STANDARDIZATION OF PROTOCOL FOR THE PREPARATION OF PUMPKIN (*Cucurbita moschata* D.) CANDY AND BISCUITS

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CERTIFICATE

This is to certify that the thesis entitled **"STANDARDIZATION OF PROTOCOL FOR THE PREPARATION OF PUMPKIN (*Cucurbita moschata* D.) CANDY AND BISCUITS"** submitted by **MISS HARSHITHA, S. B., ID No. UHS16PGM724** for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **POST HARVEST TECHNOLOGY** to the University of Horticultural Sciences, Bagalkot is a record of bonafide research work carried out by her during the period of her study at University of Horticultural Sciences, Bagalkot under my guidance, supervision and the thesis has not previously been formed the basis for the award of any other degree, diploma, associateship, fellowship or similar titles.

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Affectionately dedicated to

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LIST OF ABBREVIATIONS

1.	CFU	Colony forming units
2.	%	percent
3.	@	at the rate of
4.	µg	Microgram
5.	^{0}B	Degree brix
6.	^{0}C	Degree centigrade
7.	a_w	Water activity
8.	CD	Critical Difference
9.	Cm	Centi metre
10.	et al.	and others/associates/Co-workers
11.	etc.	And so on; and other people / things
12.	g	Gram
13.	h	Hour
14.	Kg	Kilogram
15.	LDPE	Low Density polyethylene
16.	MAS	Months after storage
17.	mg	Milligram
18.	Min	Minute
19.	nm	Nanometre
20.	ppm	Parts per million
21.	TSS	Total soluble solids

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1. INTRODUCTION

Pumpkin (*Cucurbita moschata* D.) due to its unusual and extravagant characters is considered as the marvels of vegetable, it is one of the important vegetable widely grown all over the world (Dhiman *et al.*, 2009). Pumpkin is an annual or perennial, climbing or trailing herb grown throughout tropical and subtropical countries (Dutta *et al.*, 2005). Pumpkin is a vegetable coming from tropical and subtropical zones such as Mexico and South America with high consumption in the local market (Bisognin, 2002). Based on the colour of seeds, the origin of pumpkin has been attributed to Guatemala, Central Mexico or Columbia. The name pumpkin originated from a Greek word *Pepon* which means large melon. Pumpkin belongs to the family Cucurbitaceae and the genus *Cucurbita* which comprised of five domesticated species *viz., Cucurbita moschata, Cucurbita pepo, Cucurbita maxima, Cucurbita faciola and Telfairia occidentalis* (Caili *et al.*, 2006). In India, the production of pumpkin is estimated to be 1664 thousand MT from an area of 74 thousand hectares (NHB, 2017).

Pumpkin is an angiosperm belonging to cucurbitaceous family and is characterized by prostrate or climbing herbaceous vines with tendrils and large fleshy fruits containing numerous seeds (Fedha *et al.*, 2010). Cucurbitaceae family includes around 825 species**,** derived from tropical and subtropical regions, including 26 species that are cultivated as vegetables (Henriques *et al.*, 2012).

Cucurbita spp. includes squash, gourds and pumpkins and they are grown during the summer and rainy seasons in India (Seshadri, 1989). However, there are a huge variety of pumpkins in the world, but only three common types namely; *Cucurbita maxima, Cucurbita pepo* and *Cucurbita moschata* have gained the commercial importance. *Cucurbita moschata* is one of the most important cucurbitaceous vegetable crops being cultivated extensively since prehistoric time and is commonly grown species of pumpkin (Lee *et al.*, 2003). *Cucurbita moschata* is grown in almost all the regions of the country (Nath *et al.*, 1979).

In India, pumpkin is commonly known as *'sitaphal'*, *'kashiphal'* or *'lal kaddu'*. During the storage of pumpkin, various changes in the chemical composition

occur that are related to life processes such as respiration, transpiration and aging which cause unfavorable changes in biological and sensory qualities (Ciurzynska *et al.*, 2013).

Maturity of pumpkin fruits occurs in about 90-120 days after flowering. The fruits are often allowed to ripen fully on the vine to ensure good shelf life. The fruits are variable in size, round or oval in shape, bluntly ribbed and brownish yellow or varied in colours (Pandey *et al.*, 2003).

Public as well private sector *i.e.* food and pharmaceutical industries are now giving more emphasis on cultivation of pumpkin and to develop pumpkin products in this health conscious era (Sojack and Glowacki, 2010).

In India, pumpkin is the principal ingredient of several culinary vegetables utilized at immature and mature stage. About 90 per cent of the total pumpkin is produced within six months (January-June) only. It is a seasonal crop that has been used both as human as well as animal feed. Pumpkin is eaten as vegetable and cultivated for its young shoots, flesh, edible flowers and fruits. The pulp color varies considerably from brown, completely white, bright orange to greenish light. It is very sweet, smooth and usually non-fibrous. Jun *et al.* (2006) reported that high amounts of pectin, mineral salts, carotene, vitamins and other substances are beneficial to human health.

It is a rich source of vitamin A (20 ± 4 mg/100 g) with high amount of carotenoids, especially ß-carotene and lutein (Gonzalez *et al.*, 2001; Rodriguez *et al.*, 2008). Epidemiological evidence suggests that a diet rich in carotenoids and vitamin C is associated with enhancement of the immune response and reduction of the risk of degenerative diseases such as cancer, cardiovascular diseases, atherosclerosis, cataracts and age-related macular degeneration (Gonzalez *et al.*, 2001; Rodriguez, 2003). The carotenoids protect cells from photo oxidation, damage to DNA molecules and lipids and deactivate singlet oxygen that is mutagenic (Gonzalez *et al.*, 2001).

It has been used traditionally as medicine in many countries such as China, Yugoslavia, Argentina, India, Mexico, Brazil and America. *C. moschata* is popularly used in several countries to control diabetes as well as for treating worms and parasites.

Increased attention has been focused on under-utilized indigenous crops, for example the pumpkin, and their promotion would help to maximize the available resources, eradicate the dearth in food supply and can be useful in food industries in the formulation of value added products. Thus cater for the daily needs of the citizens nutritionally. Despite the pumpkin being regarded as a poor man's food and as an orphaned crop. It represents a cheap but quality nutrition for large parts of the population in both rural and urban areas (Chweya and Eyzaguirre, 1999).

Despite being rich and cheap source of carotenoids, pumpkin is neglected for utilization in culinary purposes due to some myths and cannot be stored for longer time due to degradation of carotenoids. Cooked pumpkin has a limited shelf life in terms of nutritional as well as microbial quality and is usually associated with the loss of vitamins and degradation of polyphenols. Consumption of such kinds of food can result in occurrence of several food-borne diseases. In the wake of consumers towards nutritional and nutraceutical deterioration of food during processing, researchers are focusing on methods that involve minimal processing to retain the bioactive profile of food sources.

Due to lack of proper processing and preservation knowledge, the farmers have to sell all their produce with lower price at the harvesting season. So, they do not get economic benefit from vegetable production. If proper processing and preservation technology is applied to preserve this vegetable and ensured to supply this vegetable throughout the year, farmers can be benefitted financially as well as the nation may get rid from malnutrition (Shanmugavelu, 1989).

Pumpkin has a vast scope for diversification and can be utilized in the production of processed products like jam, pickle, beverage, candy, bakery products and confectionaries. Pumpkin can be processed into flour which has a longer shelf-life with highly-desirable flavor, sweetness and deep yellow-orange colour. It has been reported to be used to supplement cereal flours in bakery products like cakes, cookies and bread, for soups, sauces, instant noodle and spice as well as a natural colouring agent in pasta and flour mixes. Bakery products like cakes, cookies, bread *etc*. are very much liked by both young and old generation in rural and urban areas (Bhat and Bhat, 2013).

Various products has been processed and preserved from pumpkin. But so far little research has been carried out in case of standardization of protocol for the preparation and quality evaluation of pumpkin based products. Therefore, the present study has been taken up with the following objectives:

1. To standardize the protocol for the preparation of pumpkin candy
2. To standardize the level of fortification of pumpkin powder and pulp in biscuits
3. To assess the quality and stability of pumpkin candy and biscuits during storage

2. REVIEW OF LITERATURE

Pumpkin has received considerable attention in recent years because of the nutritional and health protective values such as anti-tumor, anti-bacterial and anti-hypertensive property (Caili *et al.*, 2006). Pumpkin due its exceptional nutritional and nutraceutical properties can be a good and cheap source of carotene, crude fibre, pectin, mineral salts, vitamins and other substances that are beneficial to human health (Gonzalez *et al.*, 2001; Rodriguez *et al.*, 2008).

In India with increasing urbanization, rise in middle class purchasing power, change in food habits, there is increasing demand for ready to eat food such as factory-made cakes, biscuits, bread, pickles, chutney, squash, beverages, jam, jelly, juice, candy, pie *etc.* in the domestic as well as in foreign markets (Srivastava and Kumar, 1997). Baked products are considered as an excellent vehicle for fortification, value addition and feeding at mass scale. The demand of bakery products is increasing at the rate of 10.07 per cent per annum (Kamaljit *et al.*, 2010). These facts lead to the processing of pumpkin into ready to eat food products like candy and biscuit which was fortified with dehydrated pumpkin powder and pulp.

Present investigation was undertaken to standardize the protocol for the preparation of pumpkin candy and biscuits fortified with pumpkin powder and pulp which is rich in ß-carotene and crude fibre and many more nutritional and health benefits. As far now, very little studies have been reported on the processing of pumpkin, therefore literature available in this direction is scanty. However, literature available in India and abroad has been reviewed under following heads:

2.1 Physico-chemical properties of pumpkin

An edible portion of 77.5 per cent in pumpkin have been reported by Pawar *et al.* (1985), while Wills (1987) have reviewed an edible portion of 86, 70 and 85 per cent, respectively in ‘Butternut’, ‘Golden nugget’ and ‘Queensland blue’ varieties of pumpkin.

On visual examination of the fruits of *Cucurbita moschata*, Dhiman *et al.* (2009) and Kumari (2013) noticed that flesh colour varied from pale yellow to golden

yellow. The findings of Fedha *et al.* (2010) and Norshazila *et al.* (2014) revealed that the flesh colour of pumpkin ranged from yellow to orange.

The colour of pumpkin flour was brighter than colour of pumpkin flesh. The colour values of pumpkin flour was recorded as *L** (57.81), *a** (8.31) and *b** (34.39) values (Pongjanta *et al.*, 2006). The colour measurement of pumpkin flour was analysed by four values *L** (lightness), *a** (redness) and *b** (yellowness) which have the value of 64.93, 13.53 and 51.27 respectively (Aziah and Komathi, 2009).

The three varieties of pumpkin *viz.*, 'Butternut', 'Golden nugget' and 'Queensland blue' were found to contain 85.8, 91.3 and 83.8 per cent of moisture respectively (Wills, 1987). While analyzing the moisture content of two varieties of pumpkin namely; *Cucurbita maxima* and *Cucurbita pepo*, Teotia (1992) noticed a range of 92.4 – 92.6 per cent moisture. The moisture content of 84.32 per cent was reported by Pongjanta *et al.* (2006), whereas, higher value of 92.24 per cent has been given by See *et al.* (2007) for pumpkin fruits. The edible portion is composed of almost 90 per cent of moisture content (Galina *et al.*, 2007).

Ermakov (1987) observed moisture content of 9.1 per cent in pumpkin (*Cucurbita moschata*) flour, whereas, lower value of 6.01 per cent has been revealed by Pongjanta *et al.* (2006) but higher moisture content of 14.96 and 10.64 per cent has been reported by Usha *et al.* (2010a) and Demery (2011) respectively.

Muthukrishna *et al.* (1976) obtained a value of 0.14 per cent for titratable acidity in CO-2 variety of pumpkin, while 'Solan Badami' variety recorded 0.08 per cent was observed (Anju, 2000). Dhiman *et al.* (2007) have the opinion that the titratable acidity of pumpkin was 0.07 per cent, while Noelia *et al.* (2011) observed that the titratable acidity in pumpkin ranged from 0.01-0.26 per cent with the mean value of 0.04 per cent.

A range of 9.2 -13.0 mg/100 g of ascorbic acid has been given by Sharma *et al.* (1979) in pumpkin fruit. However, higher ascorbic acid content of 25-62 mg/100 g (on dry weight basis) was reported by Pawar *et al.* (1985). Wills *et al.* (1987) revealed that ascorbic acid of Butternut, Golden nugget and Queensland Blue varieties of pumpkin was 8, 17 and 24 mg/100 g respectively. Pumpkin has been reported to

contain ascorbic acid of 8.93 - 20.63 mg/100 g (Danilchenko *et al.*, 2000), while a range of 6 - 21 mg/100 g for vitamin C was recorded by Anonymous (2000).

