DEVELOPMENT AND EVALUATION OF CHAYOTE (*Sechium edule*) BASED FOOD PRODUCTS

THESIS

By

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IN

Partial fulfilment of the requirements for the degree

OF

MASTER OF SCIENCE IN HOME SCIENCE
(FOOD SCIENCE AND NUTRITION)

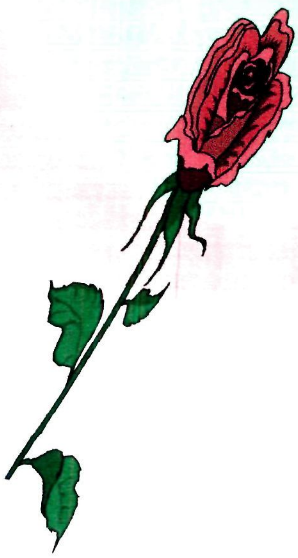
2005

AFFECTIONATELY

DEDICATED

TO MY

BELOVED PARENTS



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CERTIFICATE - I

This is to certify that the thesis entitled **"Development and Evaluation of Chayote (*Sechium edule*) Based Food Products"**, submitted in partial fulfilment of the requirements for the award of the degree of **Master of Science (Home Science)** in the subject of **Food Science and Nutrition** of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur is a bonafide research work carried out by **Ms. Kulmeet Kaur** (H-2003-30-01) daughter of **Dr. J. Singh Oberoi** under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

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

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Chairman
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Dated: 4th Oct., 2005.

CERTIFICATE - II

This is to certify that the thesis entitled **"Development and Evaluation of Chayote (*Sechium edule*) Based Food Products"**, submitted by **Ms. Kulmeet Kaur** (H-2003-30-01) daughter of **Dr. J. Singh Oberoi** to the Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur in partial fulfilment of the requirements for the degree of **Master of Science (Home Science)** in the subject of **Food Science and Nutrition** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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INTRODUCTION

Chapter-I

INTRODUCTION

Chayote (*Sechium edule*) belongs to gourd family *Cucurbitaceae* which includes melons, squash and cucumbers. It was domesticated in Mexico but now can be found cultivated across the world, primarily for its fruit. But still It is lesser known and neglected vegetable crop (Elaine, 2004). Now a day it is gaining popularity and importance as a food crop Worldwide due to some inherent qualities (Aung *et al.*, 1990).

In India it has been grown very successfully in North Eastern areas like Darjeeling, lower areas of Himachal Pradesh and in Southern states like Karnataka and Kerala (Nath, 1971). Chayote is a climbing shrub with large leaves that form a canopy over the fruit (Saade, 1996). It provides shoot up to 15 meters, which bear racemes inflorescences of male flowers and single female flowers with both male and female flowers on the same vine.

Chayote fruit comes in two common varieties, the smooth variety and a prickly variety which is covered with spines. The fruit is light green, pear shaped thin skinned with white flesh, 10-20 cm in length and 200-400 gm in weight. A well grown plant of about one year or more yields about 500-800 fruits per year. The flesh has a fairly bland taste, and a texture described as a cross between a potato and a cucumber. The seed is ovoid, compressed with a soft and smooth testa and has a nutty flavour (Saade, 1996).

Chayote is found in lower areas of Himachal Pradesh between the months of September and November where it is locally known as 'Lonku'. It is consumed as a vegetable but not relished much due to its bland taste. This crop has considerable potential for further exploitation (Aung *et al.,* 1990). However, it has remained neglected, underutilized and has hardly received any attention from post-harvest technology view point The local villagers have been asking to suggest some methods of utilization of this fruit in the preparation of value added products. Therefore, its commercial potential needs to be exploited particularly in the form of unblended and blended value added products of acceptable quality. Keeping this in view, this study was undertaken with the following objectives.

1. To develop value added chayote based food products like Nuggets, pickle, sauce, chutney, candy and dehydrated products.
2. To evaluate the raw ingredients (chayote peel, flesh, whole fruit, other fruits and pulses) and chayote based food products for different physical and chemical characteristics as well as organoleptic acceptability of the products.
3. To make recommendations regarding the preparation of value added products from chayote on the basis of outcome of this study.

REVIEW OF LITERATURE

Chapter-II

REVIEW OF LITERATURE

The relevant information pertaining to chayote (*Sechium edule*) and other food resources (soybean, black gram, plum, raw mango, tomato and galgal) used in the development of chayote based value added products (nuggets, candy, sauce, pickle, chutney, and dehydrated chayote) from chayote and similar products is reviewed under the following sections :

2.1 Chayote (*Sechium edule*)

Chayote (*Sechium edule*) is tropical or subtropical climbing shrub, which bears edible fruits (Plate-1a and 1b). Chayote belongs to the family *Cucurbitaceae*. Chayote is perennial- rooted cucurbit, with climbing vines and leaves resemble those of the cucurbits. The whole fruit is planted as a seed. Each fruit has a single large seed that sprouts as soon as the fruit reaches maturity. The vine developing from the sprouted seed is grown on the ground or more commonly on trellises (Saade; 1996). Since it is perennial, the best production is obtained 2-3 years after the plant is established. The fruit is light green and pear shaped, which contains a single flat edible seed. (James, 1994). It is consumed predominantly as seasonal vegetable in Himachal Pradesh and is locally known as '*Lonku*'. Chayote is originated in Mexico and is cultivated today

Plate 1(a). Chayote climbing shrub bearing fruits

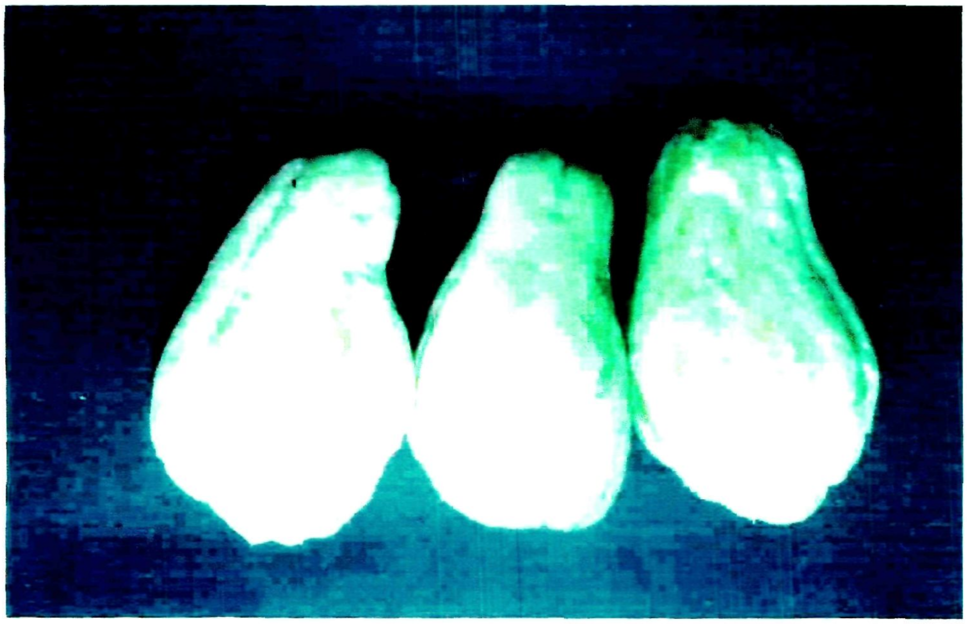


Plate 1(b). Chayote (*Sechium edule*) fruits

in many tropical countries (Monnerville *et al.*, 2001). It is also grown in Louisiana, Florida and the Southwestern U.S (Elaine, 2004). It was introduced into the South America between the eighteenth and nineteenth centuries. The first botanical description mentioning the name *Sechium* was infact done in 1756 by *P. Brown* who referred to plants Jamaica. During the same period, the chayote was introduced into Europe whence it was taken to Africa, Asia and Australia. Now it has become very popular in United States. (James, 1994; Saade, 1996). Fruit is slightly bigger in North East India (Sheshadri, 1993).

Chayote is pronounced as "chy-O-tay" is the Spanish name (from Nahuatl *hitzayotli*) used in many parts of Latin America and the rest of the world for the cultivated varieties of this plant. Within Latin America it has a vast variety of names according to the region and language of the people who use the plant, including 'tayote', 'chocho', 'gayota', 'chuchu'.In other parts of the world it is also known variously as; 'cahiota' (Portuguese), 'cajot' (Russian), 'chocho' (English), 'choko' (Australian), 'christophene' (French), 'christoferine' (Caribbean) 'chouchou' (English), 'mango squash' (English), 'mirliton' (Cajun), 'sayote' (Philippines). 'pipinella' (Portuguese), 'vegetable pear' (English), 'vilati vanga' (India), and 'zucca' (Italian).

Chayote will keep refrigerated for many days but it best to use as quickly as possible because old chayote become very wrinkled and become dry and tough Chayote has a good nutritional properties (Gopalan *et al.*, 1995). Fruit has firm detectable fruit flesh texture and can be casseroled, creamed, curried, fried, scalloped, sautéed or pickled to different palates.

The literature reported on the physico-chemical and medicinal properties of fruit chayote, along with the food uses of this fruit is reviewed in the following sections.

2.1.1 Physical Characteristics

1 Fruit Weight

Engles (1983) studied some physical characteristics of ripe fruit of chayote and he reported the weight of fruit is to be between 48-540 g. Madhu (1997) also evaluated chayote fruit from Palampur area of Himachal for physical parameters and reported the mean fruit weight of chayote as 239.50 g. Nath (1971) also reported the weight of chayote which is ranged between 200 - 450g.

2 Fruit Colour

Nath (1971) reported the availability of two strains of chayote in India. One is light green to green and other one is creamy. The former one is preferred over the latter for vegetable but the latter is high yielding and most attractive. Engles (1983) studied some physical characteristics of ripe fruit of chayote and reported the colour of chayote is to be whitish green, light green, green and dark green. Madhu (1997), Elaine (2004) and James (1994) reported the colour of fruit chayote as light green.

3. Fruit Shape

Engles (1983) reported the shape of fruit chayote is to be pyriform, subpyriform, ovoid, flattened and rounded. Madhu (1997) also reported the shape of fruit chayote as ovoid. Elaine (2004) reported the fruit chayote as Pear shaped.

4. Fruit Size

Madhu (1997) reported the length as 9.11 cm, top width as 5.08 cm, middle width as 7.35 cm and bottom width as 7.65 cm. Engles (1983) reported the length of fruit to be ranged from 4.8 to 11.8 cm. Whereas Saade (1996) reported the length of fruit chayote to vary from 10 to 20 cm.

2.1.2 Chemical Characteristics

1. Moisture

Flick *et al.* (1978) reported 94.7 per cent moisture content in chayote. Whereas, Engles (1983) reported a moisture content of 90.8g in 100g of chayote fruit. Gopalan *et al.* (1995) reported 92.5 per cent moisture in fresh chayote. Sudha *et al.* (1999) evaluated fresh Chayote *(Sechium edule)* fruits at an interval of 10 days in 5 lots and reported that the fruit showed relatively high level of moisture content varying from 92.12 to 93.80 per cent. Madhu (1997) reported the moisture content of chayote (*Sechium edule*) with and without peel as 93.13 and 93.48 per cent respectively. Gopalan *et al.* (1995) also reported the moisture content of chayote as 92.56 per 100g of fresh fruit.

2. Crude Protein

Nath (1971) reported 0.9 per cent crude protein content in chayote on fresh basis. Gopalan *et al.* (1995) reported 0.7 per cent protein on fresh weight basis in chayote. Madhu (1997) reported the crude protein content of chayote (*Sechium edule*) fruit with and without peel as 6.54 and 6.62 per cent on dry weight basis and 0.95 and 1.00 per cent on fresh weight basis respectively. Sudha *et al.* (1999) reported slightly higher crude protein contents (5.25 to 7.66%) than above on dry weight basis. The fruit and seed proteins were reported to contain some amino acids such as aspartic acid, alanine, arginine, cysteine, phenylalanine, glycine, histidine, leucine, methionine, praline, serine, tyrosine, and valine (Saade, 1996).

3. Crude Fat

Nath (1971) reported the fat content of fruit chayote as 0.3g per 100g. Flick *et al.* (1978) reported the ether extract in chayote as 0.6 per cent on dry weight basis. Gopalan *et al.* (1995) reported 0.1 per cent fat in fresh Chayote. Sudha *et al.* (1999) reported the fat content of fruit chayote to vary between 1.0 to1.85g per 100g on dry weight basis. Madhu (1997) reported the crude fat content of chayote (*Sechium edule*) whole fruit and peeled fruit samples as 1.50 and 1.35 per cent on dry weight basis and 0.22 and 0.21 per cent on fresh weight basis.

4. Ash and Minerals Constituents

Flick *et al.* (1978) reported the ash content of chayote as 3.6 per cent on dry weight basis. The value reported by Engles (1983) and Gopalan *et al.* (1995) were identical (0.4%) ash on fresh weight basis. In contrast to these Sudha *et al.* (1999) reported a ash range of 5.28 to 6.08 per cent on dry weight basis. Madhu (1997) reported the ash content of whole fruit and whole peeled samples of chayote as 4.90 and 4.63 per cent on dry weight basis and 0.73 and 0.72 per cent on fresh weight basis, respectively.

Nath (1971) reported values for phosphorus as 20mg and calcium as 19g in 100g of fruit chayote.

Flick *et al.* (1978) reported chayote to be very rich in calcium (17.90 ppm) and phosphorus (12870.0 ppm) on dry weight basis .The other minerals reported were; iron 77.9, copper 8.7, magnesium 1540.0, manganese 4.94, sodium 177.0 and zinc 6.4 ppm on per cent fresh fruit weight basis.

Engles (1983) reported 12mg calcium, 30 mg phosphorus, and 0.6mg iron per 100g on fresh chayote weight basis.

Gopalan *et al.* (1995) have reported calcium, phosphorus and iron contents of fresh chayote as 140, 30 and 0.6 mg/100 g of fresh fruit.

Sudha *et al.* (1999) evaluated the mineral content of fruit chayote which was ranging from calcium 145.5 to 314.5 mg, iron 6.7 to 18.9 mg, magnesium 117.5 to 207.0 mg, copper 0.63 to 1.55mg and sulphur 127.0 to 173mg per 100g on dry weight basis. Madhu (1997) reported the mineral contents present in fruit chayote is to be calcium 814.0mg, iron 12.33mg, phosphorus 289.67 mg and 3350.0 mg potassium on dry weight basis. Fruit was reported to be low in sodium (Elaine, 2004)

5. Carbohydrates

Hoover (1923) reported that the total carbohydrates of Florida grown fruit was 7.5 per cent on fresh fruit basis. Zinsou *et al.* (1983) studied the carbohydrates content at various levels of fruit development of chayote and reported that glucose, fructose and sucrose were the major sugars in carbohydrates fraction solubilized by ethanol/water. After 15 days of anthesis, glucose and fructose contents were maximum. However, at the time of picking the starch content increase to 27 per cent on dry matter weight basis where as fructose and glucose level decreased.

Aung *et al.* (1991) studied the qualitative and quantitative aspects of carbohydrates in the organs of chayote by HPLC, TLC and calorimetric procedures. The immature fruit showed starch content of 75 micro gram/mg in flesh on dry weight basis. The roots and tubers had 51 per cent and 72 per cent starch respectively on dry weight basis. The major sugars in chayote were identified as glucose, fructose, sucrose, and sorbitol. Raffinose and stacchyose were found to be present in lesser amounts. Two unidentified sugars were also detected. Gopalan *et al.* (1995) reported 5.7 per cent carbohydrates and 27 Kcal energy in 100 g of fresh chayote. Sudha *et al.* (1999) reported 80.17 to 82.2 per cent carbohydrates in chayote on dry weight basis.

Nath (1971) reported a total sugar content of 4 per cent. Cook (1901) reported 0.3 per cent sugars on fresh fruit basis. The sugar contents of 6.89 and 1.06 per cent were reported in whole and peeled fruits by Madhu (1997) In contrast to these, Sudha and Awasthi (1999) reported a very high content of total sugars (27.67 to 31.93%) at different stages of fruit maturity on dry weight basis.

6. Vitamins

Nath (1971) reported 11mg ascorbic acid and 50 IU of vitamin A in 100g chayote on dry weight basis. Engles (1983) conducted quality studies on *Sechium edule* collected in Central America and reported that the Ascorbic acid content on fruit chayote as 20mg on per cent weight basis.

Gopalan *et al.* (1995) also reported the presence of riboflavin (0.04mg), niacin (0.4mg) and ascorbic acid (4.0 mg) on 100 g weight basis in fruit chayote.

Sudha *et al.* (1999) also reported the ascorbic acid content, which ranged between 2.94 to 3.45 mg per 100g on fresh fruit basis. Madhu (1997) also reported the ascorbic acid content of fruit chayote as 4.00 mg per 100g on fresh weight basis.

7. Fibre Components

Flick *et al.* (1978) reported 7.6 percent crude fibre in fruit chayote on dry weight basis.

Engles (1983) reported a value of 0.6g per 100g on fresh weight basis. Whereas, Gopalan *et al.* (1995) reported 0.6 per cent crude fibre in chayote on fresh weight basis.

Sudha *et al.* (1999) reported that the crude fiber content in fruit chayote ranged from 5.5 to 7.1 per cent on dry weight basis. Gopalan *et al.* (1995) also reported the crude fibre content as 0.6g per 100g.

Madhu (1997) reported the crude fibre contents of whole and peeled chayote as 5.59 and 4.49 per cent on dry weight basis and 0.83 and 0.67 per cent respectively on fresh weight basis.

Madhu (1997) also evaluated the (ADF) acid detergent fiber and (NDF) Neutral detergent fiber contents of whole and peeled chayote fruit. The contents of ADF and NDF were reported as 17.55 and 25.73

per cent in whole fruit and 18.85 and 24.19 per cent in peeled fruit respectively on dry weight basis.

2.1.3 Medicinal Uses

The leaves and fruits of chayote have *diuretic, cardiovascular*, and *anti-inflammatory* properties, and a tea made from leaves has been used in the treatment of *arteriosclerosis* and *hypertension* and to dissolve kidney stones. Infusions of the fruit are used to alleviate urine retention. The cardiovascular properties of the infusions of leaves have been tested in modern studies, while their great effectiveness in curing kidney diseases has been known since cronical times on the Yucatan peninsula, where these aliments are very common. (Saade, 1996; James, 1994). Madhu (1997) worked on the comparative nutritional evaluation of chayote (*Sechium edule*) and bottle gourd with special reference to their *cholesterolaemic* effect and fruit was found to lower the blood cholesterol levels in the experimental animals.

2.1.4 Food Uses

Chayote has a good nutritional properties and a firm detectable fruit flesh texture and can be casseroled, creamed, curried, fried, scalloped, sauteed, baked, buttered, stuffed, mashed or pickle to different palates (Aung *et al.*, 1990; James, 1994).

The valuable fruits of chayote and its roots is an important element in the diet in many parts of Latin America, and it is a valuable export crop Saade (1996).

The immature fruits can be eaten in salads and provide a good source of vitamin C (Herklots, 1972). Young leaves and tendrils are also eaten, and seeds can be sautéed in butter as a delicacy. The large storage roots represent a rich source of starch (Chakravarty, 1990). Chayote is stuffed with a mixture of raisins, nuts, brown sugar and eggs and baked until tender (Elaine, 2004).

Although most people are familiar only with the fruit, which in culinary terms is a vegetable, the root, stem, seeds and leaves all are edible. The tuberous part of the root is starchy and is both eaten by humans and used as cattle fodder. Because of its softness, the fruit has been used for children's food, juices, sauces and pasta dishes .In Mexico the attempt has been made to increase the life of the fruit by drying it. The results have been positive and have enabled jams and other sweets to be prepared while also producing dried fruit, which can be used as a vegetable after a certain time. Its stems can also used in the manufacture of baskets and hats (Saade, 1996).

2.2 Food Legumes

Although legumes provide calories and are important sources of several B-complex vitamins, minerals and fibre, their major importance lies in their actual and potential value as a source of plant protein for human nutrition. The high fibre content in soya foods makes it role vital in dealing with the two modern killers- Cardiac diseases and Cancer (Rashid, 2002). In India legume constitute about 30- 50 percent of diet. (Deshpande and Damodaran, 1990; Deshpande, 1992; Patki and Arya, 1994). Two legumes (soybean and black gram) are widely used in the preparation of nuggets, The author has attempted utilization of these two in the development of value added chayote based nuggets. Some information on their physico-chemical characteristics and food utilization is reviewed as under:

2.2.1 Soybean (*Glycine max*)

Soybean is an important crop of Madhya Pradesh and a few others states of India (Anon, 1992). It is the lowest priced legume and has a very high protein among various legumes. It has about 20 per cent oil, 40 per cent protein (twice the protein content of common pulses), and very little starch Being an excellent source of valuable nutrients and cholesterol free fat, consumption of this legume can contribute to human nutrition by improving colonic functions, lowering of blood cholesterol, guarding against various diseases like cancer, chronic heart diseases and diabetes mellitus, etc. Soybean being rich in protein and calories has a great potential to tackle the problem of protein energy malnutrition in India and many other developing countries at lower cost. (CFTRI, 1992).

Lim *et al.* (1990) reported the weight of soybean to range from 15.24 to 35.51 g/100 beans and bulk density as 0.672 g/ml.

According to Sexena *et al.* (1994) showed six varieties of soybean having 0.69 to 0.74 g/cc bulk density, 1.05 to to1.18 g/cc true density, 94.30 to 145.6 g/1000 grain weight and 7.3 to 8.6 per cent hull content.

Jyoti (2002) reported that upon dehulling, *Bragg* variety of soybean yields about 91.38 per cent full fat cotyledons and 8.62 per cent hulls. The 1000 kernel weight of soy-grains is 160.72 g and that of soy *dhal* (cotyledons) is 70.23g and bulk densities are 0.69 and 0.71 g/ml respectively. Poonam (2002) reported the 1000 kernel weight of soybean as 204.00 g.

Krishna *et al.* (2003) showed the physico-chemical characteristics of new varieties of soybean having hull content 7.31 to 8.51 per cent, true density 1.04 to 1.18 g/cc, bulk density 0.68 to 0.74 g/cc and 1000 grain weight is 118.3 to 145.6 g.

Saxena *et al.* (1994) evaluated certain new varieties of soybean for their chemical characteristics and reported variable contents of moisture (9.8 to12.7%), protein (34.3 to 40.7), fat, (16.5 to 18.3%) crude fibre, (4.1 to 4.6%), ash (4.5 to 5.3%) and carbohydrates (20.0 to 25.4%) in these varieties.

Geetika (1997) evaluated four varieties of soybean for various chemical constituents and reported that the protein content in these varied from 35.34 to 41.96 per cent, crude fat from 19.01 to 21.07 per cent, crude fibre from 3.96 to 5.01 per cent, ash from 4.01 to 4.63 per cent and total carbohydrates from 19.43 to 35.59 per cent.

Jyoti (2002) evaluated the proximate composition of whole grains and cotyledons of *Bragg* soybean and reported that whole kernels and cotyledons contained 8.35 and 8.83 per cent moisture, 91.64 and 91.11 per cent dry matter, 43.32 and 45.77 per cent protein, 17.62 and 19.60 per cent crude fat, 4.16 and 3.95 per cent ash, and 4.48 and 3.61 per cent crude fibre.

Krishna *et al.* (2003) evaluated physico-chemical characteristics of some new varieties of soybean and reported that moisture, protein, fat, crude fibre and carbohydrate content of different varieties ranged from 9.6 to 13.2, 37.19 to 41.56, 18.8 to 22.4, 3.67 to 4.17, 4.2 to 5.2, and 17.58 to 22.47 per cent, respectively. Geetika (1997) evaluated four varieties of soybean for various chemical constituents and reported that the protein content in these varied from 35.34 to 41.96 per cent, crude fat from 19.01 to 21.07 per cent, crude fibre from 3.96 to 5.01 per cent, ash from 4.01 to 4.63 per cent and total carbohydrates from 19.43 to 35.59 per cent.

According to Gupta *et al.* (1976) the mean values for calcium, phosphorus, potassium, zinc, copper, iron and manganese in soybean ranged from 0.311 to 0.431, 0.407 to 0.855, 0.90 to 1.50 g/100g, 3.75 to 4.62, 1.33 to 2.20, 6.66 to 14.00 and 2.16 to 4.66 mg/100g, respectively.

Geetika (1997) studied the (ADF) acid detergent fibre (NDF), neutral detergent fibre and various mineral constituents in soybean. The author reported that soybean on an average contained 13.15 per cent ADF and 26.32 per cent NDF. The mean values for mineral constituents in these varieties were reported to be as 0.37 mg/100g for calcium, 0.62 mg/100g for phosphorus, 1.06 mg/100g for potassium, 4.27 mg/100g for zinc, 2.0 mg/100g for copper, 8.74 mg/100g for iron and 2.71 mg/100g for magnesium, respectively.

Ikechukwu *et al.* (2002) analysed soybean seeds for total dietary fibre and various mineral constituents. According to author the soybean on an average contained 22.80 per cent total dietary fiber (TDF), 10.0 mg/ 100g sodium, 92 mg/100g potassium, 260 mg calcium, 320 mg magnesium, 750mg phosphorus and 7 mg 100g iron on per cent dry weight basis.

2.2.2 Black gram *(Phaseolus mungo)*

Black gram or urd belongs to the genus *Phaseolus*. It is originated in India. It is the most highly prized of all pulses of the genus Phaseolus. Black gram flour is the chief constituent of the highly popular wafer biscuits known as papad. Because of its mucilaginous arabinoglactins, it is important ingredient in the preparation of idli, dosa, bari and several other food preparations. It also forms the main base of some fried savory and sweet preparation, such as vada and Jahangir.It is also fried in fats, salted and eaten as snack. Manay and Shadaksharaswamy (1987).

Despande and Demodaran (1990) reported the proximate composition black gram. According to them black gram contained 23.4 per cent protein, 1.0 per cent fat, 3.8 per cent crude fibre, 4.8 per cent ash and 57.3 per cent carbohydrates.

Patki and Arya (1994) evaluated the proximate composition of raw black gram *dahls* and reported that it contained 11.50 per cent moisture, 26.4 per cent protein, 1.4 per cent fat, 3.7 per cent ash and 68.5 per cent carbohydrates.

Aparna *et al.* (2000) reported the mean values of moisture, protein, fat, total ash and carbohydrates as 10.2, 21.25, 1.35, 2.80 and 44.30 g/100g, respectively in black gram.

