comparative study of RTS drinks prepared from Dashehari and Banganpalli mangoes. *Indian Food Packer*, 52(2): 38-40

Srivastava, M.P. 1983. Evaluation of apple cultivars for processing suitability. *M.Sc. Thesis*, HPKV, Palampur

* Srivastava, Y.; Bhatt, H.V.; Verma, Y.; Venkaiah, K. and Raval, B.H. 1993. Antidiabetic and adaptogenic properties of *Momordica charantia* extract: an experimental and clinical evaluation. *Phytotherapy Research*, 7(4): 285-289

Thakur, K.S. and Barwal, V.S. 1998. Studies on preparation and evaluation of squash from unmarketable kiwifruit. *Indian Food Packer*, 52(1): 26-27

Tomar, M.C.; Srivastava, R.K. and Bisht, N.S. 1988. Studies on the preparation and effect of diabetic jelly on blood sugar. *Indian Food Packer*, 42(2): 10-14

Wilson, E.L. and Burns, D.J.W. 1983. Kiwi juice processing using heat treatment techniques and ultra-filteration. *J. Food Sci.*, 48(4): 1101-1105

Wiseman, J.J. and McDaniel, M.R. 1991. Modification of fruit flavours by aspartame and sucrose. *J. Food Sci.*, 56(6): 1168-1170

Woodroof, J.G. and Luh, B.S. 1986. Commercial fruit processing. AVI Publishing Co., Inc. Westport, Connecticut

Yuwai, K.E.; Rao, K.S.; Kaluwin, C.; Jones, G.P. and Rivett, D.E. 1991. Chemical composition of *Momordica charantia* L. fruits. *J. Agric. Food Chem.*, 39: 1762-1763

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* Original not seen

ANNEXURES

ANNEXURE-I

MEAN MONTHLY METEOROLOGICAL DATA DURING STUDY PERIOD (2001-2002)

Month	Temperature (°C)		Relative humidity (%)
	Maximum	Minimum	
June, 2001	28.4	18.5	78.0
July, 2001	28.5	20.7	84.0
August, 2001	28.7	20.2	80.5
September, 2001	29.7	15.2	63.0
October, 2001	28.1	11.2	56.0
November, 2001	24.4	6.6	57.0
December, 2001	20.8	3.5	60.3
January, 2002	17.8	2.6	65.0

Source: Meteorological Observatory, Department of Soil Science and Water Management, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) - 173 230

ANNEXURE-II

PROFORMA FOR SENSORY EVALUATION OF BITTERGOURD RTS

Date of evaluation: ____________________

Evaluated by: ____________________

Sample No.	Appearance/ Colour	Flavour	Taste	Body	Overall acceptability	Remarks
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						

Rating on 9 point Hedonic Scale as:

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

Special observations, if any with particular treatments: ____________________

____

Signature of evaluator

ANNEXURE-III

PROFORMA FOR SENSORY EVALUATION OF SPICED BITTERGOURD SQUASH

Date of evaluation: ____________________

Evaluated by: ____________________

Sample No.	Appearance/ Colour	Flavour	Taste	Body	Overall acceptability	Remarks
1						
2						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						
11.						
12.						
13.						
14.						
15.						
16.						
17.						
18.						
19.						
20.						
21.						
22.						
23.						
24.						
25.						
26.						
27.						

Rating on 9 point Hedonic Scale as:

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

Special observations, if any with particular treatments: ____________________

____

Signature of evaluator

CURRICULUM VITAE

Name : Tuhin Kumar Singh

Father's Name : Sh. N. Singh

Date of Birth : 22.06.1976

Sex : Male

Marital Status : Unmarried

Nationality : Indian

Educational Qualifications :

Certificate/ degree	Class/ Grade	Board/ University	Year
Matric	Second	CBSE	1991
10+2	Second	CBSE	1993
B.Sc. (Ag)	First	BAU, Ranchi	2000

Whether sponsored by some state/ Central Govt./Univ./SAARC : No

Scholarship/ Stipend/ Fellowship, any other financial assistance received during the study period : M.Sc. - University Stipend only for I Semester

(***Tuhin Kumar Singh***)