Muthukrishna *et al.* (1976) found that Indian pumpkin cultivars contain 135 - 527 mg/100 g of ß-carotene (on dry weight basis). Similar ß-carotene content has been given by Gopalakishnan *et al.* (1980). ß-carotene in pumpkin varied from 1.6- 4.56 mg/100 g (Danilchenko *et al.*, 2000).

Pongjanta *et al.* (2006) observed that pumpkin fruit contain 2.43 mg/100 g of ß-carotene, whereas, Anonymous (2006) has given an amount of 3.1 mg/100 g. Pumpkin was found to possess 11.2 mg/100 g of ß-carotene (Dhiman *et al.*, 2007). Noelia *et al.* (2011) revealed that ß-carotene of pumpkin ranged from 1.32 - 4.79 mg/100 g, while the average value was found to be 2.67 mg/100 g.

Ermakov (1987) found that 5.60 mg/100 g of ß-carotene was present in pumpkin flour. The carotenoid content in Spanish pumpkin was reported to be higher than that of other pumpkin varieties and even much higher than carrot (Wu and Jin, 1998). According to Pongjanta *et al.* (2006) and Usha *et al.* (2010a), pumpkin flour was found to contain 7.29 mg/100 g and 4.8 mg/100 g of ß-carotene respectively. About 48.30 µg/100 g of vitamin A was present in pumpkin flour (Saeleaw and Schleining, 2011).

Ptitchkina *et al.* (1998) estimated that pumpkin powder contain 40 per cent cellulose, 4.3 per cent hemicellulose and 4.3 per cent lignin, which are the main component of insoluble dietary fibre. Usha *et al.* (2010a) and Demery (2011) have determined the fibre content in pumpkin flour and revealed the value of 3.08 g/100 g and 3.26 per cent, respectively. Zhang and Guo (2011) observed 2.11 per cent of fibre in pumpkin flour, while Saeleaw and Schleining (2011) have reported 3.65 per cent of crude fibre and 12.2 per cent of dietary fibre in pumpkin flour.

According to Muthukrishna *et al.* (1976), pumpkin fruit was found to contain total sugars of 3.4 per cent, while Singh (1990) reported that ‘Arka Chandan’ and ‘Arka Suryamukhi’ varieties of pumpkin possess 4.90 and 4.64 per cent of total sugars respectively. Anju (2000) revealed that total sugars in pumpkin fruit is 4.9 per cent. Pumpkin (*Cucurbita moschata*) was reported to contain total sugars of 1.36 per

cent (Anonymous, 2006) and Muzaffar (2006) observed total sugars of 4.21 per cent in pumpkin flour, while Dhiman *et al.* (2007) have revealed an amount of 3.90 per cent. Total sugars of 22.01, 19.22 and 9.11 per cent in mature, pre-ripened and ripened pumpkin (*Cucurbita moschata*) seeds respectively, were reported by Pandya and Rao (2010).

The reducing sugar in pumpkin was reported to be 1.9 per cent by Muthukrishna *et al.* (1976), whereas, Pawar *et al.* (1985) have recorded an amount of 22.99 per cent. Pumpkin fruit was found to contain reducing sugars of 0.5 per cent (Anju, 2000). Pumpkin flour has been reported to contain reducing sugars of 22.40 per cent (Muzaffar, 2006). Dhiman *et al.* (2007) recorded the reducing sugars of pumpkin as 2.1 per cent. Pandya and Rao (2010) revealed that reducing sugars in mature, pre-ripened and ripened pumpkin seeds were 10.35, 8.51 and 4.62 mg/100 g, respectively, while Noelia *et al.* (2011) have given a range of 1.01-2.44 per cent with an average of 1.69 per cent.

Pumpkin flour contains 9.0 per cent protein (Ermakov, 1987), while higher value of 9.65 per cent has been observed by Macrae *et al.* (1993). Demery (2011) recorded a value of 9.69 per cent for protein in pumpkin flour, whereas, comparatively lower content of 7.81 per cent was observed by Saeleaw and Schleining (2011).

The fat content (1.62%) in pumpkin flour was reported by Tee (1985) whereas, 1.35 per cent by Pongjanta *et al.* (2006) and Usha *et al.* (2010a). Saeleaw and Schleining (2011) have recorded comparatively higher fat content (3.60%) in pumpkin flour. Further, higher value of 4.09 per cent has been observed by Zhang and Guo (2011).

Ermakov (1987) found that 3.8 per cent of ash in pumpkin flour, while Muzaffar (2006) has observed a value of 4.73 per cent. See *et al.* (2007) reported that pumpkin flour contain 5.73 per cent of ash. Whereas, Usha *et al.* (2010a) have recorded an amount of 5.79 per cent. Saeleaw and Schleining (2011) studied the physico-chemical characteristics of pumpkin flour and noticed the ash content of 5.29 per cent.

2.2 Nutritional properties of pumpkin

Pumpkin is a valuable source of functional components like carotenoids, lutein, zeaxanthin, vitamin E, ascorbic acid, phytosterols, selenium and linoleic acid which act as antioxidant in human nutrition (Sirohi *et al.*, 1991).

Gopalan *et al.* (1996) reported that 100 g of pumpkin fruit contains calcium (10 mg), phosphorous (0.30 mg), iron (0.44 mg), magnesium (38 mg), sodium (5.6 mg), potassium (139 mg), copper (0.05 mg), manganese (0.05 mg), zinc (0.26 mg) and sulphur (16 mg). According to Anonymous (2006), pumpkin fruit (per 100 g) contains different minerals like calcium (21 mg), potassium (340 mg), magnesium (12 mg) and phosphorous (44 mg).

Ermakov (1987) reported that per 100 g of pumpkin flour contains sodium (0.65 g), calcium (0.5 g) and phosphorous (0.03 g). Eades (1994) reported that pumpkin fruit contain proteins (0.8-1%), carbohydrates (6.5%) and ß-carotene (15-350 mg/kg). Pumpkin flesh has been reported to contain 1.4 per cent of proteins, 0.1 gram of fats, 4.6 per cent of carbohydrates, 10 mg of calcium, 30 mg of phosphorous and 0.7 mg of iron (Sharma and Kumar, 1995).

Pongjanta *et al.* (2006) observed that 1.17 per cent carbohydrates are present in pumpkin. Pumpkin is a good source of carotene, pectin, minerals, salts and other substances that are beneficial to health (Jun *et al.*, 2006).

The flesh of pumpkin is rich in fibre, vitamin E, potassium and a variety of carotenoids. ß- carotene is one of plant carotenoids converted into vitamin A in the body which performs many functions in overall health (Dhiman *et al.*, 2009).

Pulp of pumpkin has been reported to be rich in sodium, potassium, iron, manganese and phosphorous (Egbekun *et al.*, 1998). Pumpkin fruit contains 1.40 g of protein, 50.00 µg of carotene, 2.00 mg of vitamin C, 0.70 mg of iron, 10.00 mg of calcium and 30.00 mg of phosphorus in 100.00 g of edible portion (Muralidhara *et al.*, 2014).

Lazos (1986) has reported that pumpkin seeds are excellent sources of both oil (37.8-45.4%) and protein (25.2-37%). Pumpkin seeds are found to be a good source of B-complex vitamins (Mansour *et al.*, 1993).

Demery (2011) revealed that 100 g of edible portion of pumpkin possesses sodium (0.949 mg), potassium (355.22 mg), calcium (46.35 mg), iron (0.835 mg) and phosphorous (44.05 mg), while 100 g of pumpkin flour contain 21.50 mg for sodium, 5185.11 mg for potassium, 616.73 mg for calcium, 14.07 mg for iron and 817.88 mg for phosphorous.

2.3 Medicinal properties of pumpkin

According Boileau *et al.* (1999) pumpkin has huge concentration of ß-carotene which protects against certain cancers. Carotenoids are the primary source of vitamin A for most of the people living in developing countries.

Pumpkin acts as a powerful antioxidant for preventing tumor growth, enhancing immune system and inhibiting mutagenesis (Kumari, 2000). Pumpkin pulp has also been used against diabetes mellitus as they are believed to exhibit hypoglycemic properties (Jaiwei *et al.*, 2003).

Cunha (2003) found that crushed pulp of pumpkin provide medicinal power, which act as anti-inflammatory, diuretic and emulsifier that helps in treatment of fever, ear pain, inflammation of urinary bladder and prostate disorders.

Pumpkin is a good source of ß-carotene (Dhiman *et al.*, 2007) and ß-carotene is converted to vitamin A in the body which is essential for healthy skin, vision, bone development and many other functions. Pumpkin rich diet could reduce the blood sugar level. The active polysaccharides from the pumpkin fruit could obviously increase the levels of serum insulin and thus, reduce the blood glucose level which improve the tolerance of glucose and therefore, could be developed as a new anti-diabetic agent (Yang *et al.*, 2007). Traditionally, the pulp is used to relieve dyspepsia, stomach disorders and intestinal inflammation (Sentu and Debjani, 2007).

Pumpkin has received considerable attention in recent years because of the nutritional and health protective values. The nutritional value of pumpkin is high but varies from one species or cultivar to another (Nawirska *et al.*, 2009).

Pumpkin is used as a medicinal plant for prostate and bladder problems and as an anthelmintic, galactogogue and antiemetic (Magdeleine *et al.*, 2011).

The presence of magnesium, potassium and folate in pumpkin highlights its heart friendly attributes. The seeds of pumpkin are rich in proteins, iron, zinc, manganese, magnesium, phosphorous, copper, potassium, polyunsaturated fatty acids and carotenoids (Patel, 2013).

2.4 Suitability of pumpkin for the development of value added products

Pawar *et al.* (1985) reported that dehydration of well matured pumpkin causes leaching losses in respect of ascorbic acid, total carotenoids, reducing sugars and ash content which were more in shreds dried under sun than in cabinet dried and sulphited samples.

Egbekun *et al.* (1998) found that there was no significant difference in acceptability between pumpkin marmalade and commercial orange marmalade.

Pumpkin could be processed into flour and incorporated in baked products as wheat-pumpkin composite flour blend for fibre enrichment and other functional purposes (Grigelmo *et al.*, 1999).

Pumpkin can be consumed in a variety of ways such as fresh or cooked vegetables as well as being stored in frozen form or canned (Figueredo *et al.*, 2000). Jam from pumpkin with different combinations of apple and quince has been prepared by Danilchenko *et al.* (2000).

Pumpkin flour has also been used as a source of ß-carotene and natural colourant (yellow colour) with most appreciable appearance, taste, texture and acceptability when supplemented in bakery products (Lee *et al.*, 2002).

Pongjanta *et al.* (2003) revealed that pumpkin powder produced by juice extraction and cabinet drying then ground with pin mill and sifted through an 80 mesh sieve was cheap to produce, good quality and easy to use as a ß-carotene supplement in food products.

Pongjanta *et al.* (2004) indicated that the use of 10-20 per cent pumpkin substituted for wheat flour in Thai desserts improved their colour and ß-carotene content and would be accepted by consumers.

Pumpkin peel is rich in pectin, which can be used as a gelling and thickening agent as well as stabilizer in food (Jun *et al.*, 2006). Pumpkin flour can be used as a thickener in soup, gravy, fabricated snacks and as an ingredient in bakery products such as sandwich, bread, sweet bread, butter cake, chiffon cake, cookies and instant fried noodles (Pongjanta *et al.*, 2006). Bread can be prepared with the supplementation of pumpkin flour (See *et al.*, 2007 and Fang, 2008).

Pectin extracted from pumpkin and then modified using an enzyme could offer an alternative for jam and confectionary (Ptitchkina *et al.*, 2008). Pulp of pumpkin have a fibre content which was processed into flour and used for the supplementation in preparation of crackers (Aziah and Komathi, 2009).

Pumpkin can be profitably converted into a variety of value added products such as jam, jelly, marmalade, candy, puree, sauce, chutney, pickle and halwa (Dhiman *et al.*, 2009).

The pumpkin fruit can be cooked as a vegetable when immature, while when mature it is used in the manufacture of beverages such as pumpkin-apple soup (Yadav *et al.*, 2010).

Preparation of weaning mix along with the supplementation of pumpkin flour increases the nutritional as well as sensory quality (Usha *et al.*, 2010a). Incorporation of pumpkin flour in instant dokhla mix resulted in significant threefold increase in protein, twofold increase in fibre and increase in ß- carotene level (Usha *et al.*, 2010b).

Tatjana *et al.* (2011) studied on use of dried pumpkins in wheat bread production with an objective to evaluate quality parameters of microwave vacuum dried pumpkins and to verify its application in wheat bread production.

Joao *et al.* (2011) studied on changes in carotenoids during processing and storage of pumpkin puree. Pumpkin flour can also be used for the preparation of toast bread (Demery, 2011).