Kamath and Belavady (1980) conducted studies on non available carbohydrates in some common Indian, pulses and reported total dietary fiber content in black gram *dhal* was 13.6 per cent. Whereas, Kumary *et al.* (1984) studied the dietary fibre content of selected foods including black gram and reported 7.9 per cent NDF, 5.3 per cent ADF, 2.6 per cent hemicellulose in black gram on dry weight basis.

Aparna *et al.* (2000) reported 20.10g/100g NDF, 267 mg/100g phosphorus, 196.0 mg/100g calcium and 5.50 mg/100g iron in black gram.

2.3 Fruits

Some fruits (plum, raw mango, tomato and citrus (galgal) were used with chayote to enhance the acceptability of chayote based food products. The related information is reviewed as under:

2.3.1 Raw mango

Mango is considered to be the king of fruits (Doreyappa and Ramanjaneya, 1994). It is the most popular fruits of the tropics. Mangoes are grown in almost all parts of India. India is a largest producer of mango in the world approaching 11 millions tones production per annum (Srivastava, 1998).

Fruits are used in the processing industry for making pickles, chutneys, candy, juice, beverages and jam (Hayes, 1953). It can also be utilized by making mango beverage (Malik, 1975), amchur (Dabhade and Khedkar, 1980) and raw mango slices (Mehta and Tomar 1982).

Bhasin and Bhatia (1981) evaluated the composition of 6 popular table varieties and 4 picking varieties of mango. They reported significant variations in moisture (80 to 90%), acidity (4.5 to 5.0%), pH (3.0 to 3.4) and TSS (8.9 °B). Total reducing sugars and ascorbic acid concentration also varied considerably.

According to Mehta and Tomar (1982) raw mangoes possessed a mean TSS 5.0, acidity 2.82 per cent, reducing sugars 0.5 per cent, total sugars 0.75 per cent and moisture 91.8 per cent. Hoang *et al.* (1989) reported the chemical composition of raw mango. According to these authors raw mango pulp contained 81.00 per cent, moisture, 8.25°B TSS, 2.46 per cent acidity, 3.05 per cent reducing sugars, 1.25 per cent non-reducing sugars, 4.30 per cent total sugar and 76.62 mg/100g ascorbic acid.

Pandey *et al.* (1995) evaluated the preparation, processing and storage of raw mango pana and reported the fresh raw mango pulp contained 85 per cent moisture, 12.0 °Brix TSS, 1.28 per cent acidity, 4.85 per cent reducing sugars, 6.24 per cent total sugars and 51.56 mg/100g ascorbic acid.

Gupta (1998) reported the chemical composition of unripe mature green mango. The values reported are 7.1 per cent for TSS, 2.5 per cent for acidity, 125 mg/100g, for vitamin C, 79.6 per cent for moisture, 2.82 for pH, 0.78 for reducing sugars and 2.7 per cent for total sugars.

2.3.2 Plum

Plum is a perishable stone fruit grown extensively in Himachal Pradesh. Owing to its perishable nature and short harvest season a glut is created resulting in unremunerative prices for growers and considerable wastage (Swaminathan, 1991; Pandey, 1994). Hence reduction in post harvest losses needs to be considered as a necessary adjacent of production and a vital link between production and processing.

At present considerable area of land in Himachal Pradesh is under stone fruit cultivation and plum accounts for 60 per cent of total production of stone fruit Joshi *et al.* (1995). Santa Rosa is one of the leading commercial cultivars of plum for mid hills of H.P (Lal and Thakur ;1978).

Plum is used both for dessert and processing purposes such as jam, nectar, squash (Woodroof and Luh, 1986; Joshi *et al.*, 1993) and chutney (Lal, 1986; Lal *et al.*, 1990)

Sahni *et al.* (1994) evaluated and reported the mean TSS as 16.0 per cent, pH as 3.20, acidity as 1.89 per cent, ascorbic acid as 10.40 mg per 100g, reducing sugars as 4.32 per cent and total sugar as 14.10 per cent in plum pulp.

Das Mohapatra and Sharma (1997) evaluated physico-chemical characteristics of 12 plum cultivars of Himachal Pradesh and they reported the ranges for acidity, TSS, reducing sugars and total sugar content of fruit pulp as 1.41 to 2.90 per cent, 12.0 to 15.2°B, 4.24 to 6.75 per cent and 6.16 to 8.96 per cent, respectively.

Gothwal *et al.* (1998) also evaluated three varieties of plum and reported values above mentioned constituents almost close to the values as reported by Das Mohapatra and Sharma (1997).

Shipra (2005) evaluate and reported the mean Moisture as 85.00 per cent, dry matter as 15.00 per cent, protein as 3.07 per cent, fat as 2.80 per cent and ash as 2.67 per cent in plum pulp.

2.3.3 Tomato

Tomato (*Lycopercicon esculentum*, Mill), is one of the important crops used as fresh vegetable and for preparing variety of processed products, such as tomato juice, ketchup, sauce, canned fruits, puree, paste, etc. (Gopalakrishna and Krishnamurthy, 1982). Commercial manufacture of tomato products ranks first among all processed vegetables. Tomatoes are widely used for culinary purposes. It not only adds to the taste and color of the vegetable preparations but also enhances their vitamin and mineral status (Sethi and Anand, 1982).

Balasubramanian (1984) evaluated the quality and nutritional aspects of tomato and reported that the tomato fruits of 7 cultivars contained 4.40 to 7.08 per cent dry matter, 2.78 to 1.54 per cent reducing sugar, 8.10 to 13.38 per cent acidity and 8.10 to 13.38 mg/100g ascorbic acid.

Gopalan *et al.* (1995) reported 94.0 per cent moisture, 0.9 per cent protein, 0.2 per cent fat, 0.5 per cent minerals, 0.8 per cent fiber, and 27 mg/100g ascorbic acid in tomatoes.

2.3.4 Galgal

Galgal (*Citrus pseudo Limon tan.)* is an excellent source of acid including ascorbic acid but has remained neglected and underutilized so far. It is an indigenous variety of lemon grows well in the lower hills and sub mountainous regions of western Himalaya. The fruit is mostly utilized for pickle making, culinary purpose and blending with other fruit juices for making squashes. This important fruit holds promise to processing industries and growers as well. Therefore, cultivation of galgal should be popularized (Attri and Maini, 1996).

Attari and Maini (1996) reported 6.0 to 8.2°Brix TSS, 5.54 to 5.90 per cent acidity and 33 to 56 mg/100g vitamin C in galgal juice. Whereas, Ranjana (1996) reported TSS as 6.20°Brix, ash as 0.40 per cent, total sugars as 9.53 per cent, acidity as 3.90 per cent and ascorbic acid as 33.11 mg/100g in juice extracted from galgal cultivar grown in Kangra valley of Himachal Pradesh.

2.4 Legume and Fruit based Food products

2.4.1 Nuggets *(warian)*

Nuggets (*Warian*) are very popular in India as they are highly relished for their taste, apart from contributing to nutritional status of the consuming population. Soybean and black gram legumes are widely used in the preparation of nuggets. In Himachal Pradesh nuggets (*warian)* are locally made from a whipped admixture containing wet ground black gram and shredded *bottle gourd (Legenaria vulgaris).* Some information pertaining to food value of nuggets is reviewed under this section

Patil and Ali (1989) prepared soybean '*badi*' at rural/cottage level and they reported 43.12 per cent protein, 19.50 per cent fat, 3.36 per cent ash and 7.5 per cent moisture in soybean *'badi'.*

Sharma *et al.* (1996) evaluated the development and storage stability of instant vegetable '*wadi*'. They reported 10.73 per cent protein, 23.95 percent fat, 5.85 per cent ash and 3.24 per cent moisture in non spiced *'badi'*. The protein content was lower, while fat and total ash contents were higher in instant-spiced '*Wadi*' as compared to non spiced '*wadi*'. These differences were attributed to the addition of vanaspati and spices. The rate of oxidative degradation was much slower in spiced '*wadi* and overall acceptability scores of spiced '*wadi*' packed in PFP did not change significantly during storage.

Kulkarni *et al.* (1997) evaluated the physico-chemical composition of black gram badi and they reported that the black gram '*badi*' contained 5.0 to 9.6 per cent moisture, 13.1 to 21.3 per cent crude protein, 3.4 to 5.5 per cent total ash, 0.23 to 0.55 per cent acid soluble ash, 0.6 to 1.9 per cent acidity and 61.3 to 77.5 g carbohydrates

Poonam (2000) reported the preparation of nuggets from colocasia petiole and tubers using soybean, black gram and bengalgram in the nugget formulations. Soybean supplemented nuggets were reported to be rich in protein, dietary fiber components (NDF and ADF) and some minerals important in human nutrition. The petiole nuggets coated with soybean contained higher contents of NDF (20.3%), ADF (10.20%) and hemicellulose (10.11%), as compared to nuggets prepared from black gram and Bengal gram flours. The nuggets prepared with soybean absorbed more water (2.99 g/g) followed by black gram (2.50 g/g) and Bengal gram (2.01 g/g), respectively. The acceptability of black gram nuggets was not affected much by partially replacing black gram or bengalgram with soybean in the nugget formulations, however, a significant reduction proportionate to the level of replacement occurred in cost by replacing black gram or Bengalgram with soybean.

2.4.2 Dehydrated Products

Dehydration is the most commonly used method of food preservation. Most vegetables and fruits are seasonal in nature. They can be preserved by this technique to extend their availability during the off-season.

Gupta and Nath (1984) reported blanched 'Pusa ruby' variety of tomato blanched for 10 second in 2.5 per cent brine, cooled, sliced into pieces of varying thickness and dried in sun and tray drier (70 and 80 °Celsius) to 8 to 10 per cent moisture. Slices of 2 and 3 cm thickness required 28 and 35 hrs drying as compared to 22 hr for 1 cm slices. Blanching whole tomatoes, slicing into 1 cm pieces and sun drying gave as good dried products than those dried in tray drier. Sundried samples had higher moisture levels. During drying about 38.8 per cent of ascorbic acid loss occurred. The loss was higher in unblanched sun dried samples. Rehydration ratio of sun-dried sample was found to vary from 4.06 to 4.19, which were close to the corresponding values for tray dried samples. Drying time of blanched sample was much less than that of unblanched samples.

Jayaraman *et al.* (1991) evaluated the quality characteristics of some vegetables dried by direct and indirect sun drying and they reported hot air drying of carrot and pea took much lesser time (6 and 7 hrs) as compared to drying in solar cabinet (14 and 15 hrs) and direct sun drying (11 and 13 hrs) respectively. Results showed that drying by direct sunlight there is a loss of pigments and development of rancid odour while indirect sun drying minimized these changes. Rehydration ratios of air dried, solar cabinet dried and direct sun dried vegetables were recorded as 3.3, 2.6 and 2.9, respectively.

Bajaj *et al.* (1993) while studying the effect of blanching treatments on the quality characteristics of dehydrated fenugreek leaves found that the ascorbic acid retention was highest in potassium meta bisulphite (0.5%) treated samples but six months of storage showed best retention of ascorbic acid in unblanched samples. Rehydration ratio, however, ranged from 5.9 to 7.2, the highest being with sulphite treatment. Quality scores were highest for water- blanched samples.

Mular *et al.* (1994) studied the effect of pretreatments (blanching, potassium meta bisulphite and sugar) on the quality of dehydrated cabbage. The moisture content of all the dehydrated cabbage samples was in a range of 4.30 to 4.74 per cent, highest retention of ascorbic acid was found in samples treated with potassium meta bisulphite solutions which was due to the inhibition of the oxidative changes of ascorbic acid by $S0_2$. The blanching and dehydration treatments resulted in considerable loss of ascorbic acid due to leaching and oxidation. Maximum decrease in acidity was observed in sugar treated samples. Highest non-enzymatic browning was noticed in untreated samples followed by 20 per cent glucose solution treated samples due to deprivation of inhibitory effect of sulphur dioxide. Minimum non-enzymatic browning observed in potassium metabisulphite treated samples. Increased concentration of KMS solution helped in increased dehydration ratio. All the treated samples had slightly higher rehydration coefficients than the unbalanced samples. Significantly higher rehydration coefficients were observed for sugar treated samples as compared to other treatments and higher rehydration was observed in sugar treated samples in comparison with sulphite samples. Overall acceptability of the 0.5 per cent potassium meta bisulphite treated sample was found to be superior in comparison with all the treated samples.

2.4.3 Chutney

Fruit chutney is a product with jam like consistence. Chutneys are relished for their sweet, salt, acid and hot spicy taste Sauces are relished for their spicy, sour and salty taste. Sauce has a thick fluid consistency. Chutneys and sauces are quite popular in Indian sub continent. Several authors have reported preparations of various kinds of fruit chutneys and sauces, and their quality characteristics.

Lal *et al.* (1989) prepared chutney from wild and cultivated apricots and evaluated the product for physico-chemical constituents. The chutney so prepared had 60.5 °Brix TSS, 1.52 percent acidity, 3.22 pH whereas the chutney made from apricot cultivated apricot pulp had 62.5°Brix TSS, 1.70 per cent acidity and 3.12 pH.

Nancy (1997) evaluated the physical, chemical and organoleptic changes during storage of aonla chutney for four months. The reducing sugars, non-reducing sugar and total sugars were found to vary from 29.5 to 32.8, 11.4 to 12.0 and 40.5 to 42.0 per cent respectively. The mean pH and ascorbic acid contents were reported as 2.9 per cent and 205.0mg/100 during storage for four months.

Gupta (2000) reported the standardization of recipes for preparation of papaya chutney and studied the product for changes in various chemical and sensory attributes for nine months of storage. The interactions between treatments and storage period progressively decreased the ascorbic acid, which was attributed to oxidation of ascorbic acid. Reducing sugars increased with the advancement of storage from 7.28 per cent to 9.80 per cent at nine months of storage. The product did not change many in terms of sensory attributes during storage.

Whereas according to Neha (2002), the amla chutney contained 68.5 °Brix TSS, 27.46 per cent moisture, 2.80 pH, 1.93 per cent acidity, 35.89 per cent reducing sugars, 29.32 per cent non reducing sugars, 66.76 per cent total sugar, 0.48 percent protein and 208.6mg/100g vitamin C.

Shipra (2005) attempted preparation and evaluation of chutney from the blends of seabuckthorn and aonla fruit pulps. Chutney prepared from seabuckthorn had little higher ascorbic acid compared to the chutneys containing variable proportion of aonla pulp. This is due to the higher ascorbic acid content of seabuckthorn pulp, which got diluted proportionate to the level of aonla pulp in chutney, as aonla pulp was relatively lower in ascorbic acid. Titrable acidity of the sample was also altered due to blending which was attributed to the differences in acid contents of individual pulps. Acidity declined slightly during storage, which is due to neutralization of acid during storage as acid probably interacted with natural chemical constituents of the chutneys. TSS also changes slightly during storage. While total and non reducing sugars decreased, reducing sugars increased during storage due to partial hydrolysis of sugars catalyzed by the acid naturally present in chutneys and the overall acceptability scores of the chutneys prepared from sea buckthorn and blends of sea buckthorn and aonla pulps reveals that all the chutneys sample were highly acceptable with the ranking liked very much to liked extremely.

2.4.4 Sauce

Lal *et al.* (1989) evaluated the wild apricot (chulli) for preparing sauce and various combinations of chulli and tomato puree were made for sauce preparation. The chulli sauce with tomato puree (1:1 ratio) was rated as the best and quite comparable to tomato alone in sensory characteristics and the products had a good acceptability even after storage of one year at an ambient temperature.

Joshi *et al.* (1996) attempted preparation of apple pomace sauce from 3 stages of apple maturity and 3 levels of sugar (per kg of pulp) were used with final TSS of 15 (T_1), 20 (T_2) and 25 (T_3) °B in the sauce. Sugars brix-acid ratio, starch, protein and crude fiber increased, but ascorbic acid content declined in stage I to stage III. The TSS, sugar (reducing and total), acidity, increased significantly during 6 months storage. Whereas non-reducing sugars, starch, crude fiber and vitamin C content decreased at various storage intervals.

Dwivedi *et al.* (2002) also reported the preparation of acceptable quality seabuckthorn sauce, which was prepared by maceration of spices, herbs and fruit pulp by boiling them in vinegar and cooking for a long period to get a smooth consistency.

Lebeda (2003) reported the production of sauce from seabeckthorn with garlic. Fifty gram of ground garlic was added to One liter of natural juice of seabuckthorn. Before the use, salt and sugar were added, depending on the taste.

2.4.5 Pickle

Pickles are generally preserved in salt and acid. Indian pickles contain a variety of spices and oil in general. There is a great demand for pickle in India, which is extending to other countries also.

According to Dwivedi *et al.* (2002) The pickle should contain 15 per cent of salt. Spices like red chili powder, cinnamon, cumin, cardamom (large), black pepper powder and headless clove are also added to improve the taste and flavour of the product.

Usha Rani *et al.* (1992) studied the quality characteristics of Indian commercial pickles during storage for one year at room temperature. These included pickle in oil, pickle in brine and pickle in vinegar. Parameter like moisture, pH, acidity, trace elements, total oil, were determined in pickle samples during storage. There were no considerable changes in moisture, pH, acidity and total oil..

Sastry *et al.* (1975) reported a reduction in moisture content to a tune of 6 to 9 per cent during the storage of mango pickle.

Narayana and Maini (1996) evaluated the changes in chemical composition of sweet pickle of turnip as affected by different types of containers. The moisture content of pickle was decreased gradually during storage and it varied form 1 to 5 per cent over a period of 3 months. This was due to osmotic action of added salt and spices. The ash content increased from 5.05 to 8.12 per cent during storage, there was not very much variation in the pH. The acidity also increased and there was gradual decrease in both reducing and total sugar contents. The fiber content gradually decreased from 1.28 to 0.48 per cent.

Gupta (1998) evaluated the standardization of concentration of additives for development and processing of oil less mango pickle and reported the treatment S_2T_2, consisting of 20 per cent salt, 7.5 per cent red chilli powder and 1 per cent hing based on mango was superior to other treatments with respect to qualitative characters and biochemical changes in oil less mango pickle. It contained 61.33 per cent moisture, 33.12 °B TSS, 1.31 per cent acidity, 13.0 per cent ascorbic acid, 2.16 reducing and 8.77 per cent total sugars and had a nine months storage life.

Poonam (2000) attempted development and evaluation of food products of colocasia and reported pickles prepared from the fried cuts of colocasia tubers and galgal juice used as an acid ingredient in the pickle was highly acceptable as compared to rest of treatments. The acceptability of pickle containing vinegar was relatively lower than the pickles containing galgal juices. The pickle prepared from brined cuts of colocasia scored lowest due to presence of acridity and the pickle prepared from cut pieces of boiled tubers was moderately acceptable.

2.4.6 Preserve and Candy.

Fruit Candies are sugar impregnated fruits/ fruit pieces done by cooking in sugar syrup concentrated to 70 °Brix, followed by draining the syrup and partially drying the candied fruit/pieces. Candies are relished for their taste and flavour and are quite popular in India.

Gupta *et al.* (1981) carried out quality analysis of ber candies prepared with sugar and gur respectively. Total sugar contents varied from 79.68 to 86.64 per cent in candies prepared with sugar, whereas, it was above 80.0 per cent in candies prepared with gur.

Dabhade and Khedkar (1982) prepared tuti fruity, which is candy like product from raw bits of blanched papaya. The product contained one per cent acid, 68°B TSS and 25.7 per cent moisture.

Sethi and Anand (1982) while studying the quality and storage stability of intermediate moisture carrot preserve observed that there is decrease in acidity and increase in sugars during storage.

Mehta and Bajaj (1984) carried out studies on the changes in composition and organoleptic quality of citrus peel candy during preparation and storage. They reported that there was a change in colour during preparation and storage. Dried candy showed in an increase in total as well as reducing sugars.

Kumar (1989) prepared good quality candy from Date fruit and observed an increase in sugars during storage at room temperature for 60 days.

Sidduque *et al.* (1990) while conducting studies on production of wax gourd candy by using high fructose syrup reported that TSS, reducing and non reducing sugars increased whereas pH and moisture content decreased with increase in concentration of syrup but Protein remained unaffected by the level of HFS in the syrup.

Sharma *et al.* (1998) studied the preparation, storage stability and nutritional quality of apple candy and reported that the higher values were found in the products prepared by the fast method. The TSS of fresh candies prepared by slow and fast methods increased after 3 months of storage. The reason for increase in TSS during storage might be due to decrease in moisture content. pH was slightly higher in candy prepared by fast method. The pH increased and titrable acidity decreased significantly with increase storage period. The Reducing, non-reducing and total sugars of the candies varied significantly with respect to methods of preparation and storage time and the values were found to increase with increase in storage time. The organoleptic evaluation of candies revealed that the method of preparation, packaging material, storage temperature and time had negligible effect on colour and flavour of candied apples. It was observed that the score for flavour of candies improved up to 3 months of storage and then decreased slightly.

Garcia (1998) attempted preparation of chayote candy and reported dehydrated flavoured candy was produced from *Sechium edule*, swartz locally known as chayote. Four products were produced One product without flavour and the rest flavoured with either orange, strawberry or pandan. The acceptability of products in terms of texture, taste, flavour and overall acceptability were evaluated by a panel of tasters using a standard score sheet. The most acceptable product was subjected to chemical analysis for the determination of its nutritive contents. Statistical analysis for the sensory evaluation showed that the dehydrated product with strawberry flavour was the most acceptable. A highly acceptable quality characteristic produced a firm but not tender texture. Very sweet taste and a very pleasant flavour can be obtained by using the step- up method of syruping. Drying candied chayote for 12 hrs in a cabinet dryer obtained a moisture content of 14.8 per cent. The increase and decrease in the nutritive contents such as vitamin C, calcium and ash were accounted for during the processing. It was found that shelf life of the product could last for three month at normal room temperature.

From the literature reviewed as above, it can be concluded that some information on the physical and nutritional aspects of chayote is available, however, the information pertaining to its post harvest utilization in the form of value added products in scanty and needs to be generated by undertaking systematic studies on the development and evaluation of chayote based food products as emphasized in the objectives of this study.

MATERIALS AND METHODS

Chapter-III

MATERIALS AND METHODS

The studies on the 'Development and Evaluation of Chayote (*Sechium edule*) based food products' were conducted in the Department of Food Science and Nutrition, College of Home Science, Himachal Pradesh Krishi Vishvavidyalaya, Palampur during the year 2004-05. The materials and methods used in the experimental work are described below:

3.1 Chayote and other Materials

The mature and tender fruits of chayote (Sechium edule) were procured from the local farmers during the months of September and October, 2004. Fruits were brought to the Post Graduate Laboratory of the Department of Food Science and Nutrition, CSKHPKV, Palampur. The fruits were washed thoroughly in water and evaluated for various physico-chemical characteristics and used in the development of value added products. Soybean, black gram, plum, raw mango, tomato, galgal, and other ingredients were purchased from the local market. Chemicals of analytical grade were purchased from the reputed suppliers. Raw mango and plum pulps were extracted from the fruits during the month of July, 2004 and preserved by pasteurization in 650 ml beer bottles as these fruits are not available after this period while chayote is available. The preserved pulps were used in blending of chayote in the preparation of chutney whereas fresh tomato and galgal juice were used in the formulation of sauce and pickle.

3.2 Value Added Products

3.2.1 Nuggets (*Warian*)

Soybean dhal or black gram *dhal* were soaked in water (1:5) overnight followed by draining and wet grinding into smooth paste with the help of a mixer grinder. Chayote fruits were shredded in to fine shreds with the help of a stainless steel shredder.

Then the chayote shreds, pastes of soybean and black gram *dhals* were mixed as per scheme given in Table 3.1.

The mixtures were whipped with the help of a hand. The resultant mixture was used in the preparation of nuggets. The nuggets (7 to 8g approx.) were shaped/ rounded with the help of hand and kept on the greased drying tray followed by drying in a cabinet tray drier at a temperature of 60°C till no further water loss occurred. The dried samples were stored in polyethylene bags for further analysis which included physico-chemical and organoleptic evaluation.

Table. 3.1 Different proportions of chayote shreds, soybean and black gram *dhal* used in the preparation nuggets (*Warian*)

Proportions	Chayote shreds (%)	Wet ground Black gram dhal (%)	Wet ground Soybean dhal (%)
1	0	0	100
2	0	100	0
3	20	80	0
4	30	70	0
5	40	60	0
6	20	70	10
7	30	60	10
8	40	50	10
9	20	60	20
10	30	50	20
11	40	40	20
12	20	50	30
13	30	40	30
14	40	30	30

3.2.2 Dehydration of Pieces and Shreds

One lot of thoroughly washed chayote was cut into small pieces *with the help of a stainless steel knife and another lot was shredded with* the help of stainless steel shredder. Potassium meta bisulphite @ 1.5 per cent was mixed with pieces and shreds and allowed to rest for half an hour. Treated samples were dried in the mechanical tray drier maintained at 55, 65 and 75°C respectively till no more drying occurred. The dehydrated samples were packed in polyethylene bags for evaluation of physico-chemical and organoleptic qualities.

3.2.3 Chutney

Chutney was prepared from chayote and its blends with raw mango and plum pulps (0 to 100%). The standardized recipe comprised of: Pulp (500g), sugar (350g), Salt (15g), black pepper (5g), garam masala (10g) and acetic acid (4 ml). The mixture of sugar and pulp were heated to dissolve the sugar followed by the addition of spices and boiling the mixture till the mass thickened. At the end acetic acid was added, mixed and the mass cooked slowly to a jam like consistency. The finished product was poured into clean, dry and sterilized wide mouth glass jars while hot and closing the lids. The chutney samples were stored in cool and dry place for further evaluations.

3.2.4 Sauce

Sauce was prepared from pure chayote pulp and from its blends with tomato pulp at 25, 50, 75, and 100 per cent levels of replacement of chayote pulp with tomato pulp. The standardized recipe comprised of pulp/blends (1Kg), sugar (100g), onion paste (50g), ginger paste (10g) garlic paste (10.0g) cloves (1.0g), cardamom (1.0g), red chilli powder (5.0g), salt (20g) and vinegar (50ml).To pulps, sugar (l/3rd), was added followed by the addition of onion, ginger and Garlic pastes and the mixture boiled till it became soft and smooth Then all the spices were tied in a muslin bag and immersed into the boiling pulp and boiled till the Concentration of pulp reached to about 1/3rd of its original volume followed by removing and squeezing the bag to extract the juice and flavour of spices. At the end salt, vinegar and remaining sugar were added and again boiled till the mass reached desired consistency. A small quantity of sodium benzoate (100 ppm) was added mixed thoroughly. The prepared sauce was poured into sterilized, clean and dry bottles while hot followed by crown corking. The bottles were pasteurized in boiling water for half an hour cooled and stored in a cool and dry place for further evaluation.

3.2.5 Pickle

The fresh chayote were taken and washed thoroughly in water. The fruits were peeled with the help of a stainless steel peeler. The peeled chayote was divided in to two lots. One lot was cut in to small and uniform cubical pieces (1cm approx.) with the help of a knife. Second lot was shredded with the help of a stainless steel shredder. Cut pieces and shreds of chayote were brined in 20 percent sodium chloride separately for 20 days followed by draining, a rinsing in water and partial drying to remove surface water. These were pickled in two sources of acids (acetic acid and galgal Juice) using the following recipe. The final acidity in pickles was maintained as 2 per cent.

The following recipe was used in the preparation of pickles. Chayote pieces or shreds (500.0g), salt (50.0g), red chilli powder (12.5g), black pepper (5.0g), mustard seeds (25.0g), mustard oil (100.0 ml), ratanjot (2.0g) and aceticacid /galgal juice (10 ml and 150 ml approx). The oil (50 ml) was heated in a container followed by the addition of spices slight frying. To this pieces or shreds of chayote were added and heated for another 2 minutes. To a spoonful of hot oil in a container, ratanjot was added and heated for 2 minutes for the extraction of colour, then added to the pickle for colouring. Finally salt and acid were added and mixed thoroughly. The pickle samples were stored in air tight plastic containers of 250ml capacity. The fresh and stored pickles were subjected to sensory evaluation by a panel of 10 judges.

3.2.6 Candy

Chayote were sorted, washed, peeled and cut into uniform cubic pieces (1.5cm approx). To retain the intactness of pieces during candying process, the pieces were soaked in 2 per cent solution of lime water overnight followed by washing in water. Lime water treated pieces were further treated in 2 per cent boiling alum solution for 2 minutes to clean and give glossy appearance to the candy followed by washing in water. The pretreated pieces were candied in sucrose by slow and rapid cook methods.

1. Slow Cook Method

Pretreated pieces (1Kg) and cane sugar (500g) were arranged in a cooking container in alternate layers and allowed to stand for 24 hours. During this period fruit gave out excess of water due to osmosis and sugar went in to solution. At this stage another 250 g sugar was added, mixed thoroughly and allowed to rest for another day. At this stage the strength of the syrup was observed to be around 58 °Brix. Citric acid @ one percent on sugar weight basis was added to invert a portion of cane sugar. The whole mass was then boiled for 4 to 5 minutes and rested for another 24 hours. Next day the strength of the syrup was raised to about 65 °Brix by adding more sugar (250g) followed by boiling for 5 minutes. The fruit was then left in syrup for another three days. Finally the strength was raised to 70 °Brix by cooking and the finished preserve was allowed to rest for two days, followed by draining the syrup and sponging the pieces with the help of a wet muslin cloth. The pieces were then dried in tray drier at 55 °C for 2.5 hours and packed in polyethylene bags for further analysis.

2. Rapid Cook Method

Pretreated fruit pieces (1Kg) and sugar (1Kg) were taken in a container and mixed thoroughly. To this 500ml water and citric acid (@ 1% on sugar weight basis) were added, mixed and rested for 4 hours. The pieces were allowed to stay in the syrup for 4 days followed by draining, sponging with the help of a wet muslin cloth and drying in the tray drier at 55°C for 2.5 hr. The candy so obtained was packed in polyethylene bags for further evaluation

3.3 Physico-Chemical Characteristics

3.3.1 Fruit Weight (g/fruit)

Ten chayote fruits were selected randomly from the whole lot and weighted in the weighing balance. The mean weight was calculated by dividing the total weight by ten and reported a g/fruit

3.3.2 Fruit Colour and Shape

Fruit colour and shape were assessed by visual evaluation.

3.3.3 Fruit Size

The sizes of ten randomly selected vegetables were measured with the help of vernier caliper in terms of length and maximum width. Average values are reported in cm.

3.3.4 Edible portions, Peel and Wastage

Edible portion, peel and wastage recover from one kg samples of fruit were weighed and reported as per cent

3.3.5 1000 Kernel weight

One thousand kernels of soybean and black gram were counted randomly in duplicate and weighed separately. The average weight is reported in g/1000 kernels/ cotyledons

3.3.6 Cotyledon (*dhal*) and Hull contents

Hulls and cotyledons from 100g duplicate samples of whole kernels were separated with help of laboratory huller, weighed and reported as g/100g

3.3.7 Bulk Density

The bulk density of whole soybean, soybean *dhal*, black gram and black gram *dhal* was determined according to Narain *et al.* (1978). A calibrated/ graduated cylinder (1000 ml) was filled with whole grains and *dhal* up to the mark. The contents of cylinder were weighed. The bulk density of individual sample was calculated by dividing the weight by 1000 and expressed as g/ml.

3.3.8 Yield of Dehydrated Chayote

The yield (%) of in relation to time of drying of pieces and shreds at three different temperatures (55, 65 and 75 °C) were calculated by taking the dried weight after every two hours of drying till the completion of drying process with the initial weight of samples taken for dehydration and multiplying with 100 in order to get per cent yield.

3.3.9 Rehydration Characteristics

1. Nuggets

Nugget samples (5g) were taken in 250 ml beakers. To this 100ml of water were added. One lot of samples was rehydrated at ambient temperature and another at 70°C maintained in a water bath. Increases in weights of samples were recorded after an interval of one hour till no more increase in weights of samples occurred. The rehydration characteristics were calculated for different intervals by dividing the increase in weight of sample (g) kept for rehydration by initial weight of sample. The values are reported as "Water absorption ml/g".

2. Chayote Pieces and Shreds

Method described by Rangana (1991) with partial modification was used to assess rehydration characteristics of dried pieces and shreds of chayote. Weighted samples (10g) were taken in a beaker and rehydrated in 100 ml of distilled water at room temperature.The samples were drained after every hour till no more increase in weight occurred. The rehydration characteristics were calculated for different intervals by dividing the increase in weight of sample (g) kept for rehydration by initial weight of sample. The values are reported as "Water absorption ml/g".

3.3.10 Cooking Quality

1. Nuggets (*Warian*)

Nugget curries were prepared which comprised of nuggets (50.00g), onion paste (50.00g), tomato paste (50.00g), ginger paste (20.00g), oil (100ml), salt (5.00g), garam masala (5.00g) and water (500.00ml). Nuggets were roasted in oil till light brown in colour and kept aside. The oil was heated in a container and onion paste was added and roasted till golden brown. To this tomato and ginger pastes were added and fried for another 3 minutes. Then spices and salt were added. Fried nuggets were added the last followed by the addition of 500 ml water and boiling/cooking for 10 minutes. These samples were subjected to organoleptic evaluation by a panel of 10 judges on a nine point hedonic scale.

2. Dehydrated Pieces and Shreds

Dehydrated pieces and shreds (25g) form each drying treatment (55, 65, 75 °C) were reconstituted in tap water (150 ml) for 4 hours. The reconstituted samples were cooked in to vegetables by using the following recipe: Onion (50 g), tomato cuts (50g), cumin seeds (5g), oil (75ml), salt (5g), turmeric powder (2.5 g) and garam masala (5g). Onion and cumin seeds were roasted in oil to light brown colour. To this tomato and salt were added and roasted slightly followed by the addition of other ingredients as well as the reconstituted pieces and shreds. The resultant mixture was mixed thoroughly and cooked gently on a slow flame for 15 minutes. Vegetable preparations prepared similarly from equivalent weights of fresh pieces and shreds of chayote were kept as controls. The cooked vegetable preparations were presented to a panel of judges for assessing the cooking quality by sensory evaluation on a nine point hedonic scale.

3.3.11 Moisture Content (AOAC, 1990)

A 10g samples were taken in a weighted moisture box and dried in an oven at 100 °C to constant weights. Moisture contents were calculated on the basis of the following formula.

$$\text{Moisture (\%)} = \frac{\text{Initial weight (g)} - \text{final weight (g)}}{\text{Weight of sample (g)}} \times 100$$

3.3.12 Protein Content (AOAC, 1990)

A 1.0g dry samples were digested with concentrated sulphuric acid (25 ml) using 10g digestion mixture (Potassium sulphate : copper sulphate, 1:10) in a kjeldahl digestion flask to a clear bluish colour. The digested samples were transferred to volumetric flask and diluted to 100ml with distilled water. Five ml aliquots were distilled using 10 ml of 40 per cent sodium hydroxide in a kjeldahl nitrogen distillation apparatus. Ammonia evolved was trapped in 10ml of 4 per cent boric acid solution containing mixed indicator. The distillate was titrated with 0.01N hydrochloric acid to an end point, which persisted for 15 seconds. A sample blank was also run similarly the nitrogen content was calculated by the following formula:

$$\text{Per cent Nitrogen} = \frac{\text{Sample titre} - \text{blank titre} \times \text{Normality of HCL} \times 14 \times \text{volume made of digest}}{\text{Aliquot of digest taken} \times \text{Weight of sample}} \times 100$$

The per cent protein contents of sample were estimated by multiplying the per cent nitrogen by a factor of 6.25.

3.3.13 Crude Fat (AOAC, 1990)

Weighed samples (5g) samples were transferred to extraction thimbles. The thimbles were placed in a Soxlet extraction apparatus and the fat was extracted with petroleum ether (B.P 60-80 °C) for 8 hours.

The extract was transferred to pre-weighted beakers and dried over a water bath till all the ether was evaporated and finally dried in the oven 80°C overnight, and weighted. Increase in weight of the beakers represented crude fat content of the samples kept for fat extraction which were calculated as under:

$$\text{Fat (\%)} = \frac{\text{Weight of dried extract g)}}{\text{Weight of sample (g)}} \times 100$$

3.3.14 Ash Contents (AOAC, 1990)

Five gram samples were taken in a previously weighted silica crucibles and charred over a low flame to volatilize as much of the organic matter as possible (until no more smoke was given off by the material) and then incinerated in a muffle furnace (550°C, 4 hr), cooled in a dessicator and weighed.

$$\text{Ash content (\%)} \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

3.3.15 Minerals (Rangana, 1991)

The dried samples were wet digested as per method given by Rangana (1991).The digested samples were analyzed for calcium and potassium using flame photometer and for iron, zinc, magnesium, manganese and phosphorus using Atomic absorption Spectrophotometer (Piper, 1966).

3.3.16 Neutral Detergent Fibre (NDF)

Neutral detergent fibre was determined according to Van Soest (1963) method. The method is based on the extraction of food with hot neutral solution of detergent, sodium lauryl sulphate and 2-ethoxy ethanol. The residue contains lignin, cellulose and hemi cellulose of cell wall. Following reagents were prepared for NDF analysis.

i) Neutral detergent solution

Ethylene diamine tetra acetic acid dehydrate (18.61g) and sodium borate decahydrate (6.81g) were dissolved in some hot distilled water and this solution was added to a solution of sodium lauryl sulphate (30g) and 2 ethoxy ethanol (2ml) then 4.56g of disodium hydrogen phosphate was taken and dissolved in the distilled water by heating and added to the solution of other chemicals. The volume was finally made to 1 liter with distilled water and pH adjusted between 6.9 to 7.1.

ii) Decahydronapthalano (reagent grade)

iii) Sodium sulphate anhydrous

iv) Acetone

The sample was ground to pass through iron sieve. Sample (1g) was taken in beaker and 10ml of neutral detergent solution, 2ml dicahydema phalene, 0.5g sodium sulphate were added. The mixture was heated to boiling in 5 to 10min. The samples were refluxed gently for 1 hour. The mixture was filtered through sintered glass crucibles. The samples in the crucibles were rinsed with hot water (90-100°C) and filtered with the help of a suction pump. The sample were then washed twice with acetone and dried by applying suction. The crucibles with sample residue were finally dried in the oven at 105°C to a constant weight. The NDF was calculated as:

$$\text{NDF (\%)} \frac{\text{Weight of dried residue}}{\text{Weight of sample}} \times 100$$

3.3.17 Acid Detergent Fibre (ADF)

Acid detergent fibre also determined by Van Soest method (1963). The method involves heating the sample with normal sulphuric acid containing acetyl trimethyl ammonium borate (CTAB). The residue after filtration is composed primarily of lignin and cellulose and is termed as ADF.

The reagents for analysis were prepared as described below:

i) Acid detergent solution:

This solution was prepared by dissolving 20g CTAB in one liter of acid.

ii) Sulphuric acid

iii) Acetone

iv) 72% sulphuric acid (w/v)

v) Decahydranaphthalene (reagent grade)

Samples (1g) were weighted into beakers (1,000 ml). To each one of these, 100ml of acid detergent reagent was added together with 2ml decahydronaphthalene. The sample mixture were heated to boiling and refluxed for 1 hour. The mixtures were filtered through sintered glass crucibles using gentle suction. The beakers and residues on the crucibles were washed twice with hot water and then washed and dried with acetone. The crucibles were finally dried in an oven at 105°C to a constant weight. Acid detergent fibre was determined as:

$$\text{ADF (\%)} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

3.3.18 Hemi cellulose (Van Soest, 1963)

Hemi cellulose was calculated by difference method, as under:

Hemi cellulose % = NDF – ADF

3.3.19 Total Carbohydrates

Total carbohydrates were determined by difference method that is by subtracting from 100, the sum of values of moisture, protein, fat and ash.

3.3.20 Available or Digestible Carbohydrates

The Available or digestible carbohydrates were determined by subtracting neutral detergent fibre from the total carbohydrates.

3.3.21 Unavailable or Indigestible carbohydrates

Unavailable or Indigestible carbohydrates were determined by subtracting available carbohydrates from the total carbohydrates.

3.3.22 Total and Available Energy

Total energy was calculated by multiplying the percent protein, fat and total CHO by 4, 9 and 4, respectively and summing up the values. Where as available energy was calculated by multiplying the percent protein, fat and available carbohydrates by 4, 9 and 4, respectively and summing up the values. The values are reported as Kilocalorie/ 100g on dry matter weight basis.

3.3.23 Total Soluble Solids (TSS)

The total soluble solids contents were determined with Hand Sugar Refractrometer by putting a drop of product on the prism and taking the readings (Rangana, 1991).

3.3.24 Titrable Acidity

The titrable acidity was determined by the method suggested by (Rangana, 1991). Five ml samples were titrated against 0.1N sodium hydroxide solution, using phenolphthalein as an indicator. Appearance of pink colour indicated the end point. Total titrable acidity was calculated and reported as per cent citric acid on the basis of following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre x normality of alkali x volume made up x Eq. Wt. of acid}}{\text{Vol. of sample taken for estimation x Wt or vol. of sample taken x 1000}} \times 100$$

3.3.25 pH

The pH was recorded with the help of pH meter. The pH meter was standardized by warming up the instrument for 30 minutes. The pH meter was calibrated with a buffer solution of 4.0 pH. The electrode was washed with double distilled water and dipped in the solution of the sample of unknown pH. The readings were recorded and expressed as pH values.

3.3.26 Ascorbic Acid (Rangana, 1991)

Ascorbic acid was determined by 2,6-dichlorophenol indophenol visual titration method for this, For this the follow reagents prepared and the procedure adopted is as under

i) Metaphosphoric acid solution (3%)

Prepared by dissolving the sticks or pellets of metaphosphoric acid in glass distilled water.

ii) Ascorbic acid standard:

One hundred milligram of L-ascorbic acid was weighed and transferred to a 100ml volumetric flask and the volume made to 100ml with 3 per cent metaphosphoric acid. Ten ml of this solution were taken and diluted 100ml with 3 per cent metaphosphoric acid (1ml = 0.1 mg of ascorbic acid).

iii) Dye solution and its standardization

Fifty mg of sodium salt of 2, 6-dichlorophenol-indophenol dye were dissolved in approximately 150ml of hot glass distilled water containing 42 mg of sodium bicarbonate and then the solution was diluted with glass distilled water to 200 ml.

Five ml of the standard ascorbic acid were taken in a beaker and to this 5ml of the metaphosphoric acid solution were added. The contents were titrated with the dye solution taken in a micro burette to a pink colour, which persisted for 15 seconds. The dye factor was determined (mg of ascorbic acid per ml of the dye) as follows:

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

Ten ml/g aliquots of samples were diluted to 100 ml with 3 per cent metaphosphoric acid and filtered if required. An aliquot of 5ml of the metaphosphoric acid extracts of the samples were taken and titrated with the standard dye to a pink end point which persisted for at least 15 seconds. The ascorbic acid content was calculated by using the formula:

$$\text{Ascorbic acid (mg/100ml)} = \frac{\text{Titre x Dye factor x Vol. Made up}}{\text{Aliquot of extract taken for estimation x Wt./Vol. of sample taken for estimation.}} \text{x100}$$

3.3.27 Sugars (Rangana, 1991)

Sugars (reducing, non-reducing and total) were estimated by Lane and Eynon's volumetric method described by Rangana (1991) by titrating the sample against Fehling's solution (A & B) before and after hydrolysis. The sugars were expressed as:

$$\text{Reducing sugars (\%)} = \frac{\text{Factor x dilution x 100}}{\text{Titre x weight or vol. of sample}}$$

Non-reducing sugars (%) = Total sugars = Reducing sugars x 0.95

$$\text{Reducing sugars (\%)} = \frac{\text{Factor x dilution x 100}}{\text{Titre x weight or vol. of sample}}$$

3.4 Sensory Acceptability

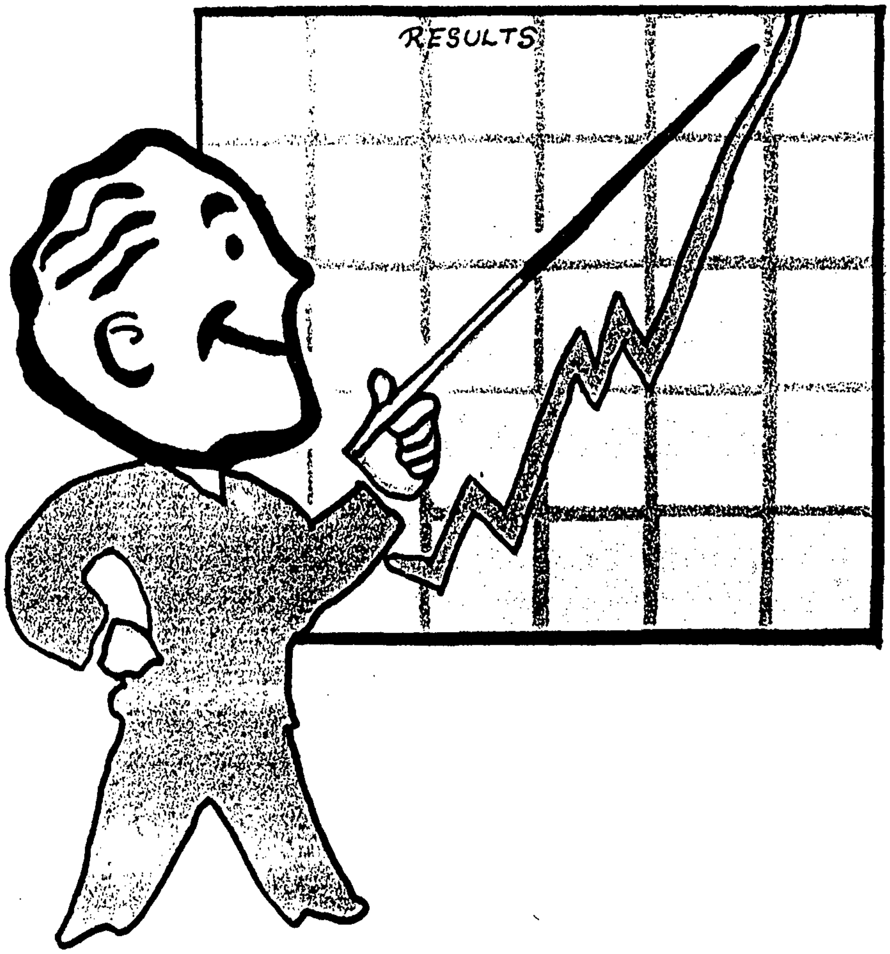
The organoleptic evaluation was conducted as suggested by Larmond (1977), by using a panel of 10 judges for evaluating the samples on a nine point hedonic scale ranging from 0-9 points (Appendix-1). Each judge was given one set of the samples and asked to evaluate the samples for different sensory attributes such as colour, flavour, taste and texture. The judges recorded the judgment according to their own judgement, experience and knowledge of the state of quality of the products. Mean scores for each attribute were calculated by summing up the scores of judges and dividing by the number of judges. Overall acceptability scores were calculated by summing up the scores of each attribute divided by the number of attributes.

3.5 Cost of Products

The cost of the products was calculated from the average cost of raw materials used in the preparation of one kilogram of finished food products. To this cost 1/3rd cost was added as processing cost. The costs calculated this way, however, do not include taxes, packaging and handling costs. The product costs are reported as Rs/Kg of finished products

3.6 Statistical Analysis (Gupta, 2000)

The statistical effects were assessed in completely Randomized design (CRD) with the help of a computer software. Data are compared at 5 per cent level of significance.



RESULTS

Chapter-IV

RESULTS

The present investigation entitled "Development and Evaluation of Chayote (*Sechium edule*) Based Food Products" was carried out in the Department of Food Science and Nutrition, College of Home Science, CSK HPKV, Palampur, Distt. Kangra (H.P.), India, during the year 2004-05. The results of the physico-chemical characteristics of chayote and other fruits/ pulses used in the preparation of value added products, physico-chemical and sensory characteristics of the food products developed from chayote and its blends with pulses and other fruits are presented under the following sections.

4.1 Chayote

4.1.1 Physical characteristics

Data pertaining to the mean weight, length, width, shape, colour, pulp recovery, peel and waste during processing of fruit chayote used in the present investigation are shown in Table 4.1. Fruit size varied from small to large as adjudged from the fruit weight which varied from 60 to 340 g/fruit with a mean weight of 229 g/fruit. The fruit length and width varied from 9.72 to 10.30 and 5.08 to 11.21 cm with a mean length and width of 9.24 and 8.10 cm respectively. The fruits are ovoid in shape having light green to green colour. The mean edible portion was found to be 81.51 per cent with a range of 80.11 to 83.24 per cent. Whereas, the wastage in the form of peel and seed varied from 14.01 to 17.21 and 2.48 to 4.08 per cent with mean values of 15.56 and 3.18 per cent respectively.

Table 4.1 Physical characteristics of fruit chayote

Physical characteristics	Range	Mean
Fruit weight (g/fruit)	60-340	229
Fruit length (cm)	7.82- 10.30	9.24
Fruit width (cm)	5.08-11.21	8.10
Peel (%)	14.01-17.21	15.56
Edible portion (%)	80.11-83.24	81.51
Wastage (%)	2.48-4.08	3.18
Fruit colour	Light green - Green	-
Fruit shape		Ovoid

*Data reported are the averages of at least ten fruits

4.1.2 Proximate Composition

Table 4.2 depicts the proximate composition of whole chayote, its edible portion and peel on fresh and dry weight basis. The fruit contained 92.78 per cent moisture and 7.22 per cent dry matter. Whereas, pulp contained 93.70 per cent moisture and 6.29 per cent dry matter. The chayote peel contained relatively lower content of moisture (88.50 %) and slightly higher contents of dry matter (11.49 %). The protein contents of chayote pulp were observed to be the highest (0.78 and 12.52%) followed by the whole chayote (0.71 and 9.94%) and chayote peel (0.47 and 4.15%) on fresh and dry weight basis, respectively. The ash contents of peel were recorded as the highest (0.89 and 7.75%) followed by the ash contents of whole chayote (0.49 and 6.79%) and ash contents of edible portion (0.39 and 6.20%) on fresh and dry weight basis, respectively.

Table 4.2 Proximate composition of chayote and its anatomical parts

Fruit/ part	Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Total Carbohydrates (%)
Whole fruit						
Fresh weight basis	92.78	7.22	0.71	0.21	0.49	5.81
Dry weight basis	-	100	9.94	2.84	6.79	79.45
Edible portion						
Fresh weight basis	93.70	6.29	0.78	0.21	0.39	4.91
Dry weight basis	-	100	12.52	3.38	6.20	77.47
Peel						
Fresh weight basis	88.50	11.49	0.47	0.1	0.89	10.03
Dry weight basis	-	100	4.15	0.87	7.75	87.25

*Data reported are the averages of duplicate determinations on dry and fresh weight basis.

The mean crude fat contents varied from 0.10 to 0.21 per cent on fresh weight basis and 0.87 to 3.38 per cent on dry weight basis among different anatomical parts of fruit chayote. Whereas, the total carbohydrates varied from 5.81 to 10.03 per cent on fresh weight basis and 77.47 to 87.25 per cent on dry weight basis among different fruit parts.

4.1.3 Fibre carbohydrates, Non-fibre carbohydrades and Energy contents

The data pertaining to the fibre, non-fibre carbohydrate and energy content of chayote and its anatomical parts are presented in Table 4.3. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents of whole chayote, edible portion and peel were recorded as 15.61, 11.98 and 18.15 per cent, respectively. Peel contained higher content of hemicellulose (16.50%) as compared to whole chayote (8.60%) and chayote pulp (6.08%). Edible portion contained highest content of digestible carbohydrates (59.40%) followed by whole chayote (55.24%) and chayote peel (52.60%) respectively.

Table 4.3 Carbohydrates and energy content of chayote and its anatomical parts

Constituents	Whole fruit	Edible portion	Peel
NDF (%)	24.21	18.06	34.65
ADF (%)	15.61	11.98	18.15
Hemi cellulose (%)	8.60	6.08	16.50
Digestible CHO (%)	55.24	59.40	52.60
Indigestible CHO (%)	24.21	18.07	34.65
Total energy (K cal/100g)	383.1	390.24	373.35
Available energy (K cal/100g)	286.28	318.08	234.75

*Data reported are the averages of duplicate determinations on dry weight basis

Indigestible carbohydrates were higher in chayote peel (34.65%) followed by whole chayote (24.21%) and edible portion (18.07%), respectively. Edible portion was also found to be rich in total and available energy (390.34 and 318.08 Kcal/100g), followed by whole (383.1 and 286.28 Kcal/100g) and chayote peel (373.35 and 234.75 Kcal/100g), respectively.

4.1.4 Mineral Contents

Mineral contents of whole fruit, edible portion and peel are given in Table 4.4. The calcium content of chayote peel was higher (200 mg/ 100g) as compared to whole fruit (190 mg/100g) and edible portion (179 mg.100g), respectively. Potassium and phosphorus contents of chayote peel, whole fruit and edible portion were recorded as 550 and 299, 530 and 278.5, and 520 and 258 mg/100g, respectively.

Table 4.4 Mineral composition of chayote and its anatomical parts

Minerals	Whole fruit	Edible portion	Peel
Macro (mg/ 100g)			
Ca	190	179	200
K	530	520	550
P	278.5	258	299
Micro (mg/100g)			
Cu	1.15	0.60	1.70
Zn	0.72	0.64	1.00
Fe	0.80	0.61	1.03

*Data reported are the averages of duplicate determinations.