Monirul *et al.* (2014) studied on evaluation of nutritional and sensory quality characteristics of pumpkin pies. The pumpkin pies containing pumpkin puree (40%),

wheat flour (12%), sugar (20%), milk powder (15%) and egg (13%) was the favorite sample of the sensory evaluation with the highest overall acceptability among all types of pumpkin pies samples. The nutritional compositions of the best sample were moisture 38.05 per cent, ash 1.15 per cent, protein 10.24 per cent, fat 7.33 per cent and total carbohydrate 43.24 per cent with energy value of 279.88 kcal/g.

Mona and Hinar (2015) studied on gluten-free flat bread and biscuits production by cassava, extruded soy protein and pumpkin powder with an objective to produce good quality gluten free flat bread and biscuits suitable for people with celiac disease.

Malgorzata *et al.* (2015) studied on partial replacement of wheat flour with pumpkin seed flour in muffins offered to children and it is observed that as the replacement of wheat flour with pumpkin seed flour increased the nutritional value of muffins improved.

Bhutkar *et al.* (2015) studied on prepration of pedha blended with red pumpkin; an acceptable pedha was prepared using khoa from standardized buffalo milk added with 10 parts of red pumpkin pulp into 90 part khoa and sugar was mixed at 30 per cent by weight of khoa before heating. The moisture in the pedha blended with red pumpkin varied between 14.50 to 25.50 per cent, fat 20.00 to 22.00 mg/100 g, protein 14.42 to 14.80 mg/100 g, ash 2.19 to 2.32 per cent and carbohydrate 38.88 to 46.06 per cent.

2.5 Standardization of protocol for the preparation of pumpkin candy

2.5.1 Preparation of pumpkin candy

Mango slices when dipped in 40°B sugar syrup in the presence of 3000 ppm SO_2, 0.2 per cent ascorbic acid and 1 per cent citric acid and dried in electric cabinet drier (60°C for 8-12 hrs) showed retention of ascorbic acid and carotenoids (Teotia *et al.*, 1976).

Thangavel *et al.* (1998) conducted studies on osmotic dehydration of red banana in which slices of 5 mm thickness were soaked in 63°B sugar syrup. They observed that when the sugar syrup was maintained at 75°C, 50 per cent of

water was removed from the slices within 1 hour of osmosis and a maximum of 57.90 per cent of water loss was obtained when the slices were soaked for 2.5 hours.

Apple rings treated with KMS (0.5%) for 30 minutes and osmotic dip in 70°B syrup at 50°C for 4.5 hours gave the best osmo dried products (Sethi *et al.*, 1999).

Chavan *et al.* (2010) revealed that osmo dried banana slices prepared by soaking the slices in 60°B sugar containing 0.1 per cent KMS + 0.1 per cent citrate + 0.2 per cent ascorbic acid were found better in relation to colour, flavor, appearance, texture, taste and overall acceptability.

Sharma *et al.* (2004) osmosed apricots in 70°B sucrose solution maintained at 50°C for different periods of time (1.5, 3, 4.5 and 6 h) prior to dehydration and recommended that 6 hour dipping is sufficient for making osmotically dehydrated apricot.

In osmo dried pineapple slices, ascorbic acid and carotenoid content was found maximum when these slices were treated with 60°B sugar syrup with 0.2 per cent citric acid and 700 ppm KMS for 24 hours (Rashmi *et al.*, 2005).

According to Sagar and Kumar (2009), the osmotically dehydrated mango slices prepared by using a solution containing sugar (60°B), KMS (0.05%) and citric acid (0.1%) and subsequent heating in mechanical cabinet drier at 58 ± 2°C had good colour, flavor and texture.

Osmotic dehydration presents some benefits such as reducing the damage of heat to colour and flavour, inhibiting the browning enzymes and decreasing the energy cost. Osmotic dehydration resulted in increased shelf-life, little loss of aroma in dried and semidried food stuffs, reducing the load of freezing and to freeze the food without causing unnecessary changes in texture. It has been reported that osmotic dehydration reduced up to 50 per cent weight of fresh vegetables and fruits (Khan, 2012).

Anis *et al.* (2012) studied on ginger (*Zingiber officinale*) preserve and candy development. They found that, the preserve (GP70) made from 70 per cent and the candy (GC75) made from 75 per cent sugar concentration was best among the similar product.

Nayak *et al.* (2012) studied on changes of nutritional and organoleptic quality of flavored candy prepared from aonla during storage. The nine months storage study revealed that the moisture content in the candy was found to decrease with storage. It decreased from an initial value of about 16 per cent to a final value of about 14 per cent at the end of storage. TSS, acidity, total reducing sugar and browning was found to increase with storage period, while the non reducing sugar decreased with storage period. On the basis of organoleptic evaluation and biochemical characters, the candy prepared from cv. Krishna and flavored with cardamom powder was found to be the best.

Priya and Khatkar (2013) studied the effect of different treatments and storage period (90 days) on various physicochemical, sensory and microbial properties of aonla preserve. TSS, pH, reducing sugar, total sugar and browning of the preserves increased during storage, while moisture content, ascorbic acid, tannin and titratable acidity of the preserves decreased during storage in all the samples. The "no-cooking method" at sugar syrup of 70°B was found most effective in retention of ascorbic acid and tannins in the preserves and showed low microbial load. Preserves with initial sugar concentration of above 60°B can be stored safely at room temperature for 90 days.

Gupta and Kaul (2013) studied on the preparation of a candy like product (*chuhara*) from ber by osmo-air drying process. The pre-treatments like dipping in boiling NaOH (5%) solution for 5 min, followed by rinsing in water along with citric acid (5%) and finally dipping in KMS solution (4000 ppm) for 12 h accelerated the rate of osmosis. Pretreated ber fruits were then dipped in different sugar concentrations of 40, 50, 60 and 70°Brix at 24, 48 and 72 h. The treated fruits were then air-dried at 52 ± 2°C. With the increase in storage period, the moisture, ascorbic acid and tannin contents were decreased whereas, total sugars were increased. On the basis of quantitative parameters and sensory traits it was found that ber chuhara prepared with 60°Brix syrup steeping for 72 h rated the best, followed by those prepared with 70 or 50°Brix sugar syrups.

Nath *et al.* (2013) studied on effect of slice thickness and blanching time on different quality attributes of instant ginger candy. The experimental parameters considered were slice thickness (5.0–25.0 mm) and blanching duration (10–30 min)

followed by dipping in 40°B and 75°B sugar solutions containing 2.0 per cent citric acid respectively, for 1 and 2 h at 95°C and dried at 60°C for 1 h. The optimum product qualities in terms of hardness (2.08kg/m^2), TSS (73.4%), acidity (1.31%), TSS: acid ratio (56.3), taste score (7.98) and overall acceptability (8.07) were obtained for slice thickness of 10.9 mm and blanching time of 24.9 min.

Araujo *et al.* (2014) used 50°B concentration of sucrose at two temperature levels for the preparation of osmotically dehydrated carrot slices and achieved the best results with osmotic solution of 50°B at 60°C with immersion time of 60 minutes.

Kukanoor *et al.* (2014) optimized the osmotic dehydration process of carrot slices and found blanching of slices for 2 minutes followed by steeping in 40°B syrup + 6 per cent salt for 2 hours was best on the basis of sensory quality.

Patil *et al.* (2014) studied the sensory quality and economics of preparation of karonda candy. They found that, the overall scores of taste and colour decreased with the advancement of storage at an interval of 30 days. The karonda candy recorded more acceptable score in cabinet drying than the solar drying. However, the treatment combination T_1D_1 (Fruit pieces impregnated with cane sugar (TSS 60ºBrix) + 0.5% citric acid + cabinet drying) and T_1D_2 (Fruit pieces impregnated with cane sugar (TSS 60ºBrix) + 0.5% citric acid + solar drying) recorded the maximum scores.

Osmotic dehydration of fruits and vegetables is achieved by placing the solid/semi solid fruit and vegetable, whole or in pieces, in a hypertonic solution (sugar and/or salt) with a simultaneous counter diffusion of solutes from the osmotic solution into the tissues (Aronika and Manimehalai, 2014).

Manjula and Suneetha (2014) studied on formulation and development of functional confectionery by incorporating pumpkin juice and they found that candy developed with addition of pumpkin juice was rich in nutrient composition compared with control candy. Protein, fibre, minerals like calcium, iron and phosphorus were significantly increased in pumpkin candy at 5 per cent level of juice, antioxidant composition was also more in pumpkin candies.

Patankar *et al.* (2014) used four different concentrations of sugar (30, 40, 50 and 60°B) at temperature of 30 and 40°C and concluded that pumpkin pretreated with

60°B syrup at 40°C osmosis temperature was more acceptable on the basis of colour and shelf life.

Devi (2014) tried 3 different recipes of sugar syrup (50, 60 and 70°B) for the preparation of osmotically dehydrated wild pear halves and revealed that concentration of 70°B got the highest scores for colour, taste and overall acceptability.

Chauhan *et al.* (2014) studied the effect of different citric acid levels on quality of papaya candy prepared by various methods. The citric acid levels of 0.5, 0.75 and 1.0 per cent were used for all three processing methods. After preparation of papaya candy, the finished products were packed in three packaging materials *viz.*, glass jars, PET jars and PP pouches and stored at room temperature for quality evaluation at 30, 60 and 90 days interval. The data obtained for acidity of fresh samples of papaya candy indicated that with increase in citric acid levels, the acidity increased in processing method.

Jothi *et al.* (2014) studied on the development and shelf-life prediction of pineapple (*Ananas comosus*) preserve and candy. The candies were processed with 65, 70 and 75°B sugar syrup. Initially the composition of pineapple preserves processed with different level of sugar were found in the range as moisture content (33.09-35.65%), ash (1.36-1.42%), protein (1.01-1.07%), fat (0.61-0.66%), total sugar (61.37-63.73%) and reducing sugar (30.52-31.46%) and pineapple candies were found in the range as moisture content (19.05-20.88%), ash (1.52-1.58%), protein (1.15-1.21%), fat (0.72-0.77%), total sugar (75.70-77.35%) and reducing sugar (45.16-46.39%). The sensory results showed that color, flavor, texture, taste and overall acceptability scores differed significantly.

Patil *et al.* (2014) studied on preparation of karonda candy and observed that, there was a gradual increase in TSS, titratable acidity, reducing sugar and total sugar content of the candy irrespective of drying methods and recipes used in experimentation. However, non-reducing sugar, ascorbic acid and moisture content of candy decreased with the advancement of storage period.

Osmotic dehydration is recommended as a processing method to obtain better quality of food products. Osmotic dehydration allows structural, nutritional, sensory and other functional properties of the raw material to be modified. Osmotic

dehydration of foods has not been extensively used as expected due to the poor understanding of the counter current flow phenomena associated with it. The principle underlying in osmotic dehydration is that water diffuses from dilute solution (hypotonic solution) to concentrated solution (hypertonic solution) through a semi-permeable membrane till equilibrium is established (Sonia *et al.*, 2015).

Kukanoor *et al.* (2015) studied on effect of pre-treatments on physicochemical and organoleptic qualities of pumpkin candy to find out a suitable recipe acceptable to the consumers. The various physicochemical parameters like ß-carotene, non-enzymatic browning, water activity, moisture content, recovery and organoleptic evaluation were carried out during storage.

Adhau *et al.* (2015) studied on development and quality evaluation of pumpkin (*Cucurbita pepo)* preserve: a value added product. They found that amongst the treatments pumpkin preserve prepared with cinnamon (0.15%), clove and nutmeg (0.5% each) was found to be the best.

Surekha *et al.* (2016) studied on standardization of pre-treatments for the development of Intermediate Moisture Food Products from papaya (*Carica papaya* L.). They found that out of various treatments tried, the pretreatment consisting of blanching of fruit slices for 1 minute with 0.2 per cent citric acid followed by dipping in 0.2 per cent KMS for 20 minutes was best. Osmotically dried papaya contained 5.6 per cent moisture, 55º B TSS, 0.2 per cent acidity, 16.4mg/100 g ascorbic acid and 1395.46 µg/100 g carotenoids whereas candied papaya contained 16.13 per cent moisture, 46.8ºB TSS, 0.12 per cent acidity, 16.5 mg/100 g ascorbic acid and 1543 µg /100 g carotenoids content.

Blanching

Baruffaldi *et al.* (1983) reported that 99.40 per cent of peroxidase activity was destroyed in carrot slices of 2 mm thickness after 4 minutes of water blanching at 92°C, whereas, Wu *et al.* (1987) revealed that peroxidase, catalase and pectin esterase enzymes in diced carrots could be inactivated (greater than 97%) after 1 min of steam blanching. However, in broccoli, 90 seconds of steam blanching was sufficient to destroy peroxidase activity (Barrett *et al.*, 2000).