Micro elements such as Cu, Zn and Fe were found to be distributed to the different extents in different fruit parts. The copper content of chayote peel was higher (1.70 mg/100g) followed by whole fruit (1.15 mg.100g) and chayote pulp (0.60 mg/100g). The zinc varied from 0.64 to 1.00 mg/100g among three different parts of fruits. The iron content of chayote peel was higher (1.03 mg/100g) followed by whole chayote (0.90 mg.100g) and edible portion (0.61 mg/100g), respectively.

4.2 Soybean and Blackgram

4.2.1 Physical Characteristics

The data pertaining to the physical characteristics of soybean and black gram used in the development of chayote-based nuggets (traditional *warian*) are presented in Table 4.5.

Table 4.5 Physical characteristics of soybean and black gram

Legumes	Characteristic	Proportions (%)	1000 kernel weight (g)	Bulk density (g/ ml)
Soybean				
	Whole	100.00	164.56	0.69
	Cotyledons (*dhal*)	91.81	71.12	0.70
	Hulls	8.19	----	0.29
Black gram				
	Whole	100.00	46.80	0.79
	Cotyledons (*dhal*)	89.50	15.98	0.83
	Hulls	10.50	----	0.39

*Data reported are the averages of duplicate determinations.

The recoveries of cotyledons (*dhal*) from whole kernels of soybean and black gram were recorded as 90.81 and 88.50 per cent respectively. Black gram contained 10 per cent hulls where as soybean contained 8.19 per cent hulls. The 1000 kernel weight of soy kernels (164.56) and cotyledon (71.12g) were higher as compared to black gram whole kernels (46.80g) and black gram *dhal* (15.98g). Bulk densities of whole kernels, cotyledons and hulls of soybean were recorded as 0.69, 0.70, 0.29g/ml and those of black gram were recorded as 0.79, 0.83 and 0.39 g/ml respectively.

4.2.2 Proximate Composition

The data pertaining to the proximate composition of soybean and black gram on fresh and dry weight basis are presented in Table 4.6. The moisture contents of soy kernels and soy *dhal* were recorded as 8.11 and 8.32 per cent on fresh weight basis, Whereas, black gram kernels and *dhal* contained 9.75 and 10.40 per cent moisture. The soy *dhal* on fresh and dry weight basis contained highest protein (40.26 and 43.91%) followed by whole soybean (39.08 and 42.53 %), black gram *dhal* (22.56 and 25.17%) and whole black gram (22.17and 24.65%) respectively. On fresh and dry weight basis, the crude fat contents of soybean, soya dhal, black gram, and black gram *dhal* were found to be 19.11, 20.71, 1.79, 1.94 and 20.80, 22.58, 1.98 and 2.16 per cent, respectively. The ash content of soybean *dhal* on wet and dry basis were highest (4.01 and 4.37%) followed by soybean (3.66 and 3.98 %), whole black gram (3.97and 4.41 %) and black gram *dhal* (3.11 and 3.46 %). The crude fiber contents of whole soybean, soya *dhal*, black gram and black gram *dhal* were found to vary from 3.01 to 3.93 on fresh weight basis and 3.41 to 4.27 per cent on dry weight basis. Significant variations in the total carbohydrates on wet and dry weight basis were also observed among whole soya (30.00 and 32.71%) soya *dhal* (26.71 and 29.15%) black gram (62.32 and 68.97%) and black gram *dhal* (62.00 and 69.35%).

Table 4.6 Proximate composition of soybean and blackgram

	Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fibre (%)	Total Carbohydrates (%)
Whole soybean							
Fresh wt. basis	8.11	91.89	39.08	19.11	3.66	3.93	30.00
Dry wt. basis	---	100.00	42.53	20.80	3.98	4.27	32.71
Cotyledons (*dhal*)							
Fresh wt. basis	8.32	91.69	40.26	20.71	4.01	3.81	26.71
Dry wt. basis	---	100.00	43.91	22.58	4.37	4.14	29.15
Blackgram whole							
Fresh wt. basis	9.75	89.95	22.17	1.79	3.97	3.76	62.32
Dry wt. basis.	---	100.00	24.65	1.98	4.41	4.18	68.97
Cotyledons (*dhal*)							
Fresh wt. basis	10.40	89.61	22.56	1.94	3.11	3.01	62.00
Dry wt. basis	---	100.00	25.17	2.16	3.46	3.41	69.35

*Data reported are the averages of duplicate determinations on fresh and dry weight basis

4.2.3 Fibre carbohydrates, Non-fibre carbohydrates and Energy contents

The results pertaining to the fibre and non-fibre carbohydrates, and energy contents of soybean, soya *dhal*, black gram and black gram *dhal* are presented in Table 4.7.

Table 4.7 Carbohydrates and energy contents of soybean and black gram

	Whole soybean	Soybean *dahl*	Whole black gram	Black gram *dahl*
NDF (%)	25.68	24.02	17.59	16.01
ADF (%)	13.63	10.95	5.17	3.81
Hemicellulose (%)	12.06	13.43	12.42	12.20
Digestible CHO (%)	7.03	4.78	51.38	53.34
Total energy (Kcal/100g)	488.06	495.38	392.26	397.44
Available energy (Kcal/100g)	385.34	397.92	321.90	333.42
Indigestible CHO (%)	25.68	24.37	17.59	16.00

*Data reported are the averages of duplicate determinations on dry weight basis

Neutral detergent fibre (NDF)) and acid detergent fibre (ADF) were found to be highest in soybean (25.68 and 13.63 per cent followed by soy *dhal* (24.02 and 10.95%), whole black gram (17.59 and 5.17%) and black gram *dhal* (16.01 and 3.81%). Hemicellulose contents among these ranged from 12.06 to 13.43 per cent. The digestible or available carbohydrates were found to be maximum in black gram *dhal* (53.34%) followed by whole black gram (51.38 %), soybean (7.03%) and soya *dhal*

(4.78%). The indigestible carbohydrates were found highest in whole soybean (25.68%), followed by soybean *dhal* (24.37%), whole black gram (17.59%) and black gram *dhal* (16.00%).

The total and available energy contents were found to be higher in soy *dhal* (495.38 and 397.92 Kcal/100g) followed by soybean (488.06 and 385.34 Kcal/100g), black gram *dhal* (397.44 and 333.42 Kcal/100g) and whole black gram *dhal* (392.26 and 321.90 Kcal/100g).

4.2.4 Mineral Contents

Date in Table 4.8 reveals mineral composition of soybean, black gram and their *dhal*. The calcium contents of soybean and soy *dhal* were found to be highest (310.7 and 240 mg/100g) followed by black gram and black gram *dhal* (154.0 and 148.6mg/100g).

Table 4.8 Mineral composition of soybean and black gram

Minerals	Soybean	Soybean *dhal*	Blackgram	Black gram *dhal*
Macro (mg/100g)				
Ca	310.70	240.00	154.00	148.60
K	1159.05	1020.04	790.06	760.00
Mg	172.95	148.58	127.96	130.00
Micro (mg/100g)				
Fe	10.40	9.43	3.80	2.80
Cu	1.12	0.98	1.05	0.93
Zn	3.40	2.61	3.30	3.00

*Data reported are the averages of duplicate determinations.

The potassium and magnesium contents of soy bean were recorded as highest (1159.05 and 172.95 mg/100g) followed by soy *dhal* (1020.04 and 148.58 mg/100g), black gram (790.06 and 127.96 mg/100g) and black gram *dhal* (760 and 130 mg/100g) respectively. Iron contents among these varied from 3.8 to 10.4 mg/100g, copper from 0.93 to 1.12 mg/100g and Zinc from 3.0 to3.4 mg/100g.

4.3 Plum, Galgal, Tomato and Raw mango

4.3.1 Proximate Composition

The data pertaining to the proximate composition of plum, galgal, tomato and raw mango are presented in Table 4.9. The moisture content of fruits varied from 81.53 to 92.51 per cent and dry matter from 7.50 to 18.47 per cent respectively. Tomato contained 0.78 per cent protein on fresh weight basis and 10.41 per cent on dry weight basis. Whereas, plum, galgal and raw mango contained 0.74,0.73 and 0.67 per cent protein on fresh weight basis and 4.75, 6.34 and 3.66 per cent on dry weight basis The crude fat content among these five fruits varied form 0.13 to 0.48 per cent on fresh weight basis and 0.68 to 3.54 per cent on dry weight basis. The ash content among these five fruits varied from 0.39 to 0.50 per cent and 2.50 to 5.81 per cent on fresh and dry weight basis, respectively. The total carbohydrates contents of these five fruits were found to vary from 6.04 to 17.19 per cent on fresh and 80.91 to 93.07 per cent on dry weight basis.

Table 4.9 Proximate composition of plum, galgal, tomato and raw mango

Fruit pulp	Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Total Carbohydrates (%)
Plum						
Fresh wt. basis	84.54	15.46	0.74	0.48	0.39	13.87
Dry wt. basis	-	100.00	4.75	3.08	2.50	89.70
Galgal						
Fresh wt. basis	88.56	11.44	0.73	0.41	0.50	9.81
Dry wt. basis	-	100.00	6.34	3.54	4.37	85.76
Tomato						
Fresh wt. basis	92.51	7.50	0.78	0.22	0.44	6.04
Dry wt. basis	-	100.00	10.41	2.88	5.81	80.91
Raw mango						
Fresh wt. basis	81.53	18.47	0.67	0.13	0.48	17.19
Dry wt. basis	-	100.00	3.66	0.68	2.60	93.07

4.3.2 Chemical Constituents

Table 4.10 depicts the average content of acidity, ascorbic acid, reducing sugars, non-reducing sugars, total sugars, TSS °B, pH, acid brix ratio in chayote, plum, raw mango, galgal juice and tomato fruit pulp. Galgal juice contained highest content of acid (4.61%) followed by raw mango (3.76%), tomato (2.80%), plum (2.14%) and chayote (1.5%). The ascorbic acid content of galgal juice was highest (50.12 mg/100g) followed by raw mango (31.26 mg/100g), tomato (26.81 mg/100g), plum (10.23 mg/100g) and chayote (4.01 mg/100g), respectively. Reducing sugar contents were highest in chayote (6.42%) and the values among other fruits varied from 2.41 to 5.64 per cent. Non-reducing sugars were found to be highest in plum (2.75%) and in other fruits varied from 0.29 to 2.75 per cent. Total sugar contents were found to be 8.55 per cent for plum, 6.89 per cent for chayote, 4.51 per cent for galgal juice, 4.31 per cent for raw mango and 2.71 per cent for tomato pulp. Total soluble solids as degree brix (°B) were recorded highest in plum pulp (11.08 °B) followed by raw mango pulp (6.20 °B), chayote pulp (5.5 °B), galgal juice (5.20 °B) and tomato pulp (4.65°B).

Table 4.10 Chemical constituents of chayote, plum, raw mango, galgal and tomato

Constituents	Chayote (Edible portion)	Plum pulp	Raw mango pulp	Galgal juice	Tomato pulp
Acidity (%)	1.50	2.14	3.76	4.61	2.80
Ascorbic acid (mg/100g)	4.01	10.23	31.26	50.12	26.81
Reducing sugar (%)	6.42	5.64	3.06	3.13	2.41
Non-reducing sugar (%)	0.47	2.75	1.18	1.31	0.29
Total sugars (%)	6.89	8.55	4.31	4.51	2.71
TSS °brix	5.5	11.0	6.20	5.20	4.65
pH	4.80	3.40	2.80	2.51	3.66
Brix acid ratio	3.33	5.14	1.65	1.13	1.69

*Data reported are the averages of duplicate determinations

The analysis of pulp for pH showed differences in pH among different fruit pulps. pH values for chayote, plum, raw mango, galgal juice and tomato pulp were recorded as 4.80, 3.40, 2.80, 2.51 and 3.66 per cent, respectively, Brix acid ratios calculated by dividing the degree brix by the acidity values showed corresponding changes in brix acid ratio values. Highest ratio was recorded for plum (5.14) followed by chayote (3.33), tomato (1.69), raw mango (1.65) fruit and galgal juice (1.13).

4.4 Chayote Based Nuggets (*Warian*)

4.4.1 Rehydration Characteristics

Nuggets were studied for their hydration characteristics at ambient temperature as well as at 70 °C and the data are presented in Tables 4.11 and 4.12. Pre weighed samples were soaked in water and the increase in their weights were recorded at an interval of 1 hour till no more increase in weight occurred. Simultaneously the tendency to disintegrate was also recorded. The rehydration depicted the water uptake by the nuggets expressed as ml/g. At ambient temperature, nugget samples from all the treatments attained full saturation after 6 hours and the nuggets remained intact. Highest water uptake (3.10 ml/g) upon full saturation occurred in pure soybean nuggets as no more increase in weight occurred after this interval. The values for rest of the treatments were found to vary from 2.58 to 2.89 ml/g after 6 hours of soaking.

Table 4.11 Water absorbtion (ml/g) characteristics of chayote and legume based nuggetsat ambient temperature (70°C) as affected by the time of hydration

Proportions Chayote:Blackgram:Soybean	Time of hydration (hr) 1	2	3	Disintegration
0 : 100 : 0	2.56	3.36	3.48	Nil
0 : 0 : 100	2.86	3.57	3.78	Slight
20 : 80 : 0	2.04	3.06	3.26	Nil
30 : 70 : 0	2.05	2.96	3.21	Nil
40 : 60 : 0	2.19	3.16	3.31	Slight
20 : 70 : 10	2.33	3.06	3.26	Nil
30 : 60 : 10	2.16	3.01	3.40	Nil
40 : 50 : 10	2.36	2.97	3.36	Slight
20 : 60 : 20	2.42	3.06	3.05	Nil
30 : 50 : 20	2.45	3.05	3.20	Slight
40 : 40 : 20	2.47	3.25	3.41	Slight
20 : 50 : 30	2.66	3.47	3.46	Nil
30 : 40 : 30	2.59	3.00	3.49	Slight
40 : 30 : 30	2.73	3.40	3.47	Slight

*Data reported are the averages of duplicate determinations

Faster and higher hydration occurred in nugget at 70 °C (Table 4.11) which took between 2 to 3 hours for attaining full saturation. It was highest (3.78 ml/g) in soybean nuggets, followed by other treatments (3.05

to 3.78ml/g). Tendency to disintegrate during soaking in hot water was highest in case of pure soybean and in nuggets containing higher quantities of chayote (30 to 40%) and soybean (30%).

Table 4.12 Water absorbtion (ml/g) characteristics of chayote and legume based nuggets at (25°C) as affected by the time of hydration

Proportions			Time of hydration (hr)						
Chayote:	Blackgram:	Soybean	1	2	3	4	5	6	Disintegration
0	100	0	1.10	1.55	2.23	2.51	2.78	2.88	Nil
0	0	100	1.37	2.06	2.46	2.90	3.08	3.10	High
20	80	0	1.32	2.14	2.26	2.36	2.68	2.77	Nil
30	70	0	1.43	2.06	2.16	2.36	2.48	2.58	Slight
40	60	0	1.44	2.17	2.35	2.46	2.59	2.66	High
20	70	10	1.22	2.00	2.28	2.35	2.48	2.74	Nil
30	60	10	1.31	2.11	2.40	2.47	2.57	2.66	Slight
40	50	10	1.32	2.20	2.32	2.37	2.48	2.74	High
20	60	20	1.56	2.09	2.41	2.48	2.56	2.70	Slight
30	50	20	1.51	2.16	2.36	2.45	2.58	2.70	Slight
40	40	20	1.50	2.20	2.27	2.46	2.66	2.68	High
20	50	30	1.56	2.05	2.27	2.52	2.74	2.89	Slight
30	40	30	1.51	2.09	2.30	2.56	2.82	2.87	High
40	30	30	1.52	2.31	2.47	2.55	2.77	2.84	High

*Data reported are the averages of duplicate determinations

4.4.2 Proximate Composition

The data recorded on chemical composition of nuggets prepared from the blends containing variable proportions of chayote shreds and wet ground legumes are presented in Table 4.13. Data revealed significant differences ($P \leq 0.05$) among different treatments with respect to crude protein, crude fat and total carbohydrate contents. Soy nuggets without chayote contained highest protein (39.95%). Whereas, the nuggets prepared exclusively from black gram dhal contained 21.53 per cent crude protein, which decreased significantly to 16.08 per cent with the increase in the proportion of chayote shreds (20 to 40%) and decrease in the proportion of black gram (40 to 20%) in the nugget formulations. Locally, nuggets (Warian) are traditionally prepared from black gram dhal and bottle gourd. Black gram legume is preferred as it has a binding effect due to the presence of mucilaginous galactoaraban, which is important in retaining the intactness of nuggets during cooking. Since black gram is an expensive legume, the author attempted partial replacement of black gram with soybean (10 to 30%) to reduce the cost and increase the nutritive value of the nuggets formulations. Replacement of black gram with soybean from 10 to 30 percent level, enhanced the protein contents of nuggets when compared at identical level of chayote in the nugget formulation, indicating a protein compensatory effect as the protein contents of the soy supplement nuggets ranged from 18.02 to 23.56 per cent. Whereas it was 21.53 per cent in black gram nuggets and 16.08 per cent in nuggets containing 40 parts chayote and 60 parts black gram.

Table 4.13 Proximate composition of chayote and legume based nuggets (*Warian*)

Proportions Chayote:Blackgram:Soybean	Moisture (%)	Dry matter (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Total Carbohydrates (%)
0 : 0 : 100	7.96	92.04	39.95	18.65	3.97	29.49
0 : 100 : 0	7.95	92.05	21.53	1.59	3.00	65.96
20 : 80 : 0	9.05	90.95	19.14	1.06	1.77	68.99
30 : 70 : 0	8.68	91.33	17.40	0.97	1.90	71.06
40 : 60 : 0	9.71	90.30	16.08	0.98	2.05	71.21
20 : 70 : 10	8.51	91.49	20.67	3.21	2.05	65.57
30 : 60 : 10	8.64	91.37	19.30	3.15	2.12	66.81
40 : 50 : 10	8.72	91.28	18.02	3.12	2.22	67.93
20 : 60 : 20	8.13	91.87	22.13	4.90	2.70	62.15
30 : 50 : 20	7.73	92.27	21.22	4.87	2.77	63.42
40 : 40 : 20	7.86	92.14	19.91	4.82	2.86	64.56
20 : 50 : 30	8.91	91.09	23.56	6.55	2.97	58.02
30 : 40 : 30	9.17	90.83	22.34	7.00	3.09	58.42
40 : 30 : 30	8.66	91.32	20.82	6.57	3.38	60.54
CD ($P \leq 0.05$)	----	---	1.50	1.45	----	3.89

*Data reported are the averages of duplicate determinations on (Dry weight basis)

Crude fat contents of the nuggets containing black gram from 60 to 100 per cent and chayote from 0 to 40 per cent ranged from 0.97 to 1.59 per cent. Replacement of black gram with soybean (10 to 30%) in chayote (20 to 40%) based nuggets resulted in an increase in crude fat ranging from 3.12 to 7.00 per cent. Total carbohydrate contents of nuggets increased from 65.96 to 71.21 per cent with the increase in the level of chayote from 20 to 40 per cent in black gram nuggets and decreased to around 58 per cent as the replacement level of soybean increased in the black gram nuggets.

4.4.3 Fiber carbohydrates, Non-fibre carbohydrates and Energy contents

Data showing the fibre, non-fibre carbohydrates and energy contents of nuggets containing variable proportions of chayote shreds and wet ground legumes in the nugget mixture are given in Table 4.14. The contents of NDF, ADF, digestible carbohydrates, total energy and available energy varied significantly ($P \leq 0.05$) among different treatments. The neutral detergent fiber (NDF), acid detergent fiber (ADF) and the hemi cellulose contents were found to be highest in pure soybean nuggets with values of 21.59, 10.72 and 10.87 percent, respectively. The lowest neutral detergent fiber (13.83%) and acid detergent fiber (3.81%) were observed in the nuggets prepared with pure blackgram dhal. Replacement of black gram (20 to 40%) with chayote (20 to 40%) in the nugget formulationincreased the NDF (15.78 to 18.26%) and ADF (5.72 to7.28%).

Table 4.14 Fibre and non-fibre carbohydrate, and energy content of chayote and legume based nuggets (*Warian*)

Proportions Chayote:Blackgram:Soybean	NDF (%)	ADF (%)	Hemi-cellulose (%)	Digestible CHO (%)	Total energy (Kcal/ 100g)	Available energy (Kcal/ (100g)
0 : 0 : 100	21.59	10.72	10.87	7.90	445.43	359.13
0 : 100 : 0	13.83	3.81	10.02	52.12	364.19	308.89
20 : 80 : 0	15.78	5.72	10.06	53.21	362.04	298.94
30 : 70 : 0	16.80	6.96	9.84	54.27	362.53	295.39
40 : 60 : 0	18.26	7.28	10.98	52.95	357.84	281.95
20 : 70 : 10	17.00	6.23	10.77	48.57	373.81	302.31
30 : 60 : 10	17.58	7.99	9.59	49.23	372.97	302.45
40 : 50 : 10	18.90	9.00	9.91	49.03	371.86	292.64
20 : 60 : 20	16.62	7.85	9.13	45.18	381.20	307.06
30 : 50 : 20	17.01	8.40	8.62	46.41	382.29	305.95
40 : 40 : 20	18.18	9.46	8.72	46.38	381.24	303.80
20 : 50 : 30	18.50	8.25	10.25	39.53	385.25	305.49
30 : 40 : 30	18.65	9.26	9.39	39.77	385.91	303.17
40 : 30 : 30	19.68	10.13	9.56	40.86	384.51	303.15
CD ($P \leq 0.05$)	1.59	0.89	----	3.75	7.54	15.18

*Data reported are the averages of duplicate determinations on (Dry weight basis)
NDF= Neutral detergent fiber
ADF= Acid detergent fiber

Partial replacement of black gram (10 to 30%) with soybean (10 to 30%) in the chayote based nuggets further enhanced the NDF up to 19.60 per cent and ADF to 10.13 per cent. Corresponding changes in the hemicellulose contents calculated by subtracting ADF values from NDF values were also observed. Partial dilution of digestible carbohydrates also occurred as the level of chayote and soybean in black gram nuggets occurred. Digestible carbohydrates contents of black gram and soybean nuggets were recorded as 52.12 and 7.90 per cent. Whereas the total and available energy contents of these formulations were recorded as 364.19, 308.89 and 445.43, 359.13 Kcal/100g respectively. The contents of these nutrients among rest of the treatments varied from 357.84 to 385.91, and 292.64 to 307.08 Kcal/100g.

4.4.4 Sensory Acceptability

The nugget curries from each treatment were prepared according to a standardized recipe as explained in Chapter III and subjected to sensory evaluation by a panel of 10 judges for evaluation of colour, flavour, taste and texture and overall acceptability. The evaluation scores are presented in Table 4.15. The overall acceptability of the black gram nuggets was higher (7.82) and did not change much with the addition of chayote up to 30 per cent level of substitution as the nuggets were rated as liked moderately (7.19) to liked very much (7.58) at this level of substitution.

A consistent decline in the overall acceptability ratings of the nuggets was reported by the judges as the level of soybean increased in the nuggets. However, the nuggets formulations containing chayote up to 20 per cent and soybean up to 20 per cent level were rated quite acceptable (liked moderately to liked very much) Pure soybean nuggets were rated as lowest (5.80) in acceptability ratings because of the presence of beany flavour and had a tendency to disintegrate during cooking.

Table 4.15 Sensory acceptability of chayote and legume based nuggets (*Warian*)

Proportions Chayote:Blackgram:Soybean	Colour	Flavour	Taste	Texture	Overall acceptibility
0 : 0 : 100	5.07	6.18	5.21	6.75	5.80
0 : 100 : 0	7.38	8.12	8.05	7.74	7.82
20 : 80 : 0	7.23	7.99	7.85	7.27	7.58
30 : 70 : 0	7.35	7.10	7.05	7.25	7.19
40 : 60 : 0	7.06	6.28	6.24	7.36	6.73
20 : 70 : 10	7.56	7.36	7.49	7.05	7.36
30 : 60 : 10	7.46	7.26	7.42	6.99	7.28
40 : 50 : 10	7.05	6.26	6.28	7.30	6.72
20 : 60 : 20	7.10	6.86	6.88	7.18	7.00
30 : 50 : 20	7.13	6.78	6.90	7.28	7.02
40 : 40 : 20	6.85	6.85	6.68	7.25	6.90
20 : 50 : 30	5.58	5.20	5.16	7.08	5.75
30 : 40 : 30	5.48	5.06	4.84	6.90	5.57
40 : 30 : 30	5.25	4.90	4.75	6.85	5.44
CD ($P \leq 0.05$)	0.42	0.19	0.54	0.18	0.28

*Data reported are the averages of ten judges

4.5 Dehydrated Chayote

4.5.1. Chayote Pieces

Table 4.16 as well as Figure 1 and 2 show the effect of temperature and time of drying on per cent weight (yield) and per cent water loss from chayote pieces during course of drying at different temperatures. Physical appearance of fresh and dehydrated chayote pieces dried at different temperatures is shown in Plate 2 .The weight of chayote pieces decreased and water loss from pieces increased significantly with the increase in temperature and duration of drying. The pieces dried at 55°C took 16 hours for attaining equilibrium in weight (110 g/Kg, 11%) and water loss (89.0%). At 65°C the equilibrium was attained in 14 hours with 88g / Kg (8.8%) weight of pieces and 91.20 per cent water loss. At 75°C, the equilibrium in the product was attained after 10 hours with 85.0 g/Kg (8.5%) weight of pieces and 91.50 per cent water loss. In conclusion, the chayote pieces dehydrated at 55°C required 16 hours, at 65°C required 12 hours and at 75°C required 10 hours. At 75°C chayote pieces were found to be little discolored towards brownish tint. But the samples dehydrated at 55 and 65°C were higher in colour than the samples dehydrated at 75°C. Solar drying was also attempted but was found to be impractical as it required 5-6 days for thorough drying. It was weather dependant as the sun light was not available for this much duration continuously, so, the samples got spoiled due to mould growth resulting in foul odour.

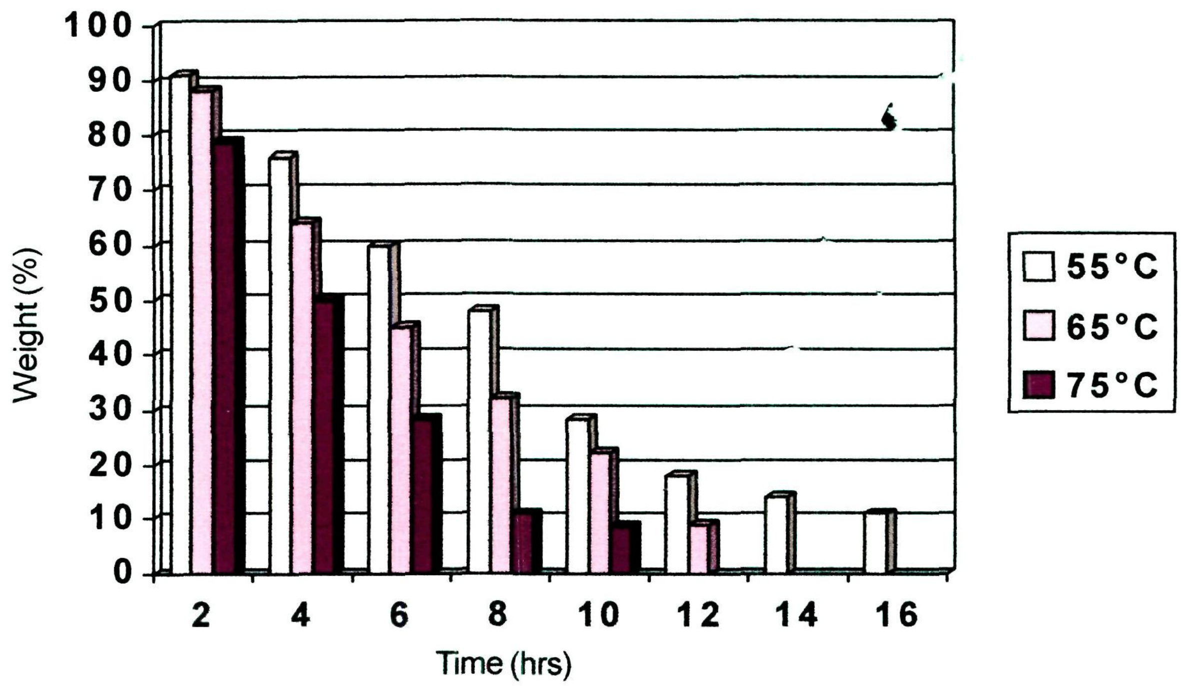


Fig. 1. Effect of drying temperature and time on the per cent weight of dehydrated chayote pieces

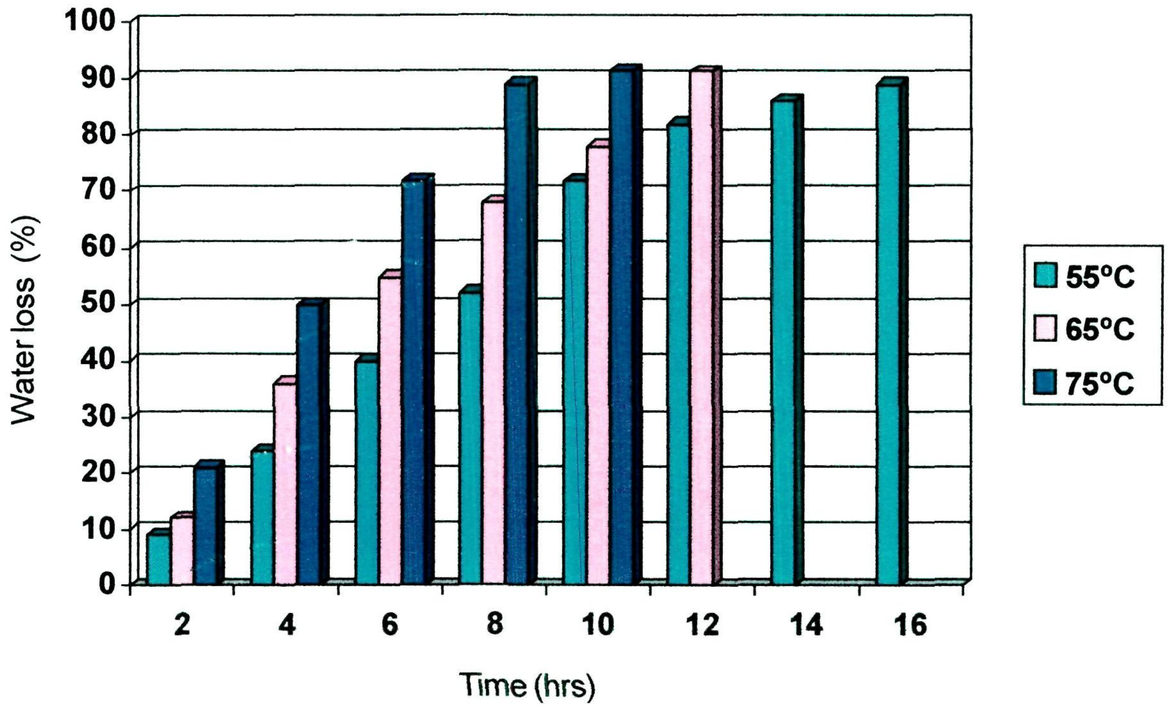


Fig. 2. Effect of drying temperature and time on the per cent water loss of dehydrated chayote pieces

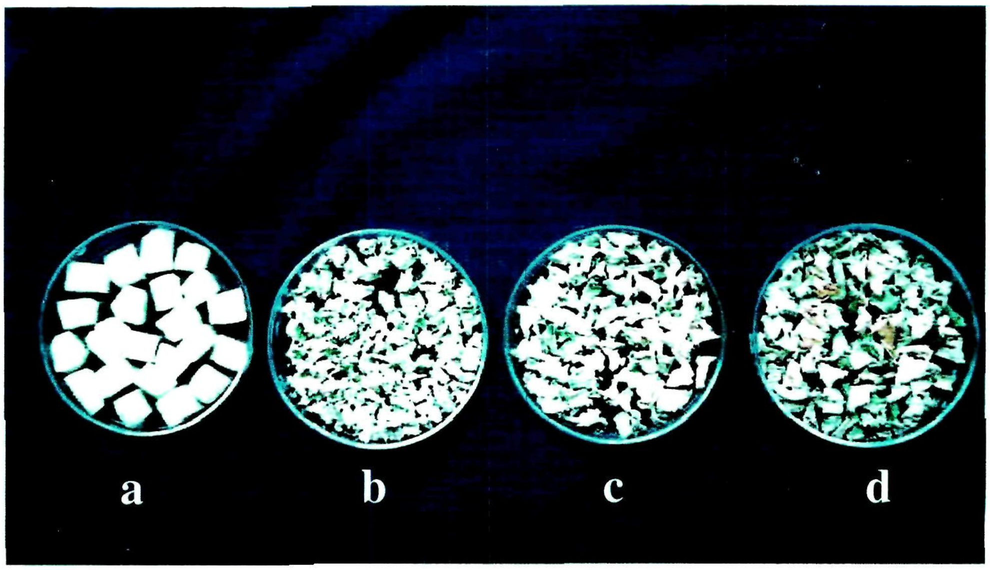


Plate 2. Physical appearance of fresh and dehydrated chayote pieces

a. Fresh
b. Dehydrated at 55°C
c. Dehydrated at 65°C
d. Dehydrated at 75°C

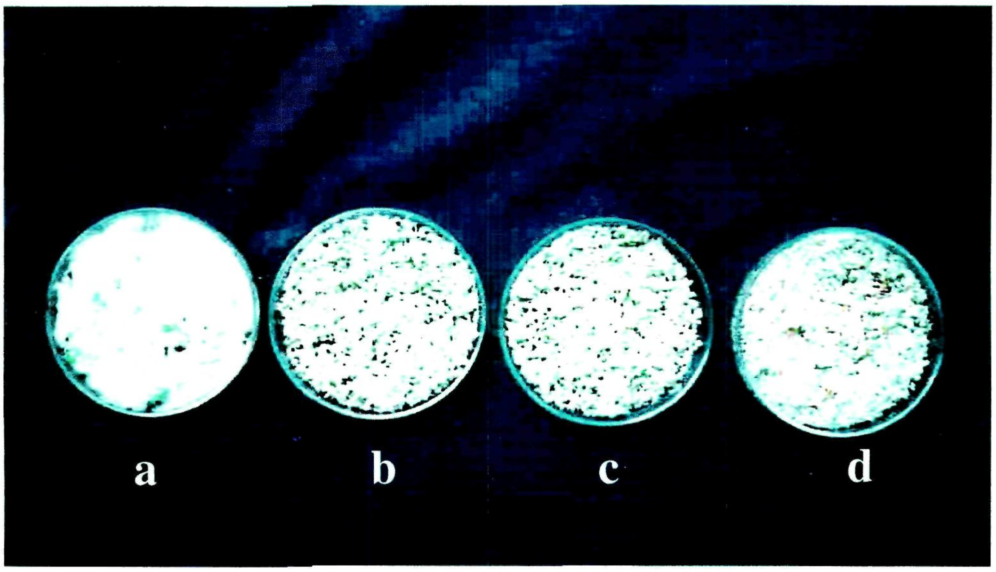


Plate 3. Physical appearance of fresh and dehydrated chayote shreds

a. Fresh
b. Dehydrated at 55°C
c. Dehydrated at 65°C
d. Dehydrated at 75°C

Table 4.16 Effect of drying temperature and time on the per cent weight and per cent water loss of chayote pieces

Time of drying (hours)	Temperature of drying°C					
	55°C		65°C		75°C	
	Dried wt. (g)	Water loss (%)	Dried wt. (g)	Water loss (%)	Dried wt (g)	Water loss (%)
0	1000	0	1000	0	1000	0
2	910	9	880	12	790	21
4	760	24	640	36	500	50
6	600	40	450	55	280	72
8	480	52	320	68	110	82
10	280	72	220	78	85	91.5
12	180	82	88	91.2	---	---
14	140	86	--	--	--	--
16	110	89	--	--	--	--

*Data reported are the averages of duplicate determinations

4.5.2 Chayote Shreds

The results of the effects of temperature and time of dehydration on the per cent weight and water loss from chayote shreds are shown in Table 4.17 and illustrated in Figures 3 and 4. Physical appearance is shown in Plate 3. As with pieces, the weight of shreds decreased and per cent loss of water from shreds increased with the increase in temperature of dehydration. The slowest drying as observed

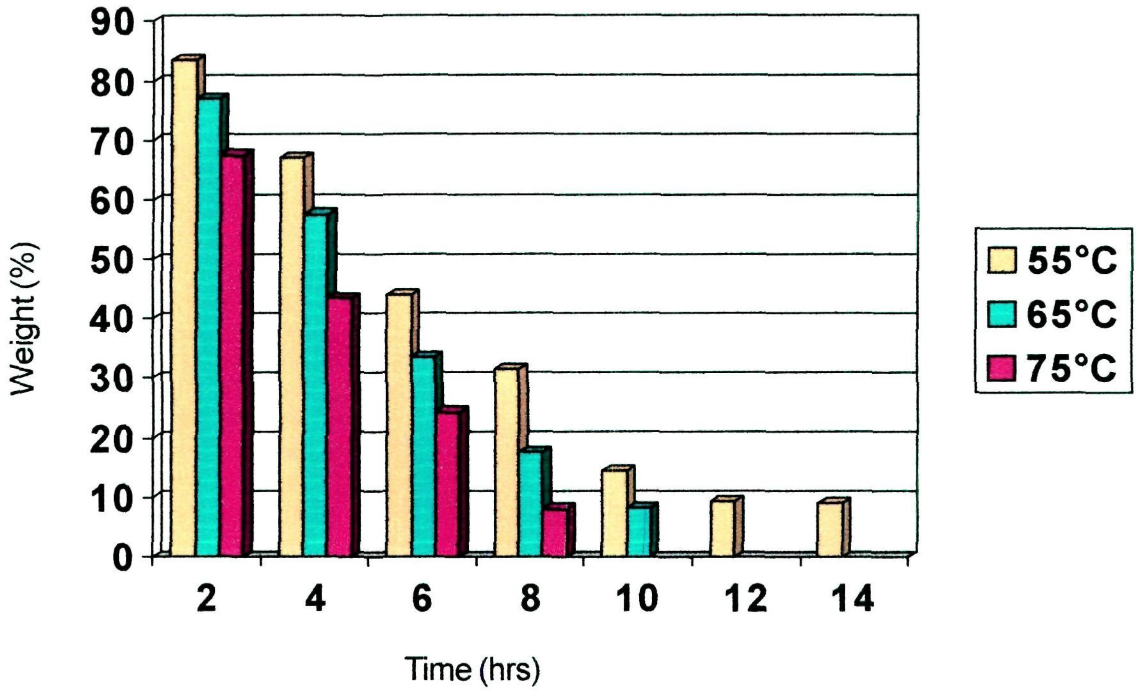


Fig. 3. Effect of drying temperature and time on the per cent weight of dehydrated chayote shreds

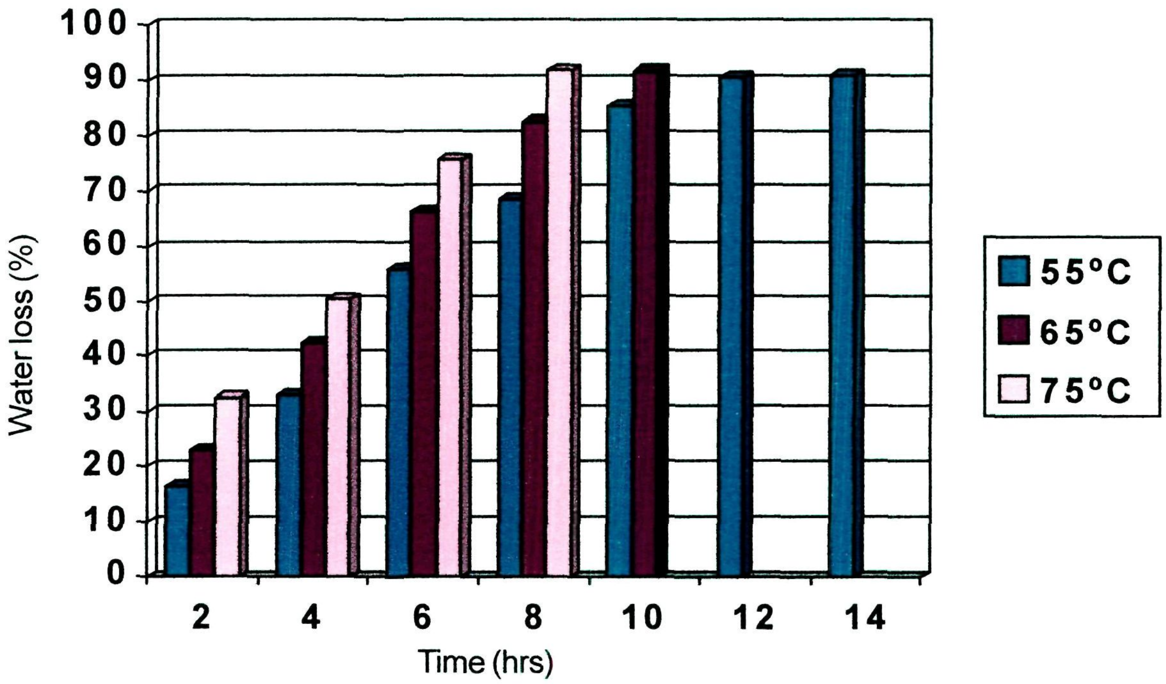


Fig. 4. Effect of drying temperature and time on the per cent water loss of dehydrated chayote shreds

Table 4.17 Effect of drying temperature and time on the per cent weight and percent water loss of chayote shreds

Time of drying (hours)	Temperature of drying°C					
	55°C		65°C		75°C	
	Dried wt. (g)	Water loss (%)	Dried wt. (g)	Water loss (%)	Dried wt (g)	Water loss (%)
0	1000	0	1000	0	1000	0
2	835	16.5	770	23	675	32.5
4	670	33	575	42.5	435	50.5
6	440	56	335	66.5	242.5	75.7
8	315	68.5	175	82.5	81	91.90
10	145	85.5	82.5	91.75	---	---
12	92.5	90.75	--	---	---	---
14	90.5	90.95	---	---	---	---

*Data reported are the averages of duplicate determinations

from the increase in per cent water loss and decrease in the weight of shreds was observed in shreds dried at 55°C which required 14 hours for attaining equilibrium weight of 90.5 g/Kg (9.05%) and water loss of 90.95 per cent after drying. At 65°C and 75°C drying required 10 and 8 hours for attaining equilibrium weights of 82.50 g/Kg (8.25%) and 81.0 g/Kg (8.10%), respectively. The shreds of chayote dehydrated at higher temperature 75°C were darker in colour than the shreds dehydrated at lower temperatures in mechanical dehydrator. At 65 satisfactory drying was achieved, however, at 55 °C the drying was pronged. Solar drying (data not reported) was slow, required very long duration for drying and the samples also started smelling indicating the growth of microorganism

4.5.3. Yield of Pieces and Shreds

The yields of dried pieces and shreds obtained at different temperatures and the time required to accomplish the equilibrium yields are presented in Table 4.18.

Table 4.18 Effect of drying temperature on the per cent yield of chayote pieces and shreds

Sample	Temperature of Drying (°C)	Time required (hrs.)	Yield (%)
Chayote Pieces	55	16	11
	65	12	8.8
	75	10	8.5
Chayote Shreds	55	14	9.05
	65	10	8.25
	75	8	8.10

*Data reported are the averages of duplicate determinations

Chayote pieces required 16 hours at 55 °C, 12 hours at 65°C and 10 hours at 75°C with equilibrium product yields of 11, 8.8 and 8.5 per cent respectively. In case of chayote shreds relatively shorter times were required to achieve equilibrium product yields of 9.05, 8.25 and 8.10 per cent respectively.

4.5.4 Rehydration Characteristics

The data pertaining to the rehydration characteristics of pieces and shreds are presented in Table 4.19 and illustrated in Figure 5. The rate of hydration of dehydrated pieces and shreds increased with the increase in the duration of soaking in plain water and decrease with the increase in temperature. It increased at a faster rate in shreds as compared to pieces but upon full saturation the dehydrated pieces came to equilibrium at higher water absorption of 5.25 ml/g at 55°C, 5.20 ml/g at 65°C and 4.20 ml/g at 75°C. Whereas, shreds came to equilibrium at lower water absorbtion of 3.50 ml/g at 55°C, 3.49 ml/g at 65°C and 3.10 ml/g at 75°C.

Table 4.19 Effect of drying temperatures on the water absorption (ml/g) characteristics of dehydrated chayote pieces and shreds.

Product	Rehydration characteristics Time (hrs.)						
	1	2	3	4	5	6	7
Chayote pieces							
55°C	1.52	2.44	3.38	4.12	4.58	5.20	5.24
65°C	1.50	2.35	3.25	4.00	4.38	5.15	5.20
75°C	1.20	2.30	2.90	3.20	3.50	4.20	4.20
Chayote shreds							
55°C	2.07	2.63	3.34	3.47	3.48	3.50	3.50
65°C	2.00	2.58	3.25	3.40	3.45	3.48	3.49
75°C	1.89	2.40	2.45	2.50	3.05	3.10	3.10

*Data reported are the averages of duplicate determinations

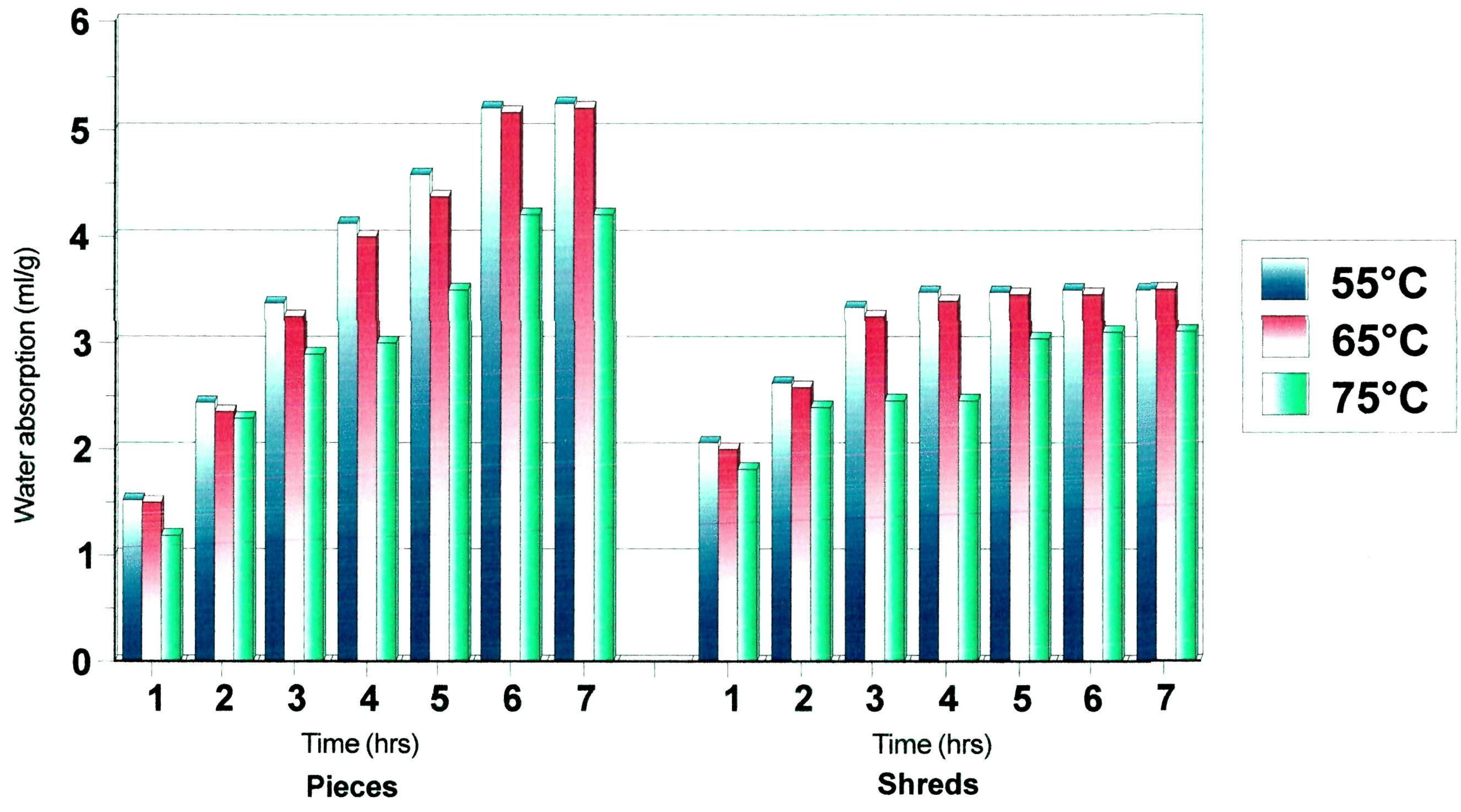


Fig. 5. Effect of drying time and temperature on the water absorption (ml/g) behaviour of dehydrated chayote pieces and shreds

4.5.4 Sensory Acceptability

Vegetables prepared from fresh, and reconstituted dehydrated chayote pieces and shreds dried at different temperatures (55, 65 and 75°C) when subjected to sensory evaluation after cooking by a panel of 10 judges revealed that the overall acceptability of fresh chayote pieces was slightly higher (7.76) as compared to fresh chayote shreds (7.67) but significantly higher than the dehydrated chayote pieces and shreds (Table 4.20).

Table 4.20 Effect of different temperatures on the sensory acceptability of chayote pieces and shreds

Product	Colour	Flavour	Taste	Texture	Overall acceptibility
Chayote pieces					
Fresh	8.01	8.06	7.30	7.66	7.76
55°C	7.20	7.29	6.75	6.80	7.00
65°C	6.82	6.55	6.61	6.12	6.91
75°C	5.25	6.38	6.22	6.15	5.99
CD≤0.05	0.42	1.09	--	1.02	0.36
Chayote shreds					
Fresh	8.13	7.90	7.40	7.20	7.67
55°C	7.18	6.96	6.91	6.48	6.88
65°C	6.80	6.25	6.70	6.30	6.81
75°C	5.31	5.57	6.45	5.76	5.77
CD≤0.05	0.30	0.88	---	---	0.31

* Data reported are the averages of duplicate determinations

However, the overall acceptability between chayote pieces and between shreds dried at 55°C and 65°C did not differ much. Chayote pieces and shreds dried at 75°C were rated as lowest (5.99 and 5.77) in terms of overall acceptability ratings.

4.6 Chutney

Two type of chutneys were prepared from chayote and from its blends with raw mango (Plate-4) and plum (Plate-5) and evaluated fresh and during storage for chemical and sensory attributes. The results of the analysis are presented as under:

4.6.1 Chayote and Mango Based Chutney

1. Ascorbic acid, Titrable acidity and Total soluble solids

The data pertaining to the effect of blending and storage on the ascorbic acid, acidity and TSS contents of chutney prepared from chayote, and blends of chayote and raw mango are presented in Table 4.21. The effects of blending as well as storage on the ascorbic acid contents were found to be significant ($P \leq 0.05$). The initial mean ascorbic acid content between unblended and blended chutneys varied from to 3.06 to10.23 mg/100g which decreased significantly and varied from 2.06 to 7.63 mg/ 100g after 180 days of storage.

Initially, the acidity of the chutneys was recorded to vary from 2.54 to 2.86 per cent between the blended and unblended fresh samples. After 180 days of storage the values varied from 1.93 to 2.00 per cent.