Mousa *et al.* (2004) optimized the blanching method for brinjal slices by using enzyme test method. They treated the slices with boiling water for different time duration (3, 5, 7, 9 and 11 min) and reported that blanching of slices at 95°C for 7 min resulted in efficient inactivation of enzymes in comparison to other treatments.

Muzzaffar (2006) recommended 4 min steam blanching for inactivation of peroxidase enzyme in pumpkin cubes. Singh *et al.* (2008) found that pretreatment before drying *i.e.* blanching for 1 min at 100°C in 0.1 per cent magnesium oxide and dipping in 1 per cent sodium sulphite solution for 10 min followed by osmo air drying was best to inactivate the catalase and peroxidase enzymes in bitter gourd slices.

There are different methods for blanching the products *viz.*, hot water, hot air, flowing steam and microwave treatment. Steam blanching is more effective than water blanching for the conservation of soluble nutrients in cauliflower (Neelavati *et al.*, 2013).

Devi (2014) recommended 2.5 min hot water blanching in wild pear halves on the basis of peroxidase test. Blanching is a unit operation applied prior to freezing, canning or drying in which fruits or vegetables are heated for the purpose of inactivating enzymes responsible for commercially unacceptable darkening and off flavors, modifying texture as well as nutritional value and removing trapped air (Murthy *et al.*, 2014).

Kukanoor *et al.* (2015) revealed that among the treatments, significantly maximum recovery was observed in pumpkin slices blanched for 10 min and steeped in 40-70ºbrix syrup + 1 per cent citric acid (82.80%). However, minimum percent recovery was found in control (37.87%).

Citric acid

Samann (1991) reported the suitability of indigenous fruits like apple, cherry and pear cultivars for the production of dried products and observed that blanching followed by dipping in solution of citric acid, ascorbic acid and NaCl improved the colour of the product.

Amitabh *et al.* (2000) revealed that the pretreated slices of osmotically dehydrated mangoes with citric acid were superior in colour, flavor, texture and taste over the slices which are not treated with citric acid.

Muzzaffar (2006) recommended the pretreatment of steam blanching for 4 minutes followed by 1.5 per cent citric acid dip for 20 minutes for the preparation of pumpkin candy.

Shakir *et al.* (2009) have recommended the dipping of apple and pear in 0.20 per cent citric acid to prevent browning.

Dar *et al.* (2011) used different concentrations (1.00, 1.50 and 2.00%) of citric acid prior to candy making and concluded that cherry candy prepared by using 1.50 per cent citric acid proved superior with respect to overall acceptability scores in terms of colour, taste, texture and flavor.

Devi (2014) applied different concentrations of citric acid (0.25, 0.5, 1.0 and 1.5%) for different time intervals (10, 20 and 30 min) for preparation of osmotically dehydrated wild pear halves and found that 70°brix sugar syrup concentration and 1 per cent citric acid for 30 minutes was best.

2.5.2 Storage stability of candy

Moisture content

Rani and Bhatia (1986) observed loss of moisture in intermediate moisture bagugosha samples from 42.6 to 28.1 per cent during storage of 16 weeks. Ayub and Alam (2002) developed intermediate moisture (IM) sweetened apple slices using dry crystalline sucrose and found that moisture content of fresh apple slices decreased from 85 to 64, 54, 52 and 49 per cent during 24, 48, 72 and 96 hours storage in crystalline sucrose, respectively.

A drop in moisture content was also observed with the storage intervals in osmotically dehydrated banana slices by Hussain *et al.* (2004), peel candy of Darunj by Verma *et al.* (2006), aonla candy by Nayak *et al.* (2012) and aonla preserve by Priya and Khatkar (2013).

Akhtar and Javed (2013) investigated overall mean values for moisture content which increased significantly from 7.17 to 7.86 per cent during storage of intermediate moisture (IM) apple slices. Kukanoor *et al.* (2015) observed an increase in moisture content of pumpkin candy as storage period prolonged.

ß-carotene

Kukanoor *et al.* (2015) studied on preparation of pumpkin candy and observed that there was no significant difference between the treatments with respect to ß-carotene content at initial storage period. However, as the storage period increased ß-carotene content decreased. At 3 months after storage, maximum ß carotene retention (6.33 ppm) was recorded in T_7 (7 min blanching and steeped in 40-70°brix syrup + 1 per cent citric acid) followed by T_4 (2.42 ppm).

Titratable acidity

In intermediate moisture aonla preserve, the acidity values gradually increased with the storage duration (Sethi, 1980). An increase in acidity of ber (Gupta *et al.*, 1980) and aonla candy (Sethi, 1980; Pathak, 1988; Nayak *et al.*, 2012; Singh *et al.*, 2008) was observed during storage.

Sharma and Kaushal (1999) reported decrease in titratable acidity of osmotically dehydrated canned plum by dipping in osmotic solution and was recorded in the range of 1.16 to 1.38 per cent from the initial range of 1.24 to 1.49 per cent.

Kumar and Singh (2001) found that acidity did not change in the beginning of storage, thereafter, it increased during storage in various aonla products. Verma *et al.* (2006) reported that acidity of Darunj candy decreased with the storage in both the methods (fast and slow cooking). Akhtar and Javed (2013) found that acidity increased during two months storage period in IM apple slices.

Ascorbic acid

Ascorbic acid content decreased in osmotically dehydrated banana slices during storage (Hussain *et al.*, 2004). Ayub *et al.* (2005) found that ascorbic acid content decreased from 293.9 to 44.51 mg/100 g during dehydration in IM guava

slices. Similar decrease in ascorbic acid was observed in different aonla products (Deen, 1992; Damame *et al.*, 2002; Nayak *et al.*, 2012; Priya and Khatkar, 2013).

Sugars

Sethi (1980) reported an increase in reducing sugar and decrease in total sugar during six months storage of intermediate aonla preserve.

Sethi and Anand (1982) also observed an increase in sugar content during storage of intermediate moisture carrot preserve. Rani and Bhatia (1986) found an increasing trend in reducing sugar during storage of sand pear candy and Bagughosa preserve.

A significant increase in the total and reducing sugars with increase in storage period was observed in Darunj candy (Verma *et al.*, 2006). Nayak *et al.* (2012) reported that total sugars in aonla candy of different cultivars increased, while reducing sugars decreased during nine months storage. Similar increase in the total and reducing sugars in aonla preserve was observed by Priya and Khatkar (2013).

Non-enzymatic browning

According to Kumar (2013), osmo dehydrated plum showed less increase in non-enzymatic browning (NEB) *i.e.* from 0.060 to 0.073 and 0.092, respectively during 3 and 6 months of storage in aluminium laminated pouches as compared to others.

Ahmed *et al.* (2014) recorded an increase in NEB from 0.76 to 2.01 respectively during 135 days of storage of osmo dehydrated peach slices packed in 300 gauge polyethylene pouches.

According to Kukanoor *et al.* (2015) minimum non-enzymatic browning was recorded in slices blanched for 7 min and steeped in 40-70°brix syrup + 1 per cent citric acid whereas maximum was recorded in control (without blanching and no citric acid).

Sensory characteristics

Ghosh *et al.* (2006) conducted studies on osmotic dehydration of carrot slices and suggested that the slices (5 mm thick) when soaked in 50°B sugar solution containing 5 per cent salt and 0.1 per cent KMS for 1 hour followed by drying in hot air at 50°C were best on the basis of organoleptic quality and rehydration ratio.

On the basis of organoleptic evaluation and biochemical characters, it was concluded that the candy prepared from cv. Krishna and flavoured with cardamom powder was found to be the best aonla candy (Nayak *et al.*, 2012).

Hiremath and Rokhade (2012) studied on the preparation of sapota candy. Sapota candy was prepared with initial steeping in different concentrations of syrup (40, 50 and 60°Brix) with or without citric acid with or without blanching. The mean maximum scores for colour and appearance, taste, flavour and overall acceptability was recorded in the candy prepared with initial syrup strength of 60°Brix with one per cent citric acid, whereas maximum score for texture was observed in candy with initial syrup strength of 40°Brix with one per cent citric acid with or without blanching.

For preparation of pumpkin candy blanching for 7 min and steeped in 40-70° brix syrup + 1% citric acid treatment was most suitable for consumer acceptance with highest scores for colour and appearance (3.60), texture (3.55), taste (3.63) and overall acceptability (3.72) at third month after storage. Whereas least scores for organoleptic parameters were noticed in control (Kukanoor *et al.*, 2015).

Microbial population

Muzzaffar *et al.* (2016) studied on effect of storage on physicochemical, microbial and antioxidant properties of pumpkin candy and they found that Vitamin C and carotene content of pumpkin can be retained by processing pumpkin into candies. Microbial load of pumpkin candies (1.74–3.2 log cfu/g) were safe for human consumption during storage.

2.6 Standardization of level of fortification of pumpkin powder and pulp in biscuits

2.6.1 Preparation of pumpkin fortified biscuits

Pongjanta *et al*. (2006) studied on utilization of pumpkin powder in bakery products. Wheat flour was substituted by 5 levels of pumpkin powder (10, 20, 30, 40 and 50%) in sandwich bread, sweet bread, butter cake, chiffon cake and cookies. The products were consumer tested and their physicochemical and sensory properties were analyzed. Results showed that 20 per cent substitution was optimum for butter cake and chiffon cake, while only 10 per cent substitution was acceptable for sandwich bread, sweet bread and cookies.

Kulkarni and Joshi (2013) studied on effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. Biscuits were prepared by replacing wheat flour with pumpkin powder at different levels *viz.*, 0, 2.5, 5.0, 7.5 and 10 per cent (w/w) in the standard formulation. The influence of replacement of wheat flour in biscuit with pumpkin powder resulted in a significant change in the textural and sensory qualities of biscuits.

Amee and Joshi (2014) studied on processing for value addition of underutilized fruit crops with an objective to develop the procedure for production of pumpkin powder.

Kumar *et al.* (2015) studied on development and quality evaluation of pumpkin powder fortified cookies. The pumpkin powder was incorporated into the traditional recipe for preparation of cookies to replace wheat flour at levels of 10, 20, 30, 40 and 50. The nutritional value of the cookies with 50-50 per cent of pumpkin powder fortified fibre cookies was higher than other samples. Result of sensory evaluation revealed that 30 per cent replacement of wheat flour with pumpkin powder has higher overall acceptability, taste, texture and flavor and it was accepted by the panelists.

Sudipta and Soumitra (2015) studied on production of pumpkin powder and its utilization in bakery product development and reported that, the substituted products had high energy content. Pumpkin powder at lower concentration was found to be the

optimum for replacement of wheat flour for production of pumpkin based bakery products.

2.6.2 Storage stability of pumpkin fortified biscuits

Width and thickness of biscuits

Pasha *et al.* (2002) reported that the cookies prepared by incorporation of different sweeteners has width, thickness and spread ratio of 23.7-25.0 mm, 6.7-8.5 mm and 27.8-36.8, respectively.

Carrot pomace powder used in biscuits recipe was analyzed for its effects on physical parameters of biscuits. Diameter of sweet and salty biscuits gradually increased but no significant difference in thickness of biscuits was found with increase in addition of carrot pomace powder. As a result, spread ratio of biscuits also increased gradually with increased incorporation of carrot pomace powder. However, no significant increase in diameter and spread ratio of biscuits beyond 20 per cent incorporation of carrot pomace powder was noticed (Kumari and Grewal, 2007).

Mahmood *et al.* (2008) reported that width, thickness and spread ratio of retinyl acetate (vitamin A) fortified cookies vary from 2.32-2.38 cm, 0.52 -0.53 cm and 0.45 -0.46, respectively during storage of 90 days.

Oluwamukomi *et al.* (2011) reported that using 40 per cent of cassava flour into wheat biscuit formula improved their diameter, spread ratio, per cent spread and shape of biscuits.

Hussein *et al.* (2011) reported that using 20 per cent of germinated fenugreek seed flour into wheat biscuit formula improved diameter, spread ratio and shape of the biscuits.

Nagi *et al.* (2012) observed that weight of biscuits prepared from cereal bran used in different proportions vary from 1.70-1.74 g. Aziah and komathi (2012) investigated the effects of moong flour in cookies on physicochemical properties. The moong bean cookies were found to have significantly higher weight, diameter, height and spread ratio.

The cookie making potential of unripe plantain and defatted sesame flours blended at different proportions were evaluated. The diameter and thickness of composite cookies were not significantly differed from control, while weight of the former was significantly higher than the latter (Chinma *et al.*, 2012).