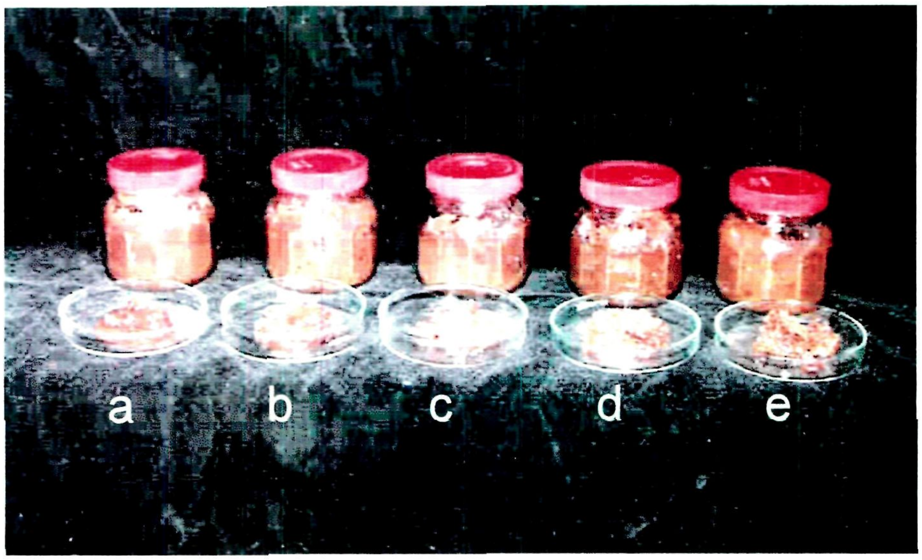


Plate 4. Physical appearance of chutney prepared from chayote and blends of chayote and raw mango

Product	Chayote	:	Raw mango
a.	100	:	0
b.	75	:	25
c.	50	:	50
d.	25	:	75
e.	0	:	100

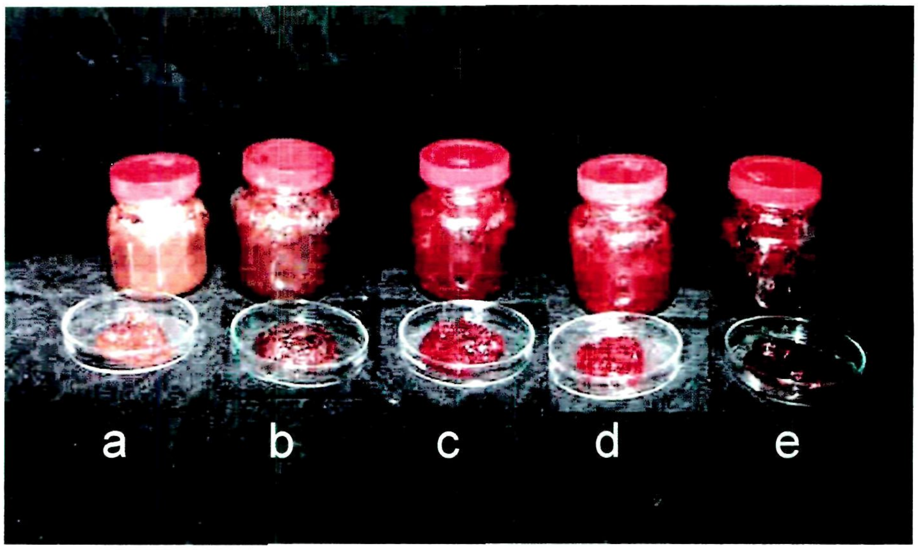


Plate 5. Physical appearance of chutney prepared from chayote and blends of chayote and plum

Product	Chayote	:	Plum
a.	100	:	0
b.	75	:	25
c.	50	:	50
d.	25	:	75
e.	0	:	100

Table 4.21 Ascorbic acid, titrable acidity and total soluble solids of fresh and stored chutney prepared from chayote and from blends of chayote and raw mango

1. Ascorbic acid (mg/100g)

Blends Chayote: Raw mango	Storage (days) 0	60	120	180	Mean
100:0	3.06	2.91	2.47	2.06	2.62
75:25	4.28	4.06	3.59	3.29	3.80
50:50	8.17	7.96	7.35	6.76	7.56
25:75	10.23	9.53	8.31	7.63	8.93
0:100	11.69	11.09	10.57	9.65	10.75
Mean	7.48	7.11	6.46	5.88	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$) Blends (B) = 0.45
CD ($P \leq 0.05$) Storage duration (D) = 0.40; CD ($P \leq 0.05$) B × D = NS

2. Titrable acidity (% C.A)

100:0	2.54	2.33	2.15	1.93	2.24
75:25	2.33	2.25	2.06	1.95	2.15
50:50	2.63	2.46	2.23	2.00	2.33
25:75	2.22	2.11	2.00	1.88	2.05
0:100	2.86	2.70	2.41	1.98	2.49
Mean	2.52	2.37	2.17	1.95	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$) Blends(B) = 0.12
CD ($P \leq 0.05$) Storage duration (D) = 0.11; CD ($P \leq 0.05$) B × D = NS

3. Total soluble solids (°B)

100:0	57.05	56.60	55.98	55.10	56.18
75:25	56.63	56.43	55.40	55.00	55.86
50:50	56.63	55.90	55.43	54.75	55.68
25:75	56.90	56.55	56.13	55.53	56.28
0:100	57.03	56.60	56.30	54.60	56.13
Mean	56.85	56.42	55.85	55.00	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$) Blends(B) = NS
CD ($P \leq 0.05$) Storage duration (D) = 0.62; CD ($P \leq 0.05$) B × D = NS

The effect of blending of chayote pulp with raw mango fruit pulp on the TSS value of chutney was recorded as non-significant, whereas, the storage duration produced significant effect in the reduction of TSS values of the chutneys. The initial mean TSS values of chutneys were 56.85 °B that decreased to a mean value of 55.00 after 180 days of storage.

2. Total, Reducing and Non-reducing sugars

Total sugars in the chutneys were observed to be lower than the TSS values of the chutneys. The effect of blending and interaction between blending and storage duration in the reduction of total sugars were slight but significant ($P \leq 0.05$) as depicted in Table 4.22. The mean initial values of total sugars in chutney formulations varied from 51.60 to 52.95 per cent and after 180 days of storage the values varied from 50.87 to 52.17 per cent.

In general, an increasing trend in the reducing sugar contents was observed with the increase in storage duration and initial values of reducing sugars varied from 20.61 to 21.08 with a mean value of 20.80 percent. After 180 days of storage, reducing sugars increased slightly and the values varied from 21.54 to 22.32 with a mean value of 22.0 per cent. The initial non-reducing sugars in chutneys varied from 28.93 to 30.27 per cent with a mean value of 29.51 per cent and after 180 days of storage the values varied from 27.40 to 28.60 per cent with a mean value of 27.93 per cent.

Table 4.22 Total, reducing and non- reducing sugars of fresh and stored chutney prepared from chayote and from blends of chayote and raw mango

1. Total sugars (%)

Blends Chayote: Raw mango	Storage (days) 0	60	120	180	Mean
100:0	51.72	51.65	51.54	51.48	51.60
75:25	52.02	51.93	51.80	51.56	51.82
50:50	51.60	51.34	51.11	50.87	51.23
25:75	52.95	52.75	52.51	52.17	52.59
0:100	51.57	51.47	51.10	51.49	51.41
Mean	51.97	51.83	51.61	51.51	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.75
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = 1.5

2. Reducing sugars (%)

100:0	20.76	21.05	21.65	22.32	21.45
75:25	20.61	20.80	21.29	21.54	21.06
50:50	20.96	21.05	21.58	22.03	21.40
25:75	21.08	21.29	21.79	22.06	21.55
0:100	20.62	21.35	21.82	22.10	21.47
Mean	20.80	21.10	21.63	22.0	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$) Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = NS

3. Non-Reducing sugars (%)

100:0	29.41	27.51	28.39	27.69	28.25
75:25	29.84	29.57	28.98	28.51	29.22
50:50	29.11	28.77	28.05	27.40	28.33
25:75	30.27	29.88	29.18	28.60	29.48
0:100	28.93	28.62	27.82	27.44	28.20
Mean	29.51	28.87	28.48	27.93	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = NS

3. Sensory Acceptability

The overall sensory acceptability score of chutney formulations containing variable proportions of chayote and raw mango pulps are presented in Table 4.23.

Table 4.23 Sensory acceptability of fresh and stored chutney prepared from chayote and from blends of chayote and raw mango

Blends Chayote : Raw mango	Storage (days) 0	60	120	180	Mean
100:0	5.40	5.31	5.20	5.16	5.27
75:25	6.45	6.37	6.27	6.21	6.32
50:50	6.85	6.76	6.00	6.57	6.71
25:75	7.40	7.37	7.20	7.12	7.27
0:100	7.65	7.56	7.42	7.30	7.48
Mean	6.75	6.67	6.55	6.47	

*Data presented are averages of ten judges.
CD($P \leq 0.05$)Blends(B) = 0.18
CD($P \leq 0.05$)Storage duration (D) = 0.16
CD($P \leq 0.05$) B × D = NS

Chutney prepared from chayote was rated as neither liked or disliked (5.40) on a nine point hedonic scale. However, a significant ($P \leq 0.05$) enhancement in the overall acceptability scores of chutneys occurred with the increase in the proportion of raw mango pulp in the chayote based chutney formulations. At 50, 75 and 100 per cent levels of substitution of chayote with raw mango the overall acceptability improved to 6.85 (liked moderately), 7.40 (liked very much) and 7.65 (liked very much). With an increase in storage period to 180 days, the overall acceptability scores of chutney samples were decreased slightly. In general, the overall mean acceptability scores initially recorded as 6.75, decreased to 6.47 after 180 days of storage.

4.6.2 Chayote and Plum Based Chutney

1. Ascorbic acid, Titrable acidity and Total soluble solids

The ascorbic acid contents of chutney formulations were diluted significantly ($P \leq 0.05$) due to decreased proportion of plum pulp in chayote based chutney (Table 4.24). The effect of blending and storage duration on the ascorbic acid content was significant ($P \leq 0.05$). Chayote chutney contained lowest content of ascorbic acid (3.06 mg/100g) whereas; plum chutney contained slightly higher content of ascorbic acid (5.38 mg/100g). Rest of the treatments contained in between these two values. Losses in ascorbic acid content of chutneys are also evident from the data due to increase in storage duration.

The effect of blending and interaction between blending and storage duration were found to non-significant in reducing the acidity values of chutneys, whereas, the storage duration produced significant effect ($P \leq 0.05$). The initial acidity values of chutneys ranged from 2.59 to 2.82 per cent with a mean value of 2.68 that decreased and ranged from 1.90 to 1.98 with a mean value of 1.93 per cent after 180 days of storage.

Table 4.24 Ascorbic acid, titrable acidity and total soluble solids of fresh and stored chutney prepared from chayote and from blends of chayote and plum

1. Ascorbic acid (mg/100g)

Blends Chayote : Plum	Storage (days) 0	60	120	180	Mean
100:0	3.06	2.91	2.47	2.06	2.62
75:25	3.44	3.21	2.99	2.75	3.10
50:50	4.17	4.06	3.98	3.73	3.98
25:75	4.49	4.20	4.10	3.94	4.18
0:100	5.38	5.19	5.00	4.55	5.03
Mean	4.10	3.91	3.70	3.40	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.13
CD ($P \leq 0.05$)Storage duration (D) = 0.11
CD ($P \leq 0.05$) B × D = NS

2. Titrable acidity (% C.A)

100:0	2.59	2.33	2.15	1.93	2.25
75:25	2.82	2.55	2.11	1.98	2.36
50:50	2.69	2.36	2.10	1.90	2.26
25:75	2.62	2.37	2.06	1.93	2.24
0:100	2.67	2.50	2.30	1.93	2.35
Mean	2.68	2.42	2.14	1.93	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = 0.18
CD ($P \leq 0.05$) B × D = NS

3. TSS (°B)

100:0	56.73	56.60	55.98	55.10	56.10
75:25	55.23	54.63	54.80	54.55	54.80
50:50	55.10	53.63	54.50	54.10	54.33
25:75	54.93	54.60	54.43	54.13	54.52
0:100	55.00	54.73	54.50	54.35	54.64
Mean	55.40	54.84	54.84	54.45	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = 0.86
CD ($P \leq 0.05$) B × D = NS

The effect of blending and interaction between blending and storage duration on the TSS values of the chutneys were recorded non-significant but the storage duration revealed significant effect on the TSS values of the chutneys. The initial mean TSS values of chutneys formulations was recorded as 55.40°B which decreased to a mean value of 54.45°B after 180 days of storage.

2. Total, reducing and Non-reducing sugars

The total sugar contents of chutneys varied from 51.72 to 51.01 percent initially, which did not change insignificantly after 180 days of storage (Table 4.25). But the blending produced significant effect ($P \leq 0.05$) on the total sugar values of the chutneys. The values among different treatments ranged from 51.01 to 51.72 per cent.

The reducing and non reducing sugars did not change significantly by blending and storage duration. The value for the former ranged from 20.68 to 21.01 per cent and for the latter from 27.63 to 29.41 per cent.

3. Sensory Acceptability

The overall organoleptic acceptability scores (Table 4.26) of the chutneys samples prepared from chayote pulp and its blends with plum pulp revealed that the chutney samples are liked slightly (5.29) to liked extremely (8.35). Blending and storage duration produced significant

Table 4.25 Total, reducing and non- reducing sugars of fresh and stored chutney prepared from chayote and from blends of chayote and plum

1. Total sugars (%)

Blends Chayote: Plum	Storage (days) 0	60	120	180	Mean
100:0	51.72	51.65	51.84	51.43	51.66
75:25	51.03	50.83	50.60	50.50	50.74
50:50	51.39	51.03	50.73	50.56	50.92
25:75	51.41	51.23	51.09	51.02	51.19
0:100	51.01	50.84	50.61	50.55	50.75
Mean	51.31	51.11	50.97	50.81	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.55
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = NS

2. Reducing sugars (%)

100:0	20.76	21.05	21.65	22.32	21.45
75:25	20.68	21.08	21.47	21.67	21.22
50:50	21.01	21.22	21.50	22.00	21.43
25:75	20.91	21.13	21.43	21.60	21.27
0:100	20.87	21.25	21.48	21.78	21.34
Mean	20.85	21.44	21.50	21.87	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D= NS

3. Non Reducing sugars(%)

100:0	29.41	29.07	28.40	27.65	28.63
75:25	28.83	28.26	27.84	27.39	28.08
50:50	28.86	28.31	27.76	27.12	28.01
25:75	27.63	28.60	28.18	27.94	28.08
0:100	28.63	28.11	28.40	27.33	28.12
Mean	28.67	28.47	28.11	27.49	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends (B) = NS
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = NS

effect on the overall acceptability scores of the chutney samples. The initial scores of chayote chutney improved from 5.29 to 8.35 by blending chayote with plum proportionate to the level of blending with plum, After 180 days of storage the scores were found to vary from 5.07 to 7.55 on a nine point hedonic scale.

Table 4.26 Sensory acceptability of fresh and stored chutney prepared from chayote and from blends of chayote and plum

Blends	Storage (days)				
Chayote : Plum	0	60	120	180	Mean
100:0	5.29	5.24	5.13	5.07	5.18
75:25	6.42	6.36	6.30	5.72	6.20
50:50	7.43	7.38	7.29	6.68	7.20
25:75	7.43	7.34	7.57	7.14	7.37
0:100	8.35	8.25	8.19	7.55	8.09
Mean	6.98	6.91	6.89	6.43	

*Data presented are averages of ten judges

CD ($P \leq 0.05$)Blends(B) = 0.29

CD ($P \leq 0.05$)Storage duration (D) = 0.26

CD ($P \leq 0.05$) B × D = NS

4.6.3 Sauce

Sauce samples prepared from chayote and from blends of chayote and tomato (Plate-6) were evaluated fresh and during storage for various chemical and sensory attributes as described below:

1. Ascorbic acid, Titrable acidity and Total soluble solids

The ascorbic acid contents of chayote sauce formulations increased significantly ($P \leq 0.05$) with the increase in proportion of tomato pulp in chayote sauce, however little but significant losses occurred during storage (Table 4.27). Blending also produced significant interactions in affecting the ascorbic acid contents. Chayote and tomato based sauce formulations initially contained 2.49 to 12.78 mg/100g ascorbic acid and after 180 days of storage the contents varied from 1.55 to 11.53 mg/100g. These value are very low and may not have much nutritional significance.

The initial acidity values of sauces ranged from 2.06 to 2.56 percent with a mean value of 2.25 that decreased significantly to 1.76 to 2.08 with a mean value of 1.89 per cent after 180 days of storage.

The effect of blending of chayote pulp with tomato fruit pulp in the preparation of sauce, on the TSS value of sauce was found to be non-significant, whereas, the storage produced significant ($P<0.05$) effect in reducing the TSS values of the sauces. The initial mean value of sauces was 25.73°B that decreased to a mean value of 24.20°B during storage of 180 days.

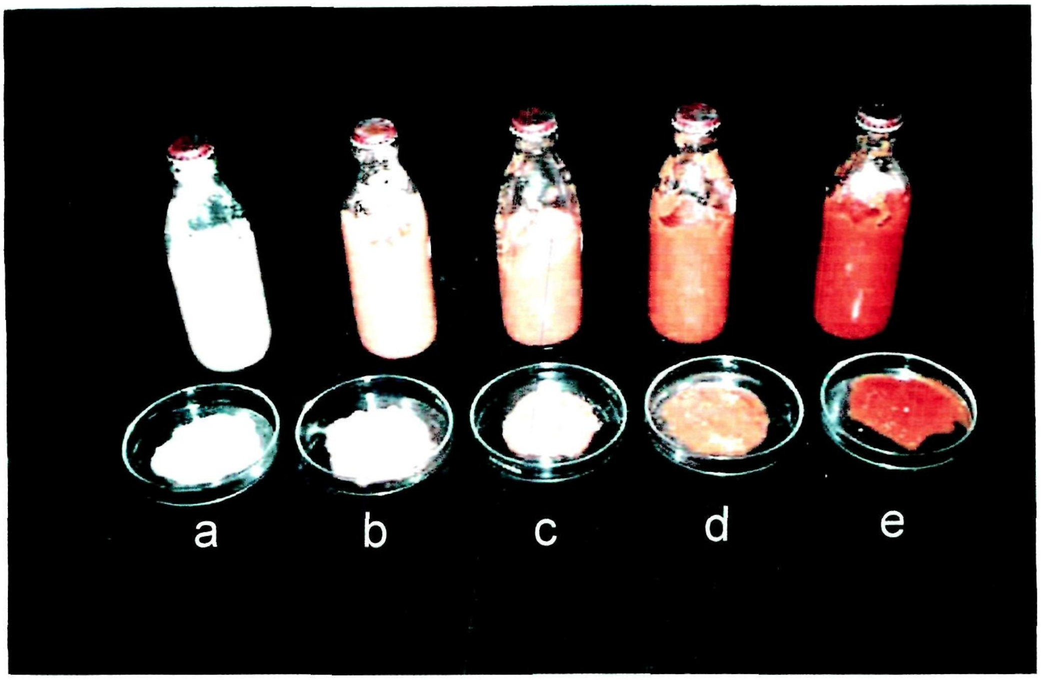


Plate 6. Physical appearance of sauce prepared from chayote and blends of chayote and tomato

Product	Chayote	:	Tomato
a.	100	:	0
b.	75	:	25
c.	50	:	50
d.	25	:	75
e.	0	:	100

Table 4.27 Ascorbic acid, titrable acidity and total soluble solids of fresh and stored sauce prepared from chayote and from blends of chayote and tomato

1. Ascorbic acid (mg/100g)

Blends Chayote: Tomato	Storage (days) 0	60	120	180	Mean
100:0	2.49	2.39	1.65	1.55	2.02
75:25	4.59	4.62	4.10	3.90	4.30
50:50	6.96	6.65	6.46	6.13	6.55
25:75	8.88	8.11	7.47	7.07	7.88
0:100	12.78	12.68	12.47	11.53	12.36
Mean	7.14	6.89	6.43	6.03	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.90
CD ($P \leq 0.05$)Storage duration (D) = 0.81
CD ($P \leq 0.05$) B × D = NS

2. Titrable acidity (% C.A)

100:0	2.14	2.04	1.88	1.76	1.95
75:25	2.09	2.05	1.93	1.88	1.98
50:50	2.06	2.00	1.87	1.91	1.96
25:75	2.40	2.34	2.19	1.81	2.18
0:100	2.56	2.48	2.28	2.08	2.35
Mean	2.25	2.18	2.03	1.89	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.09
CD ($P \leq 0.05$)Storage duration (D) = 0.08
CD ($P \leq 0.05$) B × D = NS

3. TSS (°B)

100:0	25.13	24.90	24.33	23.93	24.57
75:25	25.85	25.63	25.30	24.10	25.22
50:50	25.92	25.73	24.63	23.83	25.03
25:75	25.83	25.63	25.23	24.38	25.26
0:100	25.90	25.73	25.20	24.75	25.39
Mean	25.73	25.52	24.94	24.20	

-*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = 0.63
CD ($P \leq 0.05$) B × D = NS

2. Total, reducing and Non-reducing sugars

The total sugar contents of sauces varied from 20.78 to 21.83 per cent among all the treatments and did not change or differed significantly during the entire duration of storage (Table 4.28)

The reducing sugars were changed significantly with blending and also with enhancement in the storage. In general, an increasing trend in the reducing sugars was observed with the increase in storage period and the contents during storage period varied from 15.03 to 17.12 per cent. Changes in non-reducing sugars that were calculated by subtracting reducing sugars from total sugar also reflected simultaneous significant ($P<0.05$) changes due to blending and storage duration. The mean initial values of non-reducing sugars for different samples of sauces were recorded as 5.74 per cent which decreased to 4.17 per cent after 180 days of storage.

3. Sensory Acceptability

The overall organoleptic acceptability scores of the sauce samples prepared from chayote pulp and from blend of chayote and tomato are presented in Table 4.29. Sauce prepared from chayote was liked slightly (5.75), whereas, the sauce prepared from tomato was liked extremely (8.18). Blending improved the organoleptic rating of the chayote sauce to liked moderately to liked very much (6.65 to 8.06). A slight but significant reduction in the organoleptic rating occurred during storage.

Table 4.28 Total, reducing and non- reducing sugars of fresh and stored sauce prepared from chayote and from blends of chayote and tomato

Total sugars (%)

Blends Chayote : Tomato	Storage (days) 0	60	120	180	Mean
100:0	20.78	20.73	20.82	20.65	20.74
75:25	21.83	21.75	22.02	21.51	21.78
50:50	21.33	21.18	21.13	21.04	21.17
25:75	20.98	20.69	20.56	20.49	20.68
0:100	21.22	21.15	20.90	20.57	20.96
Mean	21.23	21.19	21.10	20.85	

-*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = NS
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) B × D = NS

Reducing sugars (%)

100:0	15.76	16.35	15.51	17.12	16.43
75:25	14.96	15.29	15.50	15.95	15.42
50:50	15.55	15.85	16.29	16.72	16.10
25:75	15.09	5.48	15.72	16.39	15.67
0:100	15.03	15.27	15.88	16.06	15.56
Mean	15.28	15.65	15.98	16.45	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.60
CD ($P \leq 0.05$)Storage duration (D) = 0.53
CD ($P \leq 0.05$) B × D = 1.20

Non-Reducing sugars (%)

100:0	4.77	4.16	4.52	3.30	4.19
75:25	6.52	6.13	6.20	5.28	6.03
50:50	5.49	5.06	4.60	4.10	4.80
25:75	5.59	4.95	4.59	3.89	4.75
0:100	6.35	5.59	4.77	4.29	5.25
Mean	5.74	5.17	4.93	4.17	

*Data presented are averages of duplicate determinations
CD ($P \leq 0.05$)Blends(B) = 0.90
CD ($P \leq 0.05$)Storage duration (D) = 0.80
CD ($P \leq 0.05$) B × D = NS

Table 4.29 Sensory acceptability of fresh and stored sauce prepared from chayote and from blends of chayote and tomato

Blends Chayote: Tomato	Storage (days) 0	60	120	180	Mean
100:0	5.75	5.45	5.25	5.13	5.39
75:25	6.65	6.40	6.25	6.15	6.36
50:50	7.85	7.73	7.60	7.48	7.66
25:75	8.06	8.00	7.83	7.69	7.83
0:100	8.18	8.12	8.05	7.98	8.08
Mean	7.30	7.14	7.00	6.88	

*Data presented are averages of ten judges.
CD ($P \leq 0.05$) Blends(B) = 0.15
CD ($P \leq 0.05$) Storage duration (D) = 0.13
CD ($P \leq 0.05$) B × D = NS

4.6.4 Pickle

Chayote cubes and shreds were pickled separately prepared by using two acid sources (Acetic acid and galgal juice) and were analyzed for ascorbic acid and titrable acidity and overall acceptability during storage intervals.

1. Ascorbic acid and Titrable acidity

The ascorbic acid contents of pickle prepared from chayote cubes or shreds did not differ much, however, the source of acid used in souring the pickle produced significant changes in the contents of ascorbic acid as depicted in Table 4.30. Pickle soured with galgal juice contained significantly higher content of ascorbic acid as compared to

Table 4. 30 Ascorbic acid and titrable acidity contents of fresh and stored pickle prepared from chayote cubes and shreds

1. Ascorbic acid (mg/100g)

Fruit shape	Acid source	Storage (days) 0	60	120	180	Mean
Cubes						
	Acetic acid	2.06	1.29	1.98	1.68	1.75
	Galgal juice	7.05	6.46	6.88	6.00	6.60
	Mean	4.55	3.88	4.43	3.84	
Shreds						
	Acetic acid	2.11	1.10	1.98	1.63	1.70
	Galgal juice	6.05	5.53	6.11	5.63	5.83
	Mean	4.09	3.31	4.06	3.63	

*Data presented are averages of duplicate determinations

	Cubes	Shreds
CD ($P \leq 0.05$) Method of preservation(M)	0.31	0.30
CD ($P \leq 0.05$) Storage duration (D)	0.44	0.43
CD ($P \leq 0.05$) M × D	NS	NS

2. Titrable acidity (% Acetic acid)

Fruit shape	Acid source	0	60	120	180	Mean
Cubes						
	Acetic acid	2.05	2.00	1.88	1.73	1.91
	Galgal juice	2.15	2.08	2.00	1.93	2.04
	Mean	2.10	2.04	1.94	1.83	
Shreds	Acetic acid	2.10	2.05	1.97	1.90	2.00
	Galgal juice	2.21	2.13	2.07	1.62	2.01
	Mean	2.15	2.09	2.02	1.76	

*Data presented are averages of duplicate determinations

	Cubes	Shreds
CD ($P \leq 0.05$) Method of preservation(M)	0.10	NS
CD ($P \leq 0.05$) Storage duration (D)	0.14	NS
CD ($P \leq 0.05$) M × D	NS	NS

pickle soured with acetic acid, however, slight reductions in ascorbic acids contents of pickles occurred during storage. The initial acidity values of the pickles prepared from cubes or shreds using two different sources of acid varied from 2.05 to 2.21 per cent that were decreased to vary from 1.62 to 1.93 after 180 days of storage.

2. Sensory Acceptability

The overall acceptability of scores of the fresh and stored pickles prepared from chayote cubes and shreds using two different acids are presented in Table 4.31 and physical appearance of pickle samples is shown in Plates-7 and 8.

Table 4.31 Overall sensory acceptability of fresh and stored pickle prepared from chayote cubes and shreds

Fruit Shape	Acid source	Storage (days) 0	60	120	180	Mean
Cubes						
	Acetic acid	6.90	6.85	6.85	6.56	6.79
	Galgal juice	7.25	7.20	6.95	7.10	7.12
	Mean	7.08	7.03	6.90	6.83	
Shreds						
	Acetic acid	7.15	7.09	6.98	6.90	7.03
	Galgal juice	7.46	7.44	7.24	7.14	7.32
	Mean	7.30	7.27	7.11	7.02	

*Data presented are averages of ten judges.