A study done by Joel *et al.* (2014) on production and quality assessment of enriched cookies from whole wheat and full fat soya revealed that width of the cookies samples A, B, C and D increased as a result of the increased level of soy-flour substitution. The reverse was observed for the thickness of the cookies.

Moisture content and water activity

Biscuits substituted with breadfruit flour had (11.5%) higher moisture content compared to biscuits prepared from 100 per cent wheat flour (Olaoye *et al.*, 2007).

Cookies prepared by replacing sucrose with dietetic sweeteners have increasing trend of moisture content when packed in polyethylene bags and stored for 60 days (Pasha *et al.*, 2002). An increase in the moisture during the storage of biscuits prepared from sweet potato flour at different proportions has been found by Srivastava *et al.* (2012).

A study by Nagi *et al.* (2012) on changes in moisture content of cereal bran biscuits revealed that the moisture content was found to increase from 2.00-4.28 and 2.00-4.09 per cent, respectively during the storage of three months when the product was packed in high density polyethylene and laminates.

Ritika *et al.* (2012) reported that the moisture content in the supplemented (composite flour) biscuits ranged from 2.9 to 3.9 per cent significantly higher (2.6%) than that of control biscuits (100% wheat flour).

The moisture content of cookies increased linearly with increase in concentration of pumpkin flour, this attributed to high water binding capacity of pumpkin powder which retained higher moisture content in the ultimate products (Kumar *et al.*, 2015).

A study by Borneo *et al.* (2007) on change in water activity of cream filled sandwich cookies revealed that water activity increased from 0.60-0.65 during the

storage of 28 days. Mushtaq *et al.* (2010) recorded an increase in water activity of cookies prepared by xylitol replacement with sucrose during storage of 60 days.

The water activity of biscuit samples are in the range of 0.45-0.47 which indicate that values are in the safe range of keeping quality (Legesse and Emire, 2012).

ß- carotene and Ascorbic acid

Butt *et al.* (2004) studied the retention of ß- carotene during the storage and noticed a moderate loss after 60 days in the cookies fortified with palm oil. Mahmood *et al.* (2008) also observed a decreasing trend in retinal acetate (vitamin A) and revealed that it decreased from 9.96-9.13 µg/100 g after storage of 90 days.

According to Kulkarni and Joshi (2013), ß- carotene in cookies prepared by replacing wheat flour with pumpkin flour was 208 µg/100 g (2.5% optimized sample). Biscuits with more pumpkin powder had a more yellow colour than those with less pumpkin powder. Adding more pumpkin powder increased the level of carotene in the biscuits.

Sudipta and Soumitra (2015) studied on production of pumpkin powder and its utilization in bakery product development and reported that adding more pumpkin powder increased the level of carotene and phytochemicals in the bakery products.

Youssef and Rasha (2012) reported that vitamin C content of fortified wheat biscuits with citrus peel powder decreased with increasing storage period.

According to Kumar *et al.* (2015) there is a significant increase in vitamin C content during incorporation of pumpkin powder because pumpkin powder has sufficient amount of vitamin C, but there was decrease in the vitamin C during storage.

Fibre and Sugars

Ahmad (1996) revealed that the fibre content of cookies was found to decrease with increase in storage time. Similar trend of decrease with increase in storage of cookies was studied by Ahad (1999) and Akbar (2000).

Utilization of 30 per cent carrot pomace powder for preparation of high fibre biscuits also resulted in increased mineral content of sweet and salty biscuits. Fibre content of sweet and salty biscuits ranged between 8.3-8.7 g per biscuit. No significance differences in mean weight of high fibre sweet and salty biscuits were observed with increased incorporation of carrot pomace powder (Kumari and Grewal, 2007).

Breadfruit was processed into flour and used to supplement wheat flour in the percentages of 0, 5, 10, 15, 20 and 25 for biscuit production. The crude fibre and ash content percent increased with an increase in the proportion of breadfruit flour (BF) level, with the 25 per cent BF level having the values of 4.98 and 6.78 per cent respectively (Olaoye *et al.*, 2007).

Cookies substituted with 30 per cent apple recorded high content of crude fibre 3.15 per cent (Bilgicli, 2010). Muffins fortified with apple skin powder had higher dietary fibre, total phenolic content and total antioxidant content than the control. The nutritional quality was positively correlated to the amount of apple skin powder incorporated into muffins (Vasantha *et al.*, 2008).

Aziah and Komathi (2009) processed pumpkin pulp, unripe banana pulp, unripe mango pulp and peel which are high in dietary fibre in to flour and substituted at 5 percent level for wheat flour in a composite flour crackers formulation.

Fibre content in cookies prepared by xylitol replacement with sucrose was reported to reduce from 0.130 to 0.124 per cent after 60 days of storage (Mushtaq *et al.*, 2010).

Biscuits substituted with 40 per cent of cassava flour recorded high content of 0.6 per cent crude fibre (Oluwamukomi *et al.*, 2011). Biscuits substituted with 15 per cent black carrot pomace recorded high (3.72%) total dietary fibre content (Turksoy and Ozkaya, 2011).

Blends of plantain and chickpea flours each with concentrations of 0, 10, 20, 30 and 40 per cent along with refined wheat flour were used for the development of biscuits. The flours were evaluated for their chemical functional properties. Plantain flour had highest crude fibre (3.6%) and carbohydrate content (80.8%). The protein

and crude fibre content of biscuits increased significantly from 7.1 to 9.2 per cent and 1.1 to 3.6 per cent, respectively with increased level of chickpea flour and plantain flours in the blends (Ritika *et al.*, 2012).

The mean fibre content of the different samples of pumpkin powder cookies was increased with the increase in amount of the pumpkin powder (Kumar *et al.*, 2015).

Sucrose is not a reducing sugar and does not participate in Maillard reactions. Hydrolysis of sucrose produces glucose and fructose, both are reducing sugars. Thus increasing trend of sugar content (reducing sugar and total sugar) was observed by Penfield and Campbell (1990) during storage. Cookies are generally baked at moderate temperatures, the role of caramelization in cookie colour and flavour was uncertain (Davis, 1995).

The total sugar range from 11.59 to 14.35 per cent in composite cookies, whereas control cookies had higher sugar content than the composite cookies (Chinma *et al.*, 2012).

Sensory characteristics of biscuits

A gradual decrease in overall acceptability of biscuit during storage was reported by Elahi (1997) who attributed it to moisture absorption, increase in peroxide value and free fatty acid content in biscuits.

Pasha (2001) observed that colour characteristics of cookies decreased with increase in storage period. The other characters like texture, flavor, taste and crispness characteristics were found to have a decreased trend during storage.

Inclusion of fenugreek flour in rice bran with wheat flour (5-20%) improved physical and sensory characteristics of breads as well as cookies (Sharma and Chauhan, 2002).

Organoleptic and nutritional quality of wheat biscuits supplemented with raw, soaked and germinated fenugreek flour was found to be better than normal biscuits (Shalini and Sudesh, 2005).

Pongjanta *et al.* (2006) reported that substituting a portion of wheat flour with pumpkin powder in sandwich bread, sweet bread and cookies were acceptable at 10 per cent level and 20 per cent in butter cakes and chiffon cake. Further increase in the substitution level would affect colour, volume and overall acceptability of the products.

Incorporation of carrot pomace powder (CCP) increased the spread ratio of biscuits where no significant differences in mean scores for all sensory attributes was observed by the addition of carrot pomace powder up to 20 per cent. However, further addition of carrot pomace powder up to 30 per cent significantly decreased the mean scores for some sensory attributes of sweet biscuits and in all the sensory attributes and salty biscuits (Kumari and Grewal, 2007).

The sensory evaluation showed that breadfruit supplemented biscuits were not significantly different from whole wheat biscuits with respect to sensory attributes of texture, appearance and general acceptability at all levels of breadfruit supplementation. Significant differences for crispness, aroma and taste were not observed up to 20 per cent breadfruit level (Olaoye *et al.*, 2007).

Mepba *et al.* (2007) investigated the feasibility of partially replacing wheat flour with plantain flour in bread and biscuit making process. The organoleptically acceptable breads and biscuits were formulated from wheat – plantain composite flours using up to 80:20 (w/w) per cent and 60:40 (w/w) ratios of wheat: plantain flour substitution for breads and biscuits, respectively.

Textural and sensory properties of cookies were studied by supplementing various proportion of sweet potato flour (0-100%) to the wheat flour (60%) which lowered the overall acceptability (2.70) because of taste and distinct flavor developed during baking (Singh *et al.*, 2008).

Pumpkin pulp, unripe banana pulp, unripe mango pulp and peel were processed into flour and substituted at 5 per cent level for wheat flour in a composite flour crackers formulation. Different types of composite flour crackers were not significantly different in terms of crispness, colour, taste and overall acceptance. The pumpkin, banana and control crackers differed significantly with the mango pulp and mango peel crackers (Aziah and Komathi, 2009).

Cookie substituted with 10 per cent of apple pomace increased the nutritional value without affecting sensory characteristics (Bilgicli, 2010). The sensory properties of cookies prepared by replacing refined wheat flour up to 50 per cent each with cocoyam flour was similar to those of control biscuits (Okpala and Okali, 2010).

The general acceptability of biscuits was good at 10 per cent level of incorporation of black carrot powder (Turksoy and Ozkaya, 2011).

In case of biscuits substituted with 11 per cent sugar beet dietary fibre flour increased the nutritional value without affecting sensory characteristics (Marijana *et al.*, 2011).

Ashoush and Gadallah (2011) observed that the incorporation of 10 per cent mango kernel powder enhanced the nutritional quality and improved the antioxidant properties of biscuits without affecting sensory attributes.

Biscuits containing twenty per cent potato flour showed the best performance in sensory and nutritional characteristics (Seevaratnam *et al.*, 2012). The sensory acceptance to the 20 per cent resistant starch rich ingredient biscuits did not differ significantly from that of the control. But, 40 per cent resistant starch rich ingredient reduced the acceptability by reducing the colour, appearance and texture without altering the taste, sweetness and overall acceptance (Laguna *et al.*, 2011).

The biscuits processed from wheat flour supplemented by 5 or 10 per cent of fenugreek seed flour had higher acceptance scores for all sensory characteristics. Yet, the biscuits containing 15 or 20 per cent of fenugreek seed flour were significantly different and were unacceptable by panelists as compared with the other samples (Hussein *et al.*, 2011).

The sensory properties of biscuits prepared by replacing refined wheat flour up to 20 per cent each with plantain and chickpea flour were more or less similar to those of control biscuits (Ritika *et al.*, 2012).

In another study, potato flour was incorporated in the traditional recipe to replace wheat flour at levels of 10, 20 and 30 percent in preparation of biscuits with maintaining all other ingredients constant. A declining trend in acceptability was

observed with the increased level of potato flour for all the sensory characteristics (Vasantharuba *et al.*, 2012).

Kulkarni and Joshi (2013) reported that amount of force required to bite the biscuit increased with concentration of pumpkin powder. When the concentration of powder was highest the hardness of the biscuits was highest, *i.e.* 3263 g. Similarly, increasing the replacement level of refined wheat flour with pumpkin powder fracturability also increased. When the replacement level of refined wheat flour with pumpkin powder was increased to 10 per cent the fracturability of biscuit increased to 1.74 mm. Biscuits made with 2.5 per cent pumpkin powder scored maximum number in all sensory parameters *viz.*, colour and appearance, flavor, texture and taste.

Saeed *et al.* (2012) investigated the effect of replacement of wheat flour with sweet potato flour on quality of cookies. Sensory evaluation in their study revealed that sweet potato flour level beyond 10 per cent lowered the overall acceptability.

Flour blends containing up to 30 per cent mango seed kernel flour were acceptable for biscuits production without adverse effect on sensory qualities (Legesse and Emire, 2012).

Aziah and komathi (2012) investigated the effects of wheat flour substitution with legume flour in cookies in terms of the physicochemical and organoleptic properties. Three formulations of cookies were prepared from (a) control (100% wheat flour) (b) Moong bean (50% wheat flour + 35% moong bean flour + 15% corn flour) and (c) Chick pea (50% wheat flour + 35% chick pea flour + 15% corn flour). The physicochemical and organoleptic attributes of the three types of cookies were evaluated. Sensory evaluation recorded that fortified chick pea cookies showed significant difference in flavor, crispness and after taste attributes but overall acceptability was recorded in significant difference. Chickpea cookies had the best flavor, crispness and acceptability.

Kumar *et al.* (2015) studied on development and quality evaluation of pumpkin powder fortified cookies. Result of sensory (appearance, colour, flavor, texture, taste and overall acceptability) evaluation revealed that the 30 per cent addition of pumpkin powder has higher overall acceptability, taste, texture and flavor

and it was accepted by the panelists. However, a declining trend in acceptability was observed with increasing level of pumpkin powder for all the sensory characteristics.

Sudipta and Soumitra (2015) reported that increasing the pumpkin flour concentration had an adverse effect on sensory analysis and colour. Pumpkin flour with low to medium concentration was found to be more acceptable from sensory point of view and thereafter sensory score was reduced.

3. MATERIAL AND METHODS

An investigation entitled "Standardization of protocol for the preparation of pumpkin (*Cucurbita moschata* D.) candy and biscuits" was carried out in the laboratory of the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture (University of Horticultural Sciences, Bagalkot), Arabhavi, Gokak taluk and Belagavi district of Karnataka state during the period 2017-18. The details of the experiment, materials used, techniques adopted and methodologies followed during the investigation are presented in this chapter.

3.1 Geographical location and climate

Arabhavi is situated in Northern Dry Zone (Zone-3) of region - 2 of agro climatic zone of Karnataka state at 60°15' North latitude, 94°45' East longitude and at an altitude of 612.05 m above the mean sea level. The average annual rainfall at Arabhavi is about 550 mm and it is distributed over a period of seven months from May to November. The mean temperature goes up to 38.5ºC (May) and mean minimum temperature drops down to 18.5ºC (February). The mean relative humidity varies between 42.65 and 81.00 per cent during April and December respectively.

3.2 Material

Ripe pumpkin fruits of uniform size, shape and maturity, free from visible damages were purchased from the Belagavi vegetable market. The fruits were washed in clean water to remove the dirt and stored in ambient condition for further use. The sugar powder, refined wheat flour, milk powder, hydrogenated fat (Dalda) and baking powder were purchased from the local market of Gokak, Belagavi district.

Experimental details

3.3 Experiment 1: Standardization of protocol for the preparation of pumpkin candy

The design of the experiment was completely randomized design (CRD) with nine treatments and three replications.

Treatment details

T_1: Control (without blanching and citric acid)

T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid

T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid

T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid

T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid

T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid

T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid

T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid

T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

3.3.1 Methodology for the preparation of pumpkin candy

Uniformly matured pumpkin fruits were washed thoroughly with tap water to remove the dirt and adhering soil and weighed using electronic weighing balance. The fruit was cut into halves using stainless steel knife; seed, fluffy portion and fibrous strands were removed manually, further fruit was cut into strands and peel was removed using hand peeler and were again made into small cubes. Pumpkin cubes were blanched in boiling water for specific period of time (7 and 10 minutes) as per the treatment details and immediately after blanching dipped in cold water to avoid over cooking. Blanched pumpkin cubes were pricked and steeped in sugar syrup (40ºB) and citric acid (0.5 and 1%) as per the treatments. After 24 hours of steeping in syrup, pumpkin cubes were strained out of syrup and degree brix of sugar syrup was raised to 50ºB and same process was repeated every next 24 hours up to 70ºB. In T_6, T_7, T_8 and T_9 after preparation of pumpkin cubes they were covered with sugar crystals in alternate layers. The mixture was left for 24 hours. Next day formed syrup was drained and TSS increased gradually by adding sugar and boiling. The process was repeated till syrup of 70ºB was formed. The cubes were left in 70ºB sugar syrup for two more days for complete absorption of syrup.

Plate 1. Methodology for preparation of pumpkin candy

Cubes were strained out of sugar syrup using strainer and slightly washed with filtered water to remove the excess syrup to avoid stickiness during drying, cubes were again given shape using small knives to remove unattractive part, then the cubes were dried at 60ºC using electric tray drier. Dried cubes were weighed and then packed in LDPE pouches with proper label. Packed candies were stored in ambient condition for further storage studies.

3.3.2 Observations recorded

The following physico-chemical parameters were recorded immediately after preparation of pumpkin candy and at monthly interval during storage up to 3 months.

3.3.2.1 Recovery (%)

Recovery percentage of pumpkin candy was calculated by recording weight of pumpkin cubes before drying and after drying and multiplying it by hundred to get percent value.

$$\text{Recovery (\%)} = \frac{\text{Final product weight}}{\text{Initial weight}} \times 100$$

3.3.2.2 Moisture content (%)

Moisture content of the pumpkin candy was determined by using moisture analyzer (Model: P1019319, A & D Company Limited, Japan). One gram of sample was placed in the sample dish and dried in the electric moisture analyzer until it automatically showed constant moisture in percentage.

3.3.2.3 Colour (*L*a*b**) values

The colour of the pumpkin candy was measured by using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with 8 mm aperture. The instrument was calibrated using black and white tiles provided. Colour was expressed in Lovibond units L^* (lightness/darkness), a^* (redness/greenness) and b^* (yellowness/blueness). In order to obtain these values, the lens of colour reader was placed over the pumpkin candy samples. The colour difference between the treatments was observed, three measurements were performed and the values were averaged to get final value.

3.3.2.4 Titratable acidity (%)

The acidity of the pumpkin candy was determined by titration method. A known amount of candy sample (1g) was taken and reconstituted with water. The known volume of the reconstituted sample (10 ml) was taken and titrated against 0.1N standard NaOH solution using phenolphthalein indicator. The appearance of light pink colour which persisted for few seconds was marked as the end point. The value was expressed in terms of citric acid as per cent acidity of sample (AOAC, 1990).

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value x N. of NaOH x Vol. made up x Eq. weight of citric acid}}{\text{Vol. of aliquot x Vol. wt of sample taken x 1000}} \text{ x } 100$$

3.3.2.5 Ascorbic acid content (mg/100 g)

Ascorbic acid content of pumpkin candies were estimated by using the method given by AOAC (1990), which was based on the reduction of 2,6-dichlorophenol indophenols (2,6-DCPIP) by ascorbate.

1 g of sample was crushed with 4 per cent oxalic acid in pestle and mortar and the filtrate was carefully extracted through layers of muslin cloth. The final volume was made up to 50 ml using 4 per cent oxalic acid.

5 ml of aliquot was taken in a 50 ml beaker and 5 ml of 4 per cent oxalic acid was added and stirred. It was titrated against the 2, 6-dichlorophenol indophenol dye solution until pink end point was observed which persisted for few seconds. Volume of dye (TV_2) consumed for each sample was noted. Same procedure was repeated with standard ascorbic acid solution and volume of dye (TV_1) consumed was recorded.

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Ascorbic acid in standard x } TV_2 \text{ x Vol. made up}}{\text{Aliquot taken x } TV_1 \text{ x Weight of sample}} \text{ x } 100$$

3.3.2.6 ß-carotene content (mg/100 g)

ß -carotene present in pumpkin candies were estimated using petroleum ether method (Ranganna, 2003).

Five grams of candy sample was crushed in 10 ml acetone by adding few crystals of anhydrous sodium sulphate with the help of pestle and mortar. The supernatant was separated into a beaker and the process was repeated with sample until it became white. The supernatants were pooled and transferred into a separating funnel and 10-15 ml petroleum ether was added to it. The two layers got separated on standing. Lower layer of acetone was removed and the volume of upper layer was made to 50 ml. The optical density (OD) was read at 452 nm using petroleum ether as blank and the quantity of ß -carotene was estimated using the following formula.

$$\text{ß -carotene (mg/100 g)} = \frac{\text{OD x 13.9 x } 10^4 \text{ x 100}}{\text{Wt. of sample x 560 x 1000}}$$

3.3.2.7 Reducing sugars (%)

The per cent reducing sugars present in pumpkin candies were estimated using 3, 5-Dinitro Salicylic Acid (DNSA) method (Miller, 1972). The values obtained are expressed as per cent.

$$\text{Reducing sugars (\%)} = \frac{\text{Value from graph x volume of alcohol free extract}}{\text{Aliquot sample used x weight of sample}} \text{ x 1000}$$

3.3.2.8 Non-reducing sugars (%)

The percent non-reducing sugars were obtained by subtracting the value of reducing sugar from total sugars and multiplying with a correction factor.

Non-reducing sugar (%) = [Total sugar (%) – Reducing sugar (%)] x 0.95

3.3.2.9 Total sugars (%)

The total sugar content in the products were estimated by the same method as in case of reducing sugar but after inversion of the non-reducing sugar using dilute hydrochloric acid.

3.3.2.10 Non-enzymatic browning (OD value)

Non-enzymatic browning was measured by using a spectrophotometer. Five grams of pumpkin candy samples were soaked in 100 ml of 60 per cent alcohol

for 12 hours (sample and alcohol in 1:5 ratios). Then it was filtered and absorbance was read at 420 nm using 60 per cent alcohol as blank. The readings displayed in the spectrophotometer were noted and expressed as optical density value (Ranganna, 2003).

3.3.2.11 Microbial load

The total bacterial and fungal count in pumpkin candy samples were taken at interval during storage as per the method of Harrigan and Mccance (1996).

Preparation of sample, enumeration and counting of microbial load

Samples were prepared by taking ten gram of representative sample from three replications in each treatment. 10 gram of sample was mixed with 90 ml sterilized water blank in a conical flask and serial dilution technique was carried out to estimate the total fungal and bacterial load in the pumpkin candy samples. The dilution 10^{-3} was used for fungi counting and 10^{-5} was used for bacterial counting. 1 gram of aliquot from respective dilution was transferred to petri plates in duplication and sterilized lukewarm molten Potato dextrose agar and Nutrient agar were poured to the respective plates for the isolation of fungi and bacteria respectively. After solidification, the plates were incubated at 37±1ºC for three to five days and colony counts were recorded, tabulated and expressed as CFU/g of sample.

3.3.2.12 Organoleptic evaluation

Organoleptic evaluation of pumpkin candy was done at initial and at monthly interval up to 3 months of storage. It was carried out by a semi-trained panel of judges consisting of teachers and post-graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi. The sensory characters like colour and appearance, texture, taste, flavour and overall acceptability were evaluated on a nine point hedonic scale using the score card mentioned below (Ranganna, 2003).

Score card:

Hedonic scale	Colour and appearance	Texture	Taste and flavour	Overall acceptability
Like extremely	9	9	9	9
Like very much	8	8	8	8
Like moderately	7	7	7	7
Like slightly	6	6	6	6
Neither like nor dislike	5	5	5	5
Dislike slightly	4	4	4	4
Dislike moderately	3	3	3	3
Dislike very much	2	2	2	2
Dislike extremely	1	1	1	1

3.3.2.13 Statistical analysis

The data recorded on the physico-chemical and organoleptic parameters were subjected to statistical analysis in Completely Randomized Design. Analysis was done by using Web Agri. Stat. Package 2 developed by ICAR research complex, Goa. Interpretation of the data was carried out in accordance with Panse and Sukhatme (1985). The level of significance used in 'F' test was p = 0.01. Critical difference values were calculated wherever 'F' test was significance.

3.4 Experiment 2: Standardization of protocol for the preparation of pumpkin fortified biscuits

The design of the experiment was completely randomized design (CRD) with nine treatments and three replications.

Treatment details

T_1: 100 % refined wheat flour

T_2: 05% Pumpkin powder + 95% refined wheat flour

T_3: 10% Pumpkin powder + 90% refined wheat flour

T_4: 15% Pumpkin powder + 85% refined wheat flour

T_5: 20% Pumpkin powder + 80% refined wheat flour

T_6: 05% Pumpkin pulp + 95% refined wheat flour

T_7: 10% Pumpkin pulp + 90% refined wheat flour

T_8: 15% Pumpkin pulp + 85% refined wheat flour

T_9: 20% Pumpkin pulp + 80% refined wheat flour

3.4.1 Preparation of pumpkin fortified biscuits

3.4.1.1 Recipe for the preparation of biscuits

Refined wheat flour (Maida) - 200 g, dalda-100 g, sugar powder-120 g, milk powder-2 table spoon, baking powder-1/4th tea spoon, ammonium bicarbonate-1/4th tea spoon and pinch of salt.

3.4.1.2 Preparation of pumpkin powder and pumpkin pulp for incorporation into biscuits

Ripe pumpkin fruits were washed, peeled, sliced with sharp knife and grated using hand grater. Grated shreds were blanched for 7 minutes in boiling water and cooled. Blanched pumpkin shreds were spread evenly on the trays to a thickness of 10 mm. These trays were loaded into electric drier which was maintained at 60ºC temperature and dried for 12 hours. After complete drying, dried shreds were collected and powdered using mixer to fine texture. Some shreds of pumpkin pulp blanched for 7 minutes, dried at 60ºC for 15 minutes to remove excess moisture and was used for treatments 6, 7, 8 and 9.

3.4.1.3 Methodology for the preparation of pumpkin fortified biscuits

A fine cream was prepared by mixing sugar with dalda. Required quantity of refined wheat flour, pumpkin powder or pulp, milk powder, sugar, salt and baking powder were sieved on the working table. Refined wheat flour and pumpkin powder was blended to the mixture and was kneaded to soft and smooth dough. The dough was made into small, uniformly round balls and placed on baking trays. The baking was performed in an oven at the temperature of 200ºC for 15 minutes. Biscuits were taken out, cooled and packed in LDPE pouches, labeled and stored in ambient condition for further studies.