	Cubes	Shreds
CD ($P \leq 0.05$) Method of preservation (M)	0.24	0.06
CD ($P \leq 0.05$) Storage duration (D)	NS	0.09
CD ($P \leq 0.05$) M × D	NS	NS

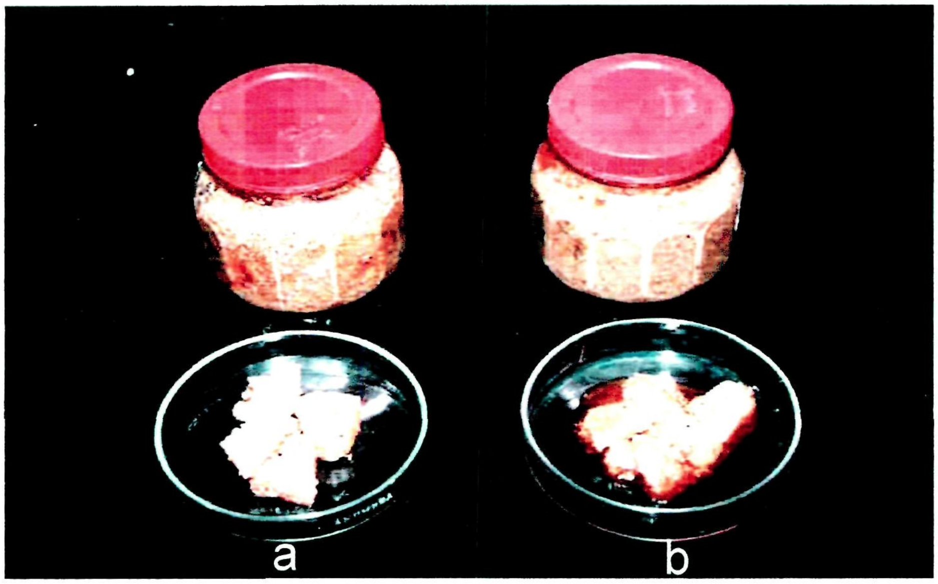


Plate 7. Physical appearance of pickle samples prepared from chayote pieces

a. Pickled with acetic acid
b. Pickled with galgal juice

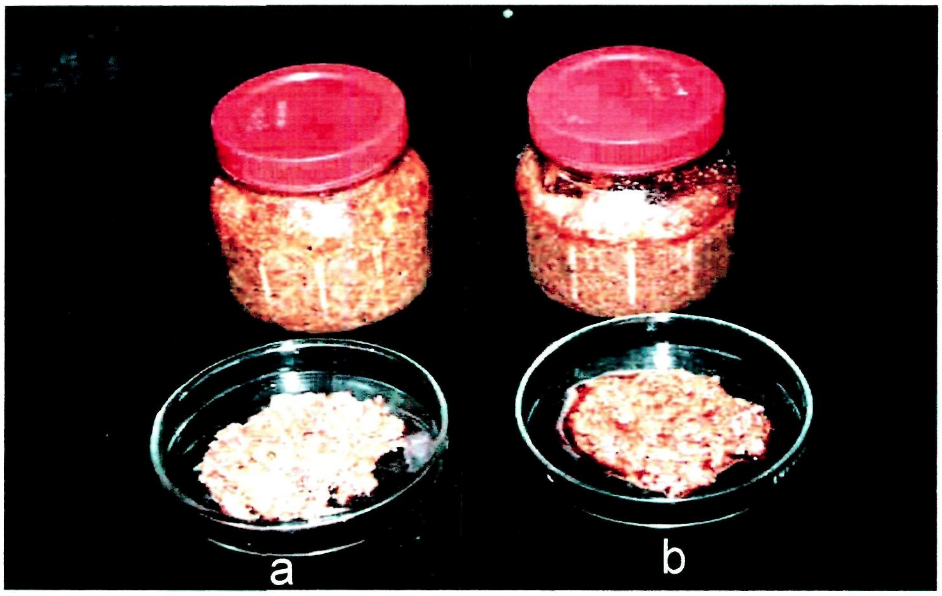


Plate 8. Physical appearance of pickle samples prepared from chayote shreds

a. Pickled with acetic acid
b. Pickled with galgal juice

The fresh pickle prepared from chayote shreds and preserved with acetic acid and galgal juice scored significantly higher (7.15 and 7.46 points) than the pickle prepared from chayote pieces and preserved with acetic acid and galgal juice (6.90 and 7.25 points) in terms of overall acceptability. The data established higher preference for shreds and pickling with galgal juice.

4.6.5. Chayote Candy

1. Total soluble solids and Titrable acidity

The data regarding total soluble solids and titrable acidity of candies prepared by slow and rapid cook method are presented in Table 4.32. The TSS of the chayote candies with respect to method of preparation varied significantly and higher values of TSS was found in product prepared by rapid cook method than the product prepared by slow cook method. The mean initial values of candies varied from 71.65 °B to 73.01 °B After 180 days of storage, TSS of fresh candies prepared by slow and rapid methods increased slightly.

The titrable acidity did not differed significantly with respect to the method of preparation. Whereas, storage duration had significant effect ($P \leq 0.05$) on the titrable acidity that decreased with increase in storage duration. The acidity values of samples prepared by slow cook method and rapid cook method varied from 1.60 to 1.65 initially and after

180 days of storage the values decreased and varied from 1.38 to 1.41 per cent respectively.

Table 4.32 Total soluble solids and titrable acidity contents of fresh and stored chayote candy prepared by slow and rapid cook methods

Total soluble solids (°B)

Blends Method of preparation	Storage (days) 0	60	120	180	Mean
Slow cook method	71.18	71.43	72.04	72.35	71.75
Rapid cook method	72.12	72.38	73.60	73.68	72.95
Mean	71.65	71.90	72.82	73.01	

*Data presented are averages of duplicate determinations

CD ($P \leq 0.05$) Method of preparation(M) = 0.25

CD ($P \leq 0.05$)Storage duration (D) = 0.35

CD ($P \leq 0.05$) M×D = NS

Titrable acidity (% C.A)

Slow cook method	1.65	1.59	1.51	1.41	1.54
Rapid cook method	1.60	1.54	1.44	1.38	1.49
Mean	1.63	1.57	1.48	1.40	

*Data presented are averages of duplicate determinations

CD ($P \leq 0.05$)Method of preparation (M) = NS

CD ($P \leq 0.05$)Storage duration (D) =0 .07

CD ($P \leq 0.05$) M × D = NS

2. Total, Reducing and Non-reducing sugars

The data pertaining to the total, reducing and non-reducing sugars of candies prepared by slow and rapid cook methods are depicted in Table 4.33. Total sugars and reducing sugars were affected significantly ($P \leq 0.05$) by the method of preparation, whereas, storage duration revealed non-significant effect. Total and reducing sugars were higher in candy sample processed by rapid cook method. In candy processed by slow cook method, the initial values for total, reducing and non-reducing sugars were recorded as 70.70, 36.56 and 32.49 per cent and after 180 days of storage the values were recorded as 72.40,38.35 and 32.35 per cent. Whereas in case of candy processed by rapid cook method the initial values for these sugars were recorded as 72.79, 37.74 and 35.67 and after 180 days of storage the values were recorded as 73.90, 39.15 and 33.01 per cent respectively.

3. Sensory Acceptability

The overall acceptability of scores of the fresh and stored candies prepared by different methods are presented in Table 4.34 and physical appearance of candy samples are shown in Plate-9. The overall acceptability of the candies prepared by slow and rapid cook methods were found to be significantly different ($P \leq 0.05$). Data indicated that the scores of candies improved up to 4 months of storage and then decrease slightly. The overall acceptability of candy prepared by slow cook method

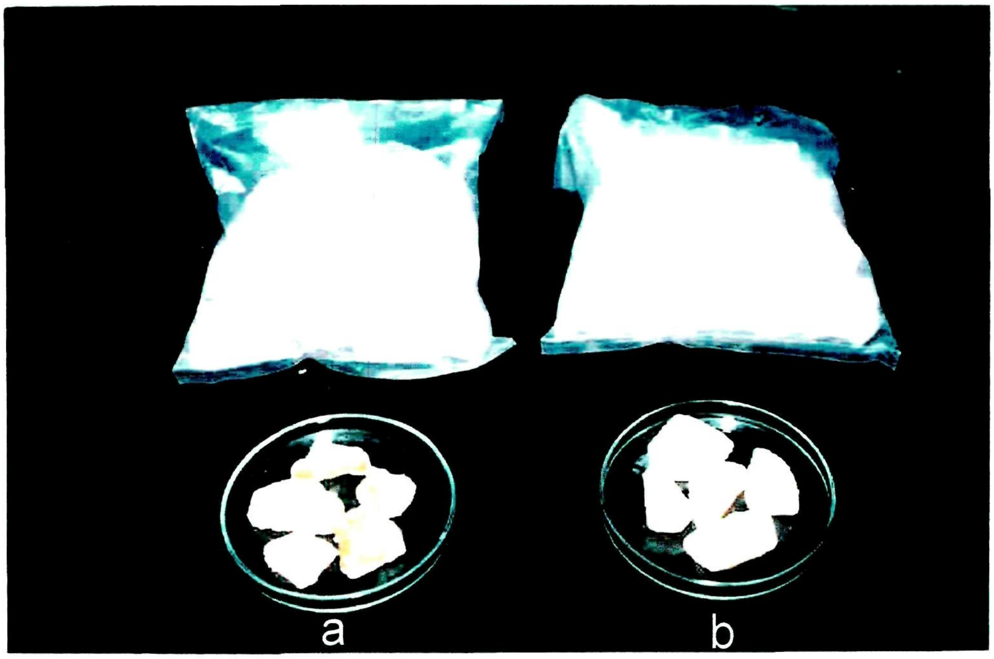


Plate 9. Physical appearance of candies prepared by slow and rapid cook method

a. Rapid cook method

b. Slow cook method

Table 4.33 Total, reducing and non-reducing sugars contents of fresh and stored chayote candy prepared by slow and rapid cook methods

Total sugars (%)

Blends Method of preparation	Storage (days) 0	60	120	180	Mean
Slow cook method	70.76	71.15	71.60	72.40	71.48
Rapid cook method	72.79	73.04	73.40	73.90	73.28
Mean	71.77	72.09	72.50	73.15	

*Data presented are averages of duplicate determinations

CD (P≤0.05)Method of preparation (M) = 1.0

CD (P≤0.05)Storage duration (D) = NS

CD (P≤0.05) M × D = NS

Reducing sugars (%)

Slow cook method	36.56	37.35	37.61	38.35	37.47
Rapid cook method	37.74	38.38	38.55	39.15	38.45
Mean	37.15	37.86	38.08	38.75	

*Data presented are averages of duplicate determinations

CD (P≤0.05)Method of preparation(M) = 0.79

CD (P≤0.05)Storage duration (D) = NS

CD (P≤0.05) M × D = NS

Non-reducing sugars (%)

Slow cook method	32.49	32.11	32.29	32.35	32.31
Rapid cook method	35.67	32.92	33.11	33.01	33.68
Mean	34.08	32.51	32.70	32.68	

*Data presented are averages of duplicate determinations

CD (P≤0.05)Method of preparation(M) = NS

CD (P≤0.05)Storage duration (D) = NS

CD (P≤0.05) M × D = NS

was relatively higher than the candy prepared by rapid cook method on a nine point hedonic scale. Slow cooking resulted in soft and smooth candy whereas rapid cooking resulted in hard and little shrunk candy. The overall acceptability scores for slow cook stored and fresh candy varied from 7.88 to 9.00 and that of rapid cook stored and fresh candy varied from 6.18 to 6.90 on a nine point hedonic scale.

Table 4.34 Sensory acceptability of fresh and stored chayote candy prepared by slow and rapid cook methods

Blends Method of preparation	Storage (days) 0	60	120	180	Mean
Slow cook method	9.00	8.45	8.16	7.88	8.37
Rapid cook method	6.90	6.65	6.48	6.18	6.55
Mean	7.95	7.55	7.32	7.03	

*Data presented are averages of ten judges
CD ($P \leq 0.05$)Method of preparation(M) = 0.45
CD ($P \leq 0.05$)Storage duration (D) = NS
CD ($P \leq 0.05$) M × D = NS

4.6.6 Cost of Products

The product costs as calculated from the cost of ingredients used in the preparation of one Kilogram of finished product including one third of this cost added as processing cost; and the market prices (including taxes and profits) of such products prepared from other fruits available in the market are shown in Table 4.35. The nuggets prepared

Table 4.35. Cost of raw materials and prepared products.

Products	Chayote : Blackgram :Soybean	Estimated cost Rs/kg	Market brands Rs/kg
1. Nuggets	0 : 0 : 100	35.00	75 - 80 (Nutri - Nuggets)
(*Warian*)	0 : 100 : 0	45.00	80 - 88 (warian)
	20 : 80 : 0	40.00	
	30 : 70 : 0	37.50	
	40 : 60 : 0	36.00	
	20 : 70 : 10	39.00	
	30 : 60 : 10	36.00	
	40 : 50 : 10	33.50	
	20 : 60 : 20	37.00	
	30 : 50 : 20	34.50	
	40 : 40 : 20	32.00	
	20 : 50 : 30	35.50	
	30 : 40 : 30	33.00	
	40 : 30 : 30	31.00	
2. (a) Dried chayote pieces		95.00	
(b) Dried chayote shreds		95.00	
3. Chutneys			60 - 70
	Chayote : Raw mango		
	100 : 0	32.00	
	75 : 25	35.00	
	50 : 50	36.50	
	25 : 75	38.50	
	0 : 100	40.00	
	Chayote : Plum		
	100 : 0	32.00	
	75 25	34.00	
	50 : 50	37.00	
	25 : 75	40.50	
	0 : 100	45.00	
4. Sauce			
	Chayote : Tomato		40 - 90
	100 : 0	42.00	
	75 : 25	48.00	
	50 : 50	52.00	
	25 : 75	54.00	
	0 : 100	56.00	
5. Pickle			35- 50
	Pickle of chayote cubes in galgal juice	25.00	
	Pickle of chayote cubes in acetic acid	28.00	
	Pickle of chayote shreds in galgal juice	26.00	
	Pickle of chayote shreds in acetic acid	28.00	
6. Candy			58
	Slow cook method	30	
	Rapid cook method	29	

*Cost have been estimated from the cost of ingredients and their preparation in the products.

from pure soybean are cheaper (Rs. 35/Kg) than the nuggets prepared from pure black gram (Rs. 45/Kg). The addition of Chayote to black gram in the preparation of nuggets reduced the cost of the nuggets to Rs.36 to 40/Kg depending upon its proportion. The cost was further reduced to Rs. 31 to 39/Kg by incorporating soybean in the chayote based black gram nuggets proportionate to its level. The cost upon dehydration of chayote pieces or shreds increased almost eight to nine times (Rs. 95/Kg) of dehydrated product over the fresh chayote (Rs. 7/Kg). Cost of pure chayote chutney was calculated as Rs. 32/Kg. However, cost increased significantly with the increase in the level of either mango (Rs. 35 to 40/ Kg) or plum (Rs. 34 to 45/kg) in chayote based chutneys. Similarly the cost of chayote sauce recorded as Rs. 42/Kg that increased to Rs 56/Kg as the level of tomato increased to 75 percent in chayote. The cost of pickles and candy prepared from chayote ranged from Rs.25 to 28/Kg. and Rs.29 to 30/Kg. The costs of some market brands of the similar products as shown in the table are quite high. Although the product costs in the market include taxes, packaging, handling, transportation and profit but still the products made at home will be cheaper than the commercial products.

DISCUSSION

Chapter-V

DISCUSSION

The results of present investigation entitled "Development and Evaluation of chayote (*Sechium edule*) based Food Products" presented in chapter IV (Results) are discussed under the following sub-sections:

5.1 Chayote

5.1.1 Physical Characteristics

Perusal of the data presented in Table 4.1 show that the average mean weight of chayote (*Sechium edule*) collected from local resources, Palampur, India is 229 g/fruit with mean size parameters of 9.24 cm length and 8.10 width, respectively. Thereby meaning that the average fruit size is large. Most of the fruits are light green to green in colour and ovoid in shape. The pulp and wastage recoveries during processing are 81.51 and 3.18 per cent. The data with almost simlar observations on these parameters are also reported earlier by Engles (1983) and Madhu (1997).

5.1.2 Proximate Composition

The proximate composition of whole fruit and its anatomical parts recovered during extraction of pulp as byproducts/wastage as reported in Table 4.2 varies widely among whole fruit, edible portion and its peel. Whole fruit, edible portion and peel contain 92.78, 93.70 and 88.50 per cent moisture and 7.22, 6.29 and 11.49 per cent dry matter. The values for protein, fat and ash in these parts are ranging from 0.47 to 0.78, 0.10 to 0.21 and 0.39 to 0.89 per cent, on fresh weight basis and 4.15 to 12.52, 0.87 to 3.38 and 6.20 to 7.75 per cent on dry weight basis, respectively. The total carbohydrates present in whole fruit, edible portion and peel varied from 4.91 to 10.03 and 77.47 to 87.25 per cent, respectively. Thus broadly these values are in conformity with those reported by Nath (1971), Flick *et al.*, (1978), Madhu (1997) and Gopalan *et al.* (1995). Slight variation between the values of proximate constitutes observed in the present investigation and those reported earlier by some authors as above may be attributed to the variations in the agro-climatic conditions under which fruits are grown.

5.1.3 Fibre carbohydrates, Non-fibre carbohydrates and energy contents

The results of the evaluation of NDF (Neutral detergent fiber) and ADF (Acid detergent fibre), digestible carbohydrates, total energy, available energy and indigestible carbohydrates contents of whole, edible portion and peel of fruit chayote presented in Table 4.3 varied widely. Data reveal that chayote peel is rich sources of ADF and NDF (18.15 and 34.65%) followed by whole chayote (15.61 and 24.21%) and edible portion of fruit chayote (11.98 and 18.06%). The total and available energy are maximum in edible portion (390.24 and 318.08 Kcal/100g) followed by whole chayote (383.1 and 286.28 Kcal/100g) and chayote peel (373.35 and 234.75 Kcal/100g). The digestible carbohydrates are highest in edible portion (59.40%) followed by whole chayote (55.24%) and chayote peel (52.60%). Date with some variations on the above mentioned constituents of fruit chayote have been reported by Gopalan *et al.* (1995) for carbohydrates and energy, Sudha *et al.* (1999) for carbohydrates and Madhu (1997) for ADF and NDF contents. Data reveals that the fruit parts are rich in dietary fiber constituents and low in available energy to different extents. The food exploitation of this fruit and its anatomical parts may be beneficial to the persons suffering from fiber deficiency related diseases of the modern World (cardiovascular disease, hypertension, diabetes, colon cancer, obesity etc.) and can be used as a low calorie ingredient in formulating low calorie diets (Dreher,1987).

5.1.4 Mineral Contents

Mineral composition of whole chayote, edible portion and peel component were studied and presented in Table 4.4. Calcium and potassium contents are observed to be highest in peel (200 and 550 mg/100g) followed by whole chayote (190 and 530 mg/100g) and edible portion (179 and 520 mg/100g). Phosphorus content is highest in peel (299 mg/100g) and in other parts varies from 258 to 278.5 mg/100g. Copper, zinc and iron contents are vary form 0.60 to 1.70, 0.64 to 1.0 and 0.61 to 1.03 mg/100g, respectively. The fruit and its anatomical parts seem to be valuable sources of different minerals important in human nutrition as also reported earlier by Nath (1971), Flick *et al.* (1978), Engels (1983) Sudha *et al.* (1999) and Madhu (1997), can benefit the consuming population with mineral nutrition as the importance of these mineral is very well documented (Swaminathan, 1991; Srilakshmi, 2002).

5.2 Soybean and Black gram

5.2.1 Physical Characteristics

Perusal of data presented in Table 4.5 show that upon milling soybean has yielded 90.81 per cent full fat cotyledon and black gram yielded 88.50 per cent cotyledons. Thosand kernel weight of soybean and soy cotyledons are higher (164.56 and 71.12 g) than black gram and its cotyledons (46.80 and 15.08g). Variation in the various physical parameters have been reported earlier by Bal and Mishra (1986); Lim *et al.* (1990); Saxena *et al.* (1994); Krishna *et al.* (2003) and Jyoti (2002) for soybean.

5.2.2 Proximate Composition

The results pertaining to the proximate composition of soybean and black gram legumes on fresh and dry weight basis are presented in Table 4.6. The crude protein contents of soybean *dhal* and soybean are maximum (43.91 and 42.53%) and followed by black gram *dhal* and black gram (25.17 and 24.65%) on dry weight basis. Crude fat contents are observed to be higher in soybean *dhal* and soybean (22.58 and 20.80%)

than black gram dhal and black gram (2.16 and 1.98%) on dry weight basis. Whereas, the total carbohydrates are higher in black gram *dhal* and black gram (69.35 and 68.97%) than soybean and soybean dhal (32.71 and 29.15%) on dry weight basis. A varietal variation in the various proximate constituents of soybean and black gram were also reported by Geetika (1997); Jyoti (2002); Deshpande and Demodaran (1990) and Patki and Arya (1994). The nutritional importance of various proximate constituents found in legumes is very well described by several authors (Deshpande and Damodaran, 1990, Deshpande,1992).

5.2.3 Fibre carbohydrates, Non-fibre carbohydrates and Energy contents

The data presented in Table 4.7 show differences in various fiber, non-fiber carbohydrates and energy contents of soybean, soybean dhal, black gram and black gram *dhal*. Data reveals that soybean is very rich in ADF and NDF contents followed by soybean *dhal*, whole black gram and black gram *dhal*. The soy cotyledons are rich in in available energy (397.92 Kcal/100g) when compared with black gram cotyledons (333.42 Kcal/100g). The results of the findings are supported by the work of Geetika (1997), Kamath and Belavady (1980), Ikechukwu (2002) and Poonam (2002). Because of high content of ADF and NDF in soybean dietary use of soybean as an important source of dietary fibre has been advocated by various dieticians and nutritionists (Dreher, 1987; Rashid, 2002).

5.2.4 Mineral Constituents

The results pertaining to the Mineral contents of soybean and black gram legumes (Table 4.8) depict that soybean and soybean *dhal* contain variable amounts of macro and micro nutrients namely calcium, magnesium, potassium, iron, zinc and copper in higher amounts as compared to black gram and black gram *dhal*. (Gupta *et al.* 1976; Geetika, 1997; Aparna, 2000; Ikechukwu *et al.* 2000). Increased consumption of soybean can be beneficial in supplementing the mineral nutrition of the consuming population.

5.3 Plum, Galgal, Tomato and Raw mango

5.3.1 Proximate Composition

Data presented in the Table 4.9 reveal that the moisture content of four different fruits used in the present study vary from 81.53 to 92.51 per cent and dry matter from 7.50 to 18.47 per cent. Whereas on dry weight basis crude protein, ash content among four fruits vary from 3.66 to 10.41, 0.68 to 3.54 and 2.50 to 5.81 per cent, respectively. The total carbohydrates contents are highest in raw mango (93.07%) and in other fruits vary form 80.91 to 89.70 per cent on dry weight basis. The values of the proximate constituents obtained in this study are almost in agreement with those reported by Bhasin and Bhatia (1981) ; Mehta and Tomar (1982) ; Hoang *et al.* (1989) ; Pandey *et al.* (1995) and Gupta

(1998) for raw mango, by Shipra (2005) for plum, by Balasubramanin (1983) and Gopalan *et al.* (1995) for tomato and Gopalan *et al.* (1995) for citrus fruits. Slight variations are attributable to the varietal and agroclimatic differences.

5.3.2 Chemical constituents

Data presented in the table 4.10 depict that the acidity and ascorbic acid content are maximum in galgal juice (4.61% and 50.12mg/ 100g) followed by raw mango (3.76% and 31.26 mg/100g), tomato (2.80% and 26.81 mg/100g), plum (2.14% and 10.23 mg/100g) and chayote (1.5% and 4.01 mg/100g). Total sugar contents are maximum in plum (8.55%) followed by other fruits. pH value is highest for chayote (4.80) and among other fruits varies from 2.51 to 3.66. The present results are supported by the data reported by Nath (1971), Gopalan *et al.* (1995) and Madhu (1997) for chayote, Bhasin and Bhatia (1981); Mehta and Tomar (1982); Hoang *et al.* (1989); Pandey *et al.* (1995); Das Mohapatra and Sharma (1997) and Gupta (1998) for raw mango, by Shipra (2005) for plum, by Balasubramanin (1983) Gopalan *et al.* (1995) for tomato; and by Attari and Maini (1996) and Ranjana (1996) for citrus fruits. Some Variations in some of the constituents of individual fruits than those reported in the literature are attributable to the genetic and agroclimatic differences.

5.4 Chayote Based Nuggets *(Warian)*

5.4.1 Rehydration Characteristics

Data presented in Table 4.11 and Table 4.12 with respect to rehydration characteristics of nuggets containing variable proportions of chayote shreds and legumes namely black gram and soybean depict that the water absorption shows increasing trend with the increase in soaking period and temperature and came to equilibrium in shorter time at higher temperature. This is due to the fact that at higher temperature the rate of absorption and swelling due to geletinization increased at a faster rate. The water absorption at ambient temperature and at 70°C upon full saturation are higher (3.10 and 3.78 ml/g) for pure soybean nuggets and the values among other nuggets vary from 2.58 to 2.89 ml/g at ambient and from 3.05 to 3.48 ml/g at 70°C upon full saturation. Rehydration characteristics of nuggets prepared from admixtures of colocasia mash and wet ground legume were also reported by Poonam (2000). The rehydration behavior of the products is an important parameter in determining the eating and cooking quality of foods as well as physiological benefits offered by such products. The food materials absorbing more water generally have soft texture and good eating quality and are physiologically more digestible and more beneficial to the digestive system in promoting satiety and diluting the calorific values of foods (Dreher, 1987).