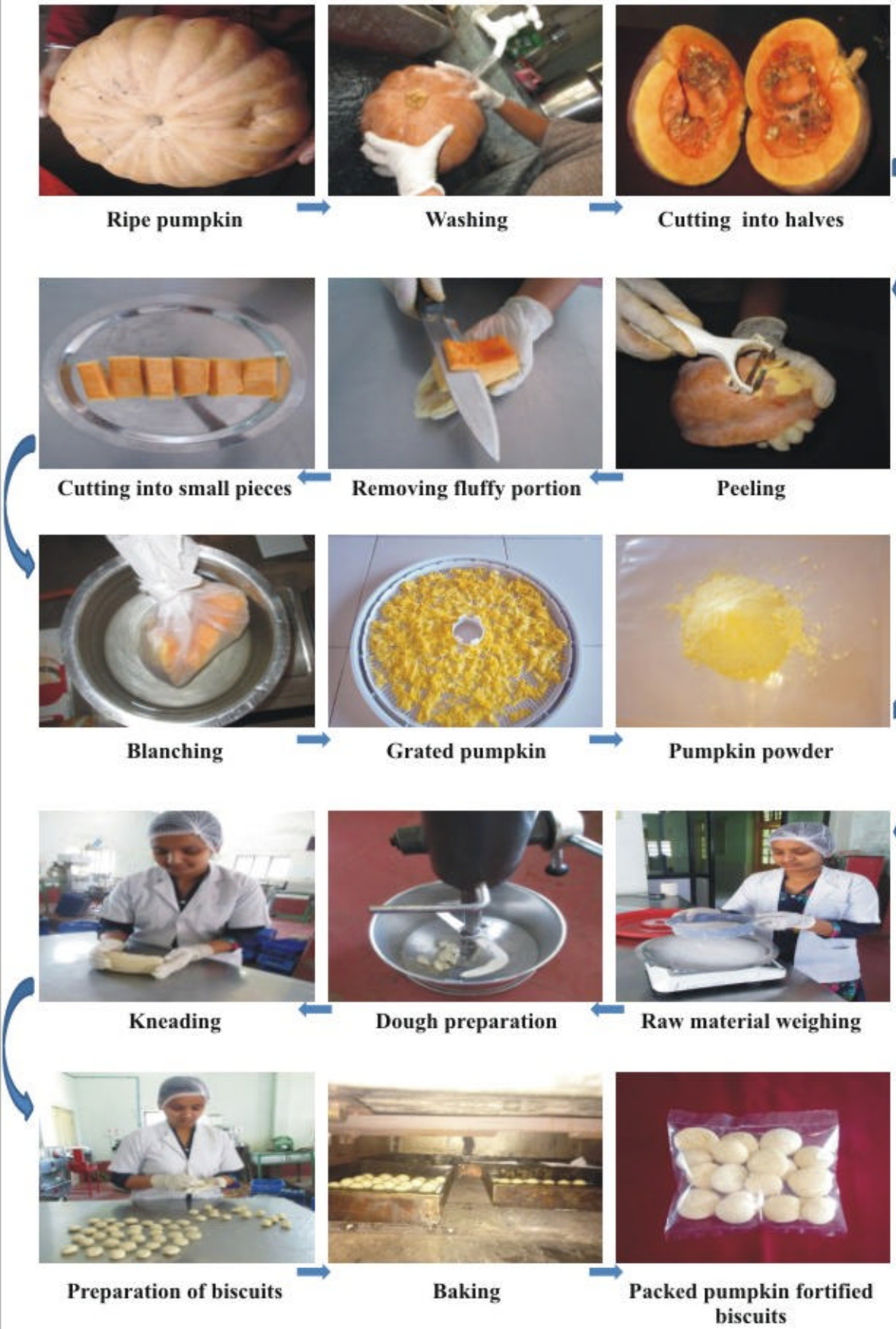


Plate 2. Methodology for preparation of pumpkin fortified biscuits

The wheat flour was replaced with pumpkin powder and pumpkin pulp in the proportion as detailed in the treatments.

3.4.2 Observations recorded

The following physico-chemical parameters were recorded immediately after preparation of pumpkin fortified biscuits and at monthly interval during storage up to 3 months.

3.4.2.1 Moisture content (%)

The moisture content of pumpkin fortified biscuits were measured as mentioned in 3.3.2.2

3.4.2.2 Water activity (a_w)

Water activity of pumpkin fortified biscuit samples were measured using a digital water activity meter (Model: Novasiwa AG, Switzerland). One fourth the volume of container was filled with the sample and it was closed with a lid containing sensor and left few minutes undisturbed. After stabilization the water activity was displayed by the digital water activity meter.

3.4.2.3 Width and Thickness (cm)

The width and thickness of pumpkin fortified biscuits were measured using digital vernier caliper by placing biscuits in between the measuring arms of the instrument and values were recorded in centimeter.

3.4.2.4 Ascorbic acid (mg/100 g)

The ascorbic acid content of pumpkin fortified biscuit was measured as mentioned in 3.3.2.5.

3.4.2.5 ß-carotene (mg/100 g)

The amount of ß-carotene present in pumpkin fortified biscuit was measured as mentioned in 3.3.2.6.

3.4.2.6 Reducing sugars (%)

The amount of reducing sugars present in pumpkin fortified biscuit was measured as mentioned in 3.3.2.7.

3.4.2.7 Non-reducing sugars (%)

The amount of non- reducing sugars present in pumpkin fortified biscuit was measured as mentioned in 3.3.2.8.

3.4.2.8 Total sugars (%)

The amount of total sugars present in pumpkin fortified biscuits were measured as mentioned in 3.3.2.9.

3.4.2.9 Crude fibre (%)

Two gram of sample was homogenized with pestle and mortar using petroleum ether to extract fat. After extraction, the fat free residue was boiled with 200 ml of (0.255 ± 0.005 N) dilute sulphuric acid for 30 minutes with glass beads. After 30 minutes, it was filtered through muslin cloth and washed with boiling water until washings were no longer acidic. Again boiled with 200 ml of (0.313 ±0.005 N) sodium hydroxide solution for 30 minutes and filtered through muslin cloth. Later, it was washed with 25 ml of boiling 1.25 N sulphuric acid. The residue was collected and transferred to ashing dish (pre-weighed dish W_1) dried for 2 hours at 130 ± 2ºC. Dish was cooled in a desiccator and weighed (W_2). Samples were ashed in muffle furnace at 600ºC temperature and the ash content was cooled in desiccators and weighed (W_3). The difference represents the crude fibre content of the sample and was expressed in per cent (Ranganna, 2003).

$$\text{Crude fibre (\%)} = \frac{\text{Loss in weight on ignition } (W_2 - W_1) - (W_3 - W_1)}{\text{Weight of the sample}} \times 100$$

3.4.2.10 Microbial load

The microbial studies of pumpkin fortified biscuits was carried out as mentioned in 3.3.2.11.

3.4.2.11 Organoleptic evaluation

Organoleptic evaluation of pumpkin fortified biscuits was done as mentioned in 3.3.2.12.

3.4.2.12 Statistical analysis

The Statistical analysis of pumpkin fortified biscuits was done as mentioned in 3.3.2.13.

4. EXPERIMENTAL RESULTS

The results of the experiment entitled "Standardization of protocol for the preparation of pumpkin (*Cucurbita moschata* D.) candy and biscuits" conducted at the department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi, Karnataka during 2017-2018 are presented in this chapter.

4.1 Experiment 1: Standardization of protocol for the preparation of pumpkin candy

4.1.1 Recovery (%)

The data pertaining to recovery percentage of pumpkin candy as influenced by different treatments are presented in table 1. The data reveals that there was a significant difference between the treatments with respect to recovery. Significantly maximum percent recovery of candy was recorded in T_3 -Blanching for 7 minutes + steeping in 40 to 70ºB syrup + 1 % citric acid (80.10%) which was followed by T_2- Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid (74.50%), T_5 (72.37%) and T_4 (70.50%) whereas, minimum per cent recovery was recorded in T_1 (36.57%).

4.1.2 Moisture (%)

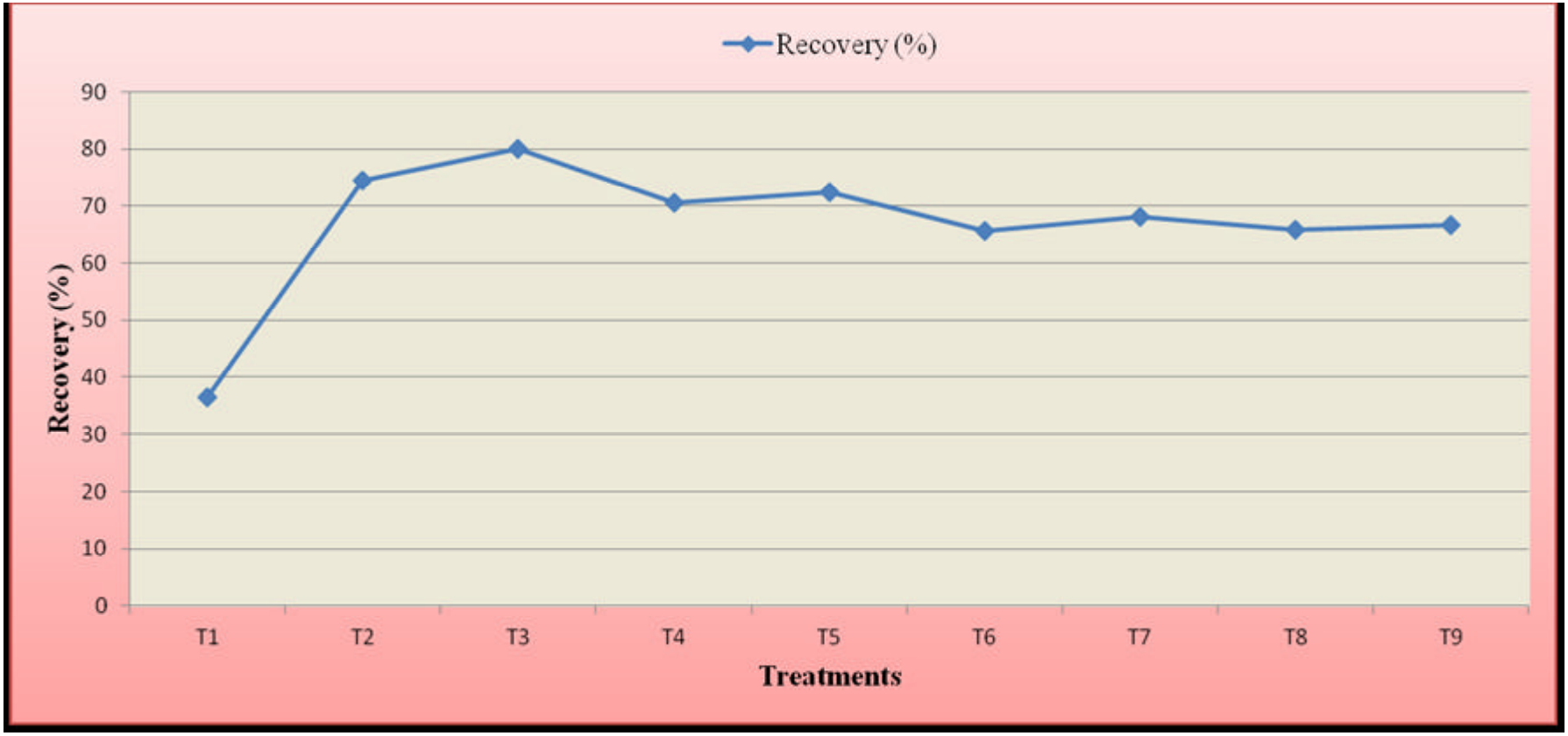
The data showing the changes in moisture percentage of pumpkin candy as influenced by different treatments and storage periods are presented in table 1. The data reveals that there was a significant difference between the treatments and percent moisture content was found to increase throughout the storage period.

Minimum per cent of moisture content was recorded in T_1- control (10.01, 10.20, 10.33 and 10.47%), it was followed by T_6 (10.50, 10.63, 10.73 and 10.83%) at initial, 1, 2 and 3 months after storage respectively. Whereas, maximum per cent moisture content was recorded in T_3- Blanching for 7 minutes + steeping in 40 to 70ºB syrup + 1 % citric acid (12.01, 12.11, 12.34 and 12.47%) at all intervals of storage.