5.4.2 Proximate Composition

From the results presented in Table 4.13, it is observed that the protein content of nuggets prepared from pure soybean *dhal* is 39.95 per cent, whereas the crude protein contents of the nuggets prepared from pure black gram dhal is 21.53 per cent. Replacement of black gram *dhal* with chayote in the nugget mix has diluted the protein contents and replacement with soybean has enhanced the protein contents of the resultant nuggets proportionate to the level of replacement. Similar trend is also observed in crude fat content of various nuggets. This is attributable to the higher inherent contents of crude protein and fat in soybean and negligible amounts of these nutrients in fruit chayote. An opposite trend in the total carbohydrate contents with the replacement of black gram *dhal* with soybean is also observed because of much lower contents of total carbohydrates in soybean as compared to black gram. The information on the chayote based nuggets and their proximate composition is not available in literature, however, Patil and Ali (1989) developed a cost effective technology for making soybean '*badi*' at rural/ cottage level. The crude protein, crude fat and ash contents of these '*badi*' are reported to be 43.12, 19.5 and 3.36 per cent, respectively. Kulkarni *et al.* (1997) also reported the physico-chemical composition of black gram '*badi*'. Sharma *et al.* (1996) developed instant vegetable '*warian*' (nuggets) using bengal gram, black gram, carrots, bottle guard, potatoes and various spices in the nuggets mix. The protein contents of these '*warian*' ranged from 10.73 to 14.94, fat from 6.65 to 23.25 and ash from 4.72 to 5.85 per cent. Whereas the protein, crude fat, and total carbohydrate contents of '*warian*' prepared from black gram and its admixture with chayote and soybean varies from 16.08 to 23.56, 0.97 to 7.00 and 58.42 to 71.21 per cent respectively. These results explain the value addition to chayote with legumes in the form of nutritive enhancement of the chayote-based products.

5.4.3 Fibre carbohydrates, Non-fibre carbohydrates and Energy contents

The results pertaining to the fibre, carbohydrates and energy contents presented in Table 4.14 depict that NDF, ADF, hemicellulose, total and available energy are higher in plain soybean nuggets due to the higher contents of these nutrients in soybean and lower in black gram. With the increase in percentage of chayote (20 to 40%) in black gram nuggets, the NDF and ADF values have increased, total and available energy have not changed much. Whereas, replacement of black gram with soybean (10 to30%) in black gram has also increased ADF, NDF, total and available energy contents. Poonam (2000) and Poonam and Sharma (2003) also reported the preparation of colocasia based black gram nuggets supplemented with soybean. The soy-based nuggets are reported to contain higher contents of NDF, ADF, hemicellulose, total and available energy as compared to nuggets prepared from black gram.

5.4.4 Sensory Acceptability

The Sensory acceptability scores of nugget curries prepared from different nugget formulations presented in Table 4.15 reveal that black gram nuggets containing either no or up to 30 per cent chayote shreds do not differ much with respect to overall acceptability as per judgment indicated by the taste panel on a nine point hedonic scale. Nuggets prepared with pure soybean as well as the nuggets containing 40 percent chayote are less acceptable due to poor organoleptic attributes and higher tendency to disintegrate during cooking. The use of soybean (10 to 20%) and chayote (20 to 30%) with black gram is also technologically feasible, as these combinations have not affected the overall acceptability as well as intactness of the nuggets during cooking. The nuggets prepared by replacing black gram with soybean in chayote-based nuggets (10 to 30%) are more advantageous as these contain high contents of protein and other nutritionally relevant constituents, and are fairly acceptable. Additionally, promoting use of soybean and its byproducts in such formulations can lower the cost of production of such products. (Geetika, 1997, Poonam, 2000; Poonam and Sharma, 2003;).

5.5 Dehydrated Chayote (*Sechium edule*)

5.5.1 Chayote Pieces

The effect of drying temperature and duration of drying on the water loss and weight of pieces presented in Table 4.16 reveal that the pieces dried at 55°C require 16 hours, pieces dried at 65°C require 12 hours and pieces dried at 75°C required 10 hours for complete drying. Drying at higher temperature (75°C) results in darkening of colour due to non-enzymatic browning. The pieces dehydrated at 65°C are superior in colour as well as the drying was also achieved satisfactory. Drying at low temperature (55°C) is also satisfactory but may be costly due to high-energy costs for running the drier for longer duration to achieve through drying.

5.5.2 Chayote Shreds

The effect of drying temperature and duration of drying on the water loss and weight of shreds presented in Table 4.17 reveal that the drying of chayote shreds is accomplished faster than the chayote pieces at the higher temperatures as compared to lower drying temperatures as it is likely to take 14 hours at 55°C, 10 hours at 65°C and 8 hours at 75°C, for attaining equilibrium moisture contents and constant weights after drying. As with pieces, at 75°C, the colour of shreds turns little brown. But the samples dehydrated at 55°C and 65°C remains lighter in colour. At higher temperature browning is attributable to the onset of maillard reactions. A satisfactory drying can be achieved at 65°C without having any detrimental effect on the quality of the product as is observed from the visual appearance of the product.

5.5.3 Yield of Pieces and Shreds

The data pertaining to the yield of chayote pieces and shreds in Table 4.18. depict that at 55°C the chayote pieces are likely to take 16 hours for attaining 11 per cent equilibrium yield, whereas, at 65 and 75°C, the samples require 12 and 10 hours for attaining 8.8 and 8.5 per cent yield, respectively. However, chayote shreds at 55, 65 and 75°C require 14, 10 and 8 hours for attaining 9.05, 8.25 and 8.10 per cent equilibrium yields of dried shreds respectively.

5.5.4 Rehydration Characteristics

Rehydration characteristics of dehydrated chayote pieces and shreds as depicted in Table 4.19 reveal that chayote shreds absorb water at a faster rate than chayote pieces upto full saturation and that decreased with the increase in temperature of dehydration. The higher water absorption behaviour at slow rate exhibited by the pieces may be attributed to the intactness of tissue cells in pieces and higher diffusion distance that in case of shreds has follow an opposite trend due to more disruption of tissues and lower distance of diffusion. Jayaraman *et al.* (1991) also reported variable rehydration characteristics (water absorption) of air dried, solar cabinet dried and direct sun dried vegetables as 3.3, 2.6 and 2.9 ml/g, respectively.

5.5.5 Sensory Acceptability

Overall acceptability scores of vegetables prepared from fresh, and reconstituted dehydrated chayote pieces and shreds dried at different temperatures (55, 65 and 75°C) as depicted in (Table 4.20). reveal that vegetable prepared from fresh chayote pieces is preferred more than the vegetable prepared from fresh chayote shreds. The overall acceptability however, decreased significantly upon drying. The vegetables prepared from dehydrated pieces or shreds dried at 55°C and 65°C are equally acceptable but the pieces are more acceptable than the shreds because at these temperatures the drying is satisfactory and did not alter the quality of the dehydrated products. Overall acceptability ratings of chayote pieces and shreds dried at 75°C has been rated as lowest because at this temperature the product become little brown in colour, with little hard textured due to poor reconstitution.

5.6 Chutney

5.6.1 Chayote and Mango based Chutney

1. Ascorbic acid, Titrable acidity and Total soluble solids

Data presented in Table 4.21 depict the Ascorbic acid, titrable acidity and TSS contents of chayote and mango based chutney samples. Data reveal that chayote chutney is poor in ascorbic acid compared to the chutneys containing variable proportions of raw mango pulp which have higher contents of ascorbic acid. This is due to the lower content of ascorbic acid in chayote pulp and higher contents in mango pulp. Loss of ascorbic acid during storage is attributable to its slow oxidation may be due to the presence of some dissolved oxygen and oxidizing substances in chutney which interacted with ascorbic acid and oxidized it to dehydro-ascorbic acid (Mihelic and Vazic, 1969; Chauhan *et al.,* 2001). Titrable acidity of the sample was also altered due to blending. Acidity decline slightly during storage which is due to the neutralization of acid during storage as acid probably intracted with natural chemical constituents of the chutneys. TSS also changed slightly during storage due to internal intertactions taking place between different constituents of chutney during storage (Chauhan *et al.,* 2001 and Gupta, 2000).

2. Total, Reducing and Non-reducing sugars

Table 4.22 depicts the changes in various sugar components due to blending as well as due to storage of 180 days. Non-reducing and total sugars decrease while reducing sugars increase during storage due to partial hydrolysis of total sugars catalyzed by the acid naturally present in the chutneys. Such like phenomena have been reported to occurs in food products containing natural and added sugars and acid (Chauhan *et al.*, 2001; Gupta, 2000).

3. Sensory Acceptability

Overall acceptability scores of the chutneys prepared from chayote and its blends with raw mango suggest that all the chutney samples range from liked slightly to liked very much in terms of overall acceptability (Table 4.23). The acceptability scores are not altered much during storage. Chutneys are highly spiced containing substantial quantities of sugar and acids, spices and salt. Presence of such ingredients in general, mask the off taste and flavour and enhance the sensory acceptability of the products formulated from the fruit which are not generally good to taste. Blending of such fruits with the other fruits, which are generally preferred for chutney making, can further enhance the sensory acceptability of fruits possessing poor sensory quality attributes. Technology of preparation of value added chutneys of acceptable quality from different fruits has been described by Gupta (2000).

5.6.2 Chayote and Plum Based Chutney

1. Ascorbic acid, Titrable acidity and Total soluble solids

Appraisal of data presented in Table 4.24 indicate that ascorbic acid increases significantly due to blending of chayote with plum and decreases with increase in storage duration of chutney. This is attributable to the enrichment of chayote pulp with ascorbic acid with the addition of plum pulp as the chayote pulp is poor in ascorbic acid. Losses during storage are attributable to the oxidation of ascorbic acid and its interactions with other organic constituents of the chutney formulations (Mihelic and Vajic, 1969; Chauhan *et al.*, 2001). Phenomena leading to slightly decreases in titrable acidity and TSS of chutney formulations are due to blending, storage and interactions between blending and storage are also evident from the data.

2. Total, Reducing and Non-reducing Sugars

Data presented in Table 4.25 reveal that the total sugars in the chutneys are lower than TSS values of the chutneys almost by 4 to 5 per cent. The effect of blending on total sugars and interaction between blending and storage reveals significant effects. While, total sugars and non-reducing sugars have decreased slightly, the reducing sugars have increased with the increase in storage duration up to 180 days. The hydrolysis of non-reducing sugars to reducing sugars by the acid present in chutneys is the reason for increased content of reducing sugars during storage.

3. Sensory Acceptability

Sensory data presented in table 4.26 reveal that pure chayote chutney had lower acceptability, which can be improved by blending with plum pulp. Incorporation of plum in chayote pulp in chutney formulations helped in imparting better flavour, colour and texture to chutneys. Slight reductions in the overall acceptability scores of chutney formations are also observed during storage of 180 days. For promotion of chayote in the preparation of a variety of value added chutneys, blending has a tremendous potential in launching highly acceptable chutney formations in the market. Blending of chayote up to 50 per cent with plum was quite reasonable combination as above this level the plum flavour dominated and also the proportion of chayote decreased in the chutney.

5.6.3 Sauce

1. Ascorbic acid, Titrable acidity and Total soluble solids

Data presented in Table 4.27 depict the ascorbic acid, titrable acidity and TSS of the chayote based sauce samples. Sauce prepared from tomato has little higher ascorbic acid as compared to the sauce containing variable proportions of chayote pulp. This is due to higher content of ascorbic acid of tomato pulp. Loss of ascorbic acid during storage is due to its oxidation or degradation (Joshi *et al.* 1996). Titrable acidity of the samples was also altered due to blending. A slight decrease in titrable acidity of samples is also observed during 180 days of storage. The acidity decline during storage, which is due to the neutralization of acid during storage (Chauhan *et al.*, 2001; Gupta, 2000). TSS also changed slightly during storage due to internal chemical interactions.

2. Reducing, Non-reducing and Total sugars

Changes in various sugar components due to blending as well as due to storage are also depicted in Table 4.28. During storage of 180 days, total and non-reducing sugars decreased while, reducing sugars increased. The increase in reducing sugars and decreased in non-reducing sugars is the result of hydrolysis of non-reducing sugars into reducing sugars (Joshi *et al.*, 1996 and Ragab, 1987). No drastic changes could be observed the values of total sugars during storage.

3. Sensory Acceptability

Overall acceptability scores of the sauces prepared from chayote pulp and its blends with tomato pulp in (Table 4.29) reveal that the pure chayote sauce is rated as neither liked or disliked on a nine point hedonic scale. However, the overall acceptability scores of the sauces show an increasing trend due to blending with tomato pulp and decreasing trend during storage also. The acceptability ratings of apple sauce was also reported to decrease slightly during storage of 6 months. (Joshi *et al.*, 1996).

5.6.4 Pickle

1. Ascorbic acid and Titrable acidity

Perusal of data presented in Table 4.30 on the changes taking place in ascorbic acid and acidity values of pickle prepared from chayote shreds and pieces, soured with two different acid ingredients (acetic acid and galgal juice) reveal that the fresh pickles contain variable contents of ascorbic acid. However, some loses in ascorbic acid are seem to have occured during storage in all the pickles. The ascorbic acid contents are higher in pickles soured with galgal juice as compared to pickles soured with acetic acid due to higher contents of ascorbic acid naturally present in citrus fruits. The acidity shows a slightly decreasing trend during storage intervals due to neutralization of some acidity during storage.

2. Sensory Acceptability

The overall acceptability scores of pickle sourced with galgal juice and acetic acid presented in Table 4.31 show that pickle prepared from shreds and soured with galgal juice has got higher acceptablility compared to the pickle prepared from chayote cubes. Salt and acid are not only helpful in preserving the pickles against spoilage during storage but they also play a vital role in preserving the ascorbic acid loses and enhancing the taste and flavours of the pickled products. The use of galgal juice as a source of acid preservative and as a flavour ingredient in pickles is more advantageous as this is a natural juice extracted from galgal fruit and is rich in various nutritional components inherent to the fruit. The galgal is grown in Himachal Pradesh has remained an under utilized fruit. Its utilization as a pickling ingredient as a substitute for vinegar needs to be encouraged so that the utilization of this underutilized fruit is promoted in the interest of the farmers for better remunerative prices for this fruit.

5.6.5 Chayote Candy

1. Total soluble solids and Titrable acidity

The data presented in the Table 4.32 depict the TSS and titrable acidity of candy prepared by slow and fast cook methods. Data reveals significant differences in TSS of the chayote candies with respect to method of preparation. Higher values of TSS are found in candy prepared by fast cook method. During storage of 6 months, the TSS of candies have increased this may be due to decrease in moisture content due to surface evaporation and drying of candy samples (Sharma *et al.*, 1998). Data also reveal that storage duration has decreasing effect on the acidity values of candies. Similar observations regarding acidity are also reported earlier by Sharma *et al.* (1998) and Sethi and Anand (1982).

2.Total, Reducing and Non-reducing sugars

The data depicted in the Table 4.33 show the total, reducing and non-reducing sugars of the candies prepared by slow and fast cook methods varied significantly with respect to method of preparation. The values of total and reducing sugar indicate an increasing trend whereas the values for non-reducing sugars show a decreasing trend during storage. Increase in reducing sugars might be due to conversion of sucrose to reducing sugars. However, increase in total sugars might be due to decrease in moisture content during storage. Results of storage of candies were in accordance with the results reported by Kumar (1989); Sethi and Anand (1982); Sharma *et al.* (1998) and Siddique *et al.* (1990).

3. Sensory Acceptability

The overall acceptability of the scores of the fresh and stored candies prepared by fast and slow cook methods presented in Table 4.34. Indicate that the scores of the candies improved up to 4 months of storage and then decreased slightly. The candy prepared by slow cook method has been liked more due to its juicy and soft texture than the candy prepared by rapid cook method on a nine point hedonic scale. Candies prepared from both treatments become slightly hard during storage but more hardening occured in candy prepared by rapid cook method probably due to shrinkage and crystallization of sugar on the surface.

5.6.6 Cost of Products

The product costs which have been calculated from the cost of ingredients used in the preparation of one kilogram of finished products are depicted in table 4.35. The preparation cost of various food products varies with the cost of ingredients used in the preparation of these products. The preparation cost of chayote-based nuggets prepared with soybean is less than those prepared with black gram *dhal*. The cost of preparation of dehydrated chayote is likely to increase from Rs 7/Kg before dehydration to Rs 95/Kg after dehydration. Similarly the cost of chutneys is likely to increase with addition of raw mango and plum in chutney formulations. Similar trend is also observed in case of sauce. No doubt that blending of chayote with other fruits will result in enhanced costs but not at the cost of quality, which is important in marketing of the products in the form of increased sale. The pickle prepared with galgal juice is likely to be cheaper than the pickle prepared with acetic acid. The calculated cost prices are much less than the market prices of various brands of similar product available in the market.

In addition it can be said that commercially, valuable products can be prepared from chayote at a much lower cost as compared to the market prices of such like products available in hte market. Although, in marketing the manufacturer has to include the cost of processing, packaging, handling, transportation, taxes and profit even than the products are likely to be cheaper than the market prices.

SUMMARY

Chapter-VI

SUMMARY

This project entitled "Development and Evaluation of Chayote (*Sechium edule*) Based Food Products" was undertaken as a thesis research project by the author to explore the post harvest potential of fruit chayote in the form of various value added products The author has made attempt to develop value added products and blended food products based on chayote, legumes (black gram and soybean), plum, raw mango, tomato and galgal and has evaluated the fruit chayote and its anatomical parts, legumes (black gram and soybean) and other fruits used with chaoyte for various physico- chemical characteristics and sensory acceptability of the products developed as a part of this project. The results of the experimental work conducted under this investigation are summarized as under:

1. The evaluation of the physical characteristics of fruit chayote revealed that fruit is large in size with a mean weight of 229g/fruit with mean length and width of 9.24 and 8.10 cm respectively. The fruit is ovoid in shape and the colour is light green to green as observed from visual appearance. On an average the fruit is comprised of 81.51 per cent edible portion, 15.56 per cent peel and 3.18 per cent wastage.

. Proximate analysis of fruit chayote and its anatomical parts (edible portion and peel) revealed significant differences in various proximate constituents present in various anatomical parts. The fruit and its anatomical parts are low in protein, fat, ash and carbohydrates on as is basis but these nutrients are higher on dry matter basis. Major portion of dry matter constitutes carbohydrates including digestible and indigestible carbohydrates. Chayote peel is richer in ADF, and NDF as compared to whole fruit and its edible portion respectively. Edible portion contains higher content of digestible carbohydrates and available energy as compared to whole fruit and peel respectively. The presence of higher content of fibrous carbohydrates in fruit chayote and its anatomical parts suggests that fruit is a rich source of dietary fiber and may be useful in formulating high fibre and low calorie value added products. Dietary consumption of such products is beneficial in cure and prevention of fiber deficiency related diseases such as hyper-cholesterolemia, hypertension, diabetes, colon cancer and many others. The uses of peel in this context also need to be exploited in future studies.

. Fruits and its anatomical parts are also rich in various macro and micro minerals of nutritional significance. Use of chayote and chayote- based food products may be beneficial in supplementing the mineral nutrition of the consuming population.

4. The analysis of two legumes (black gram and soybean) used in formulating chayote based nuggets (*Warian*) revealed that soybean is richer source of protein, fat, ADF and NDF as compared to black gram legume. The black gram is exclusively used in preparation of traditional nuggets in the villages of Himachal Pradesh. However because of its high cost, its partial replacement with soybean in the nugget formulations can enhance the protein, fat, ADF and NDF values at a lower cost and reduce the cost of preparation of traditional nuggets with increased nutritional benefits.
5. Chemical analysis of fruits used in present study also revealed significant differences in various proximate constituents i.e. ascorbic acid, acidity, pH, reducing, non-reducing and total sugars. These constituents are important from nutritional and from the product quality view points.
6. Physical evaluation of the nuggets prepared from blends of chayote shreds, black gram and soybean revealed that pure soybean nuggets absorbed more water at high temperature (70°C) at higher rate as compared to low temperature (25°C). The nuggets prepared from black gram *dhal* remained intact at both temperatures and had little lower water absorption as compared to soybean nuggets upon full saturation. Addition of chayote to black gram *dhal* in the formulation of nugget mix up to 20 per cent was feasible in terms of intactness

of nuggets in hot and cold water. Such formulations are likely to retain their intactness and also absorbing significant amount of water during cooking, which is reflected in the texture of the curried nugget. Replacement of black gram with soybean up to 20 per cent in chayote-based black gram nuggets is technologically feasible in terms of rehydration, swelling and retention of intactness during rehydration and cooking.

Chemical evaluation of nuggets prepared from chayote and its blends with black gram and soybean, revealed significant differences in protein, fat, ash, carbohydrates, available and total energy. Additions of soybean to black gram *dhal* enhanced the protein, fat, dietary fiber (ADF and NDF), total and available energy contents of nuggets formulations.

Sensory evaluation of nuggets revealed that nuggets prepared from pure soybean were least acceptable by the panelists. Black gram nuggets containing up to 20 per cent chayote were highly acceptable and replacement of black gram with soybean up to 20 per cent in this formulation did not alter the acceptability ratings of nuggets to a significant extent as adjudged from the results of organoleptic evaluation. It was concluded that black gram nuggets containing up to 20 per cent chayote and 20 per cent soybean are acceptable in terms of their cooking and eating quality.

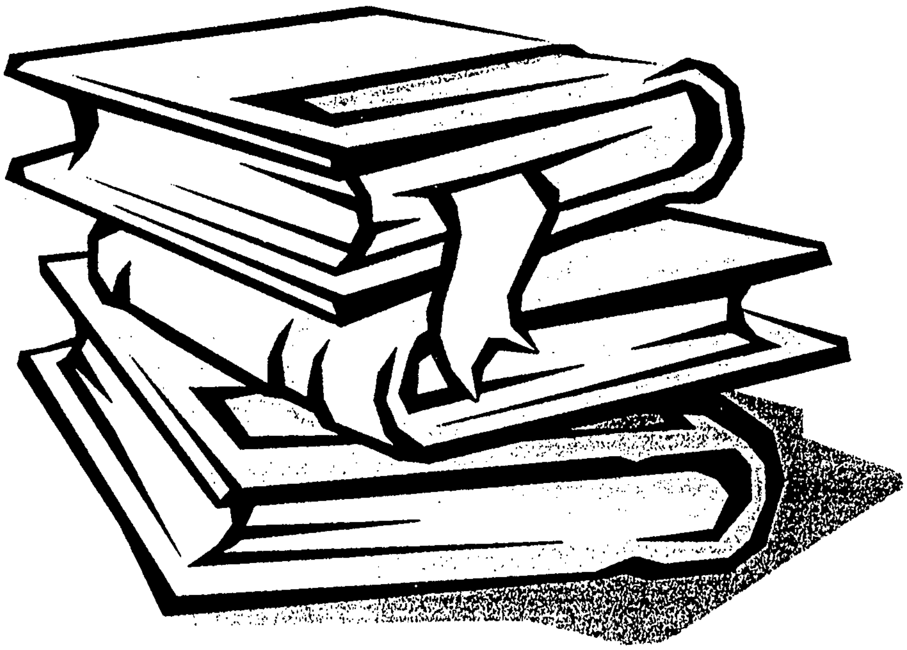
9. Evaluation of dehydration process of chayote pieces and shreds attempted at three different temperatures in a mechanical drier revealed that drying to equilibrium weights at higher temperature (75°C) is accomplished faster as compared to drying at lower temperatures (55 and 65°C). The drying of shreds was, however, accomplished faster than the drying of pieces.
10. The results of rehydration characteristics of chayote pieces and shreds dried at 55, 65 and 75°C revealed significant differences in the water absorption behaviour. Pieces absorbed more water at a slower rate and shreds absorbed lower amount of water at a higher rate till full saturation. Pieces and shreds dried at higher temperature absorbed less water as compared to pieces and shreds dried at low temperatures. Good quality dehydrated products were obtained at 55 and 65°C. However, at 55°C the drying was prolonged where as at 75°C the product quality was poor as adjudged from visual appearance and rehydration characteristics.
11. Results of the sensory analysis of reconstituted dehydrated pieces and shreds after cooking in to vegetable revealed that the overall sensory acceptability of pieces is higher than the shreds but lower than their fresh counterparts. The dehydrated product obtained by drying at 55 and 65°C were almost equally acceptable, however, a significant reduction occurred in the cooking quality of the products dried at 75°C.

12. Chutney prepared from chayote and from its blends with raw mango and plum revealed significant difference in various chemical quality attributes. The ascorbic acid content of chutney increased slightly with addition of either ráw mango or plum to chutney formulations proportionate to the level of either mango or plum. Total sugars did *not change much, however, some changes in the reducing and non-*reducing sugars were observed during storage. Similar observations were observed in case of sauces also.
13. The addition of either raw mango or plum to chayote based chutney formulation or tomato to chayote based sauce (25 to 75%) enhanced the overall acceptability of chayote chutney and sauce. Replacement of chayote with either raw mango or plum in chutney or tomato in sauce up to 50 per cent was found to be feasible as the level of replacement above this level resulted in dominance of flavor of blended fruit in chayote based products. The dilution or blending of chayote up to 50 per cent with other fruits can be technological justified from post harvest utilization of chayote in the preparation of value added products.
14. Pickle prepared from chayote shreds and pieces did not differ much in terms of various chemical quality attributes, however, slight changes occurred in these constituents i.e. titrable acidity and ascorbic acid during storage. Pickle prepared from chayote shreds

was found to be highly acceptable as compared to the pickle prepared from pieces. However, souring of these pickles with galgal juice resulted in higher sensory acceptability as compared to souring with acetic acid.

15. Candy prepared by rapid cook method contained higher content of TSS and total sugars. Some differences in the chemical constituents of the candies prepared by slow and rapid cook methods as well as during storage were also observed.
16. Sensory analysis of chayote based candies revealed that candy prepared by slow cook method was tender, soft and juicy and more acceptable than the candy prepared by rapid cook method as rapid cooking resulted in hard and shrunk candy, which was liked to a lesser extent by the taste panelists.
17. The estimated costs of chayote-based products are calculated to be lower than the market prices of some brands of similar nature.

The study concluded with the findings that fruit chayote is a rich source of various valuable nutrients. The fruit has, however, remained neglected from post harvest utilization view point. This study has explored its value addition potential either alone or by blending through the formulation and development of various value added, nutritious health enhancing chayote-based products. Such products can be exploited at household as well as on commercial scale. This can encourage farmers to grow more chayote and earn income from this fruit.



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Appendix-I

EVALUATION CARD FOR HEDONIC RATING TEST FOR FOOD PRODUCTS

Name--------------------

Product---------------- **Dated: ----------**

Please evaluate the food samples presented to you and check how much you like or dislike each one for a particular attribute. Use the hedonic scale explained below to show your attribute by checking at the point that best describe your feeling about the sample. Please give reason for your attitude. An honest expression of your personal feeling will help us in assessing the organoleptic acceptability of the samples presented to you for evaluation.

Sample code	Colour	Flavour	Texture/ Consistency	Overall acceptability	Remarks (if any)

Signature ------------------
Hedonic scale

Expression	**Points to be assigned**
Liked extremely	9
Liked very much	8
Liked moderately	7
Liked slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1