Table 1: Effect of treatments and storage period on recovery and moisture content of pumpkin candy

Treatments	Recovery (%)	Moisture (%)			
		Months after storage			
		Initial	1	2	3
T_1	36.57	10.01	10.20	10.33	10.47
T_2	74.50	11.54	11.76	11.86	11.96
T_3	80.10	12.01	12.11	12.34	12.47
T_4	70.50	11.20	11.30	11.42	11.55
T_5	72.37	11.20	11.31	11.42	11.55
T_6	65.67	10.50	10.63	10.73	10.83
T_7	68.16	11.05	11.13	11.27	11.37
T_8	65.85	10.70	10.82	10.93	11.20
T_9	66.72	11.02	11.20	11.34	11.54
Mean	**66.71**	**11.02**	**11.16**	**11.30**	**11.44**
S.Em±	1.08	0.17	0.08	0.09	0.10
C.D. @ 1%	4.42	0.68	0.31	0.36	0.38

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid



T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 1. Effect of treatments on recovery (%) of pumpkin candy

4.1.3 Titratable acidity (%)

The data related to titratable acidity of pumpkin candy as influenced by different treatments and storage period are tabulated in table 2. The data on titratable acidity was expressed in terms of per cent citric acid and observations showed a significant difference among the treatments at initial and also throughout the storage period.

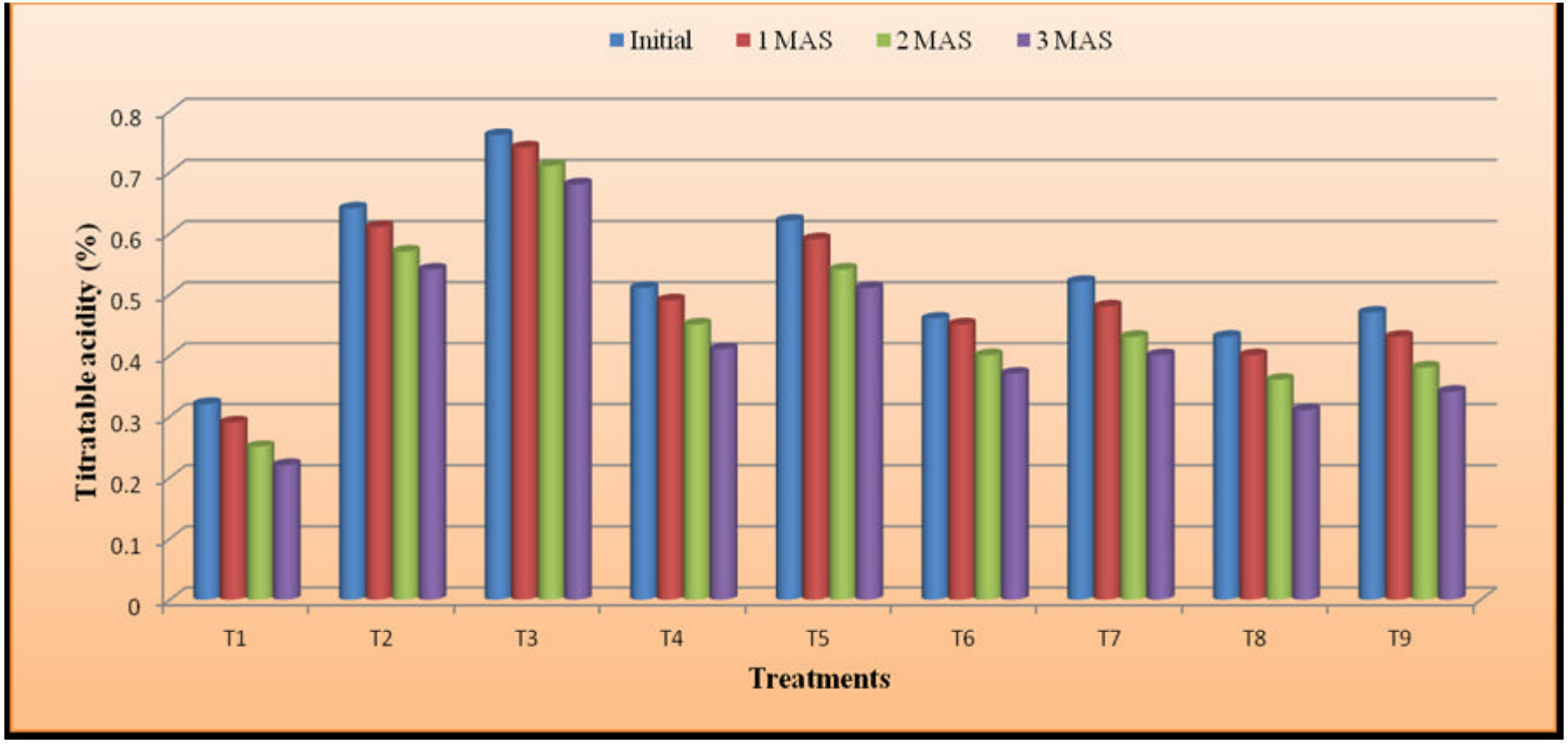
At initial day of storage maximum per cent titratable acidity of pumpkin candy was observed in T_3 (0.76%) and it was statistically followed by T_2 (0.64%) and T_5 (0.62%), while minimum per cent of titratable acidity was observed in T_1 (0.32%). After 1 month of storage maximum per cent titratable acidity was found in T_3 (0.74%), followed by T_2 (0.61%) and T_5 (0.59%) and minimum was recorded in T_1 (0.29%).

After 2 and 3 months of storage, maximum percent titratable acidity was recorded in T_3 (0.71 and 0.68%) it was followed by T_2 (0.57 and 0.54%) and T_5 (0.54 and 0.51%) whereas, minimum was found in T_1 (0.25 and 0.22%) respectively. Decreasing trend was observed in the titratable acidity content of pumpkin candy throughout the storage period.

4.1.4 Ascorbic acid (mg/100 g)

The data on the influence of different treatments and storage period on ascorbic acid content of the pumpkin candies were presented in table 2. The data reveals that there was a significant difference in ascorbic acid content and the mean ascorbic acid content of the candies gradually decreased with the increase in storage period among all the treatments.

Initially maximum ascorbic acid content of pumpkin candy was found in T_1 (8.20 mg/100 g) and it was followed by T_3 (7.63 mg/100 g) and T_2 (7.39 mg/100 g) whereas minimum ascorbic acid content was recorded in T_9 (6.53 mg/100 g). After 1 and 2 months of storage, maximum ascorbic acid content of pumpkin candy was found in T_1 (7.35 and 6.72 mg/100 g) and it was followed by T_3 (6.45 and 5.91 mg/100 g) and T_2 (6.23 and 5.64 mg/100 g) while minimum ascorbic acid content was recorded T_9 (5.30 and 4.73 mg/100 g) respectively.



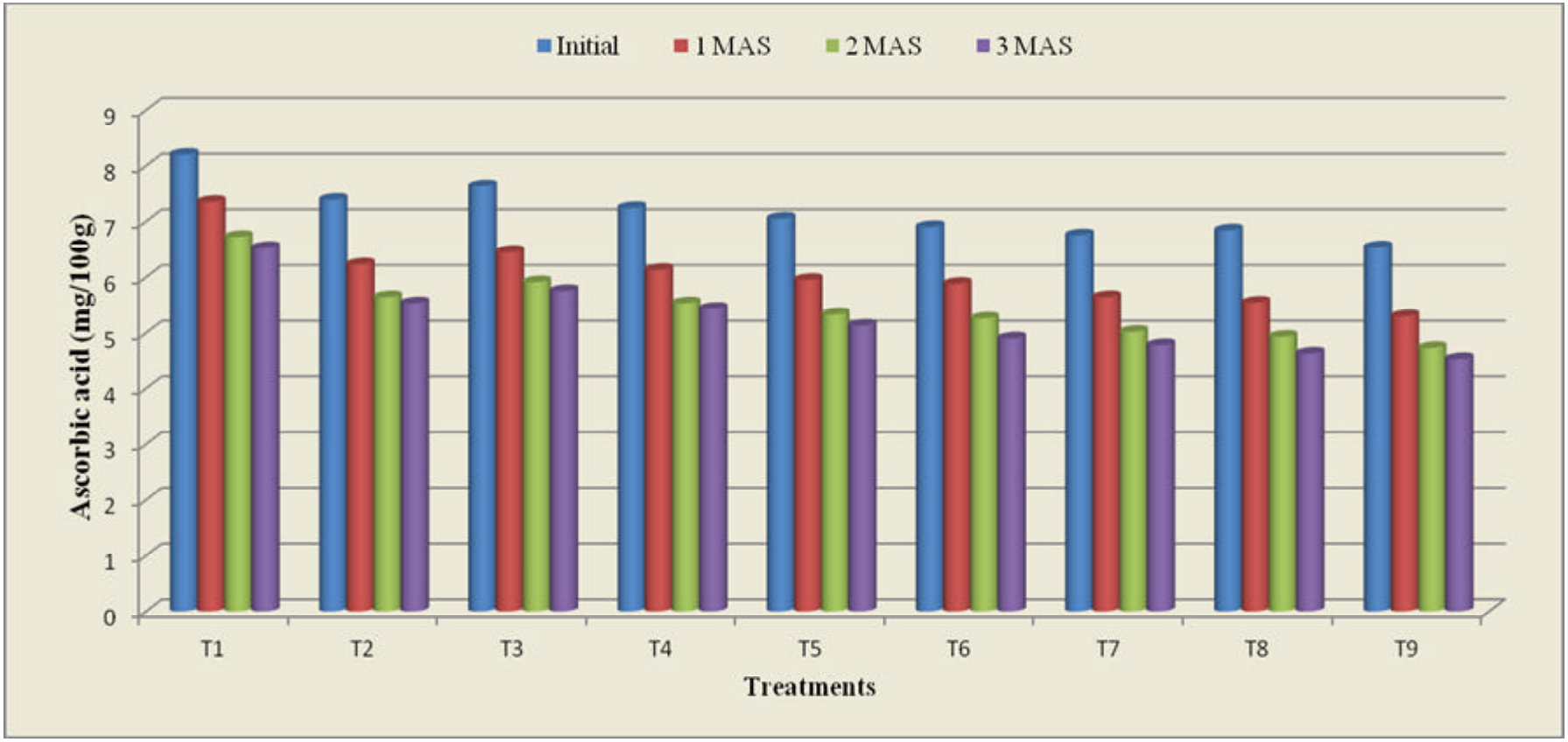
T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 2. Effect of treatments and storage period on titratable acidity (%) of pumpkin candy

Table 2: Effect of treatments and storage period on titratable acidity and ascorbic acid of pumpkin candy

Treatments	Titratable acidity (%)				Ascorbic acid (mg/100g)			
	Months after storage							
	Initial	**1**	**2**	**3**	**Initial**	**1**	**2**	**3**
T_1	0.32	0.29	0.25	0.22	8.20	7.35	6.72	6.52
T_2	0.64	0.61	0.57	0.54	7.39	6.23	5.64	5.53
T_3	0.76	0.74	0.71	0.68	7.63	6.45	5.91	5.75
T_4	0.51	0.49	0.45	0.41	7.24	6.13	5.53	5.43
T_5	0.62	0.59	0.54	0.51	7.05	5.95	5.33	5.13
T_6	0.46	0.45	0.40	0.37	6.90	5.88	5.26	4.90
T_7	0.52	0.48	0.43	0.40	6.75	5.64	5.02	4.78
T_8	0.43	0.40	0.36	0.31	6.84	5.54	4.93	4.63
T_9	0.47	0.43	0.38	0.34	6.53	5.30	4.73	4.53
Mean	**0.53**	**0.50**	**0.46**	**0.42**	**7.17**	**6.05**	**5.45**	**5.24**
S.Em±	0.018	0.016	0.017	0.016	0.07	0.09	0.07	0.05
C.D. @ 1%	0.03	0.02	0.02	0.02	0.31	0.35	0.28	0.21

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid



T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 3. Effect of treatments and storage period on ascorbic acid (mg/100 g) of pumpkin candy

After 3 months of storage, maximum ascorbic acid content was found in T_1 (6.52 mg/100 g), it was followed by T_3 (5.75 mg/100 g) and T_2 (5.53 mg/100 g) whereas, minimum was recorded in T_9 (4.53 mg/100 g).

4.1.5 ß -carotene (mg/100 g)

The data regarding changes in the ß–carotene content of the pumpkin candy as influenced by the different treatments and storage period are presented in table 3.

Data reveals a significant difference between treatments and there was a gradual decrease in ß–carotene content of pumpkin candy during storage. Maximum ß–carotene content (6.15 mg/100 g) was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and it was followed by T_5 (5.76 mg/100 g) and T_2 (5.72 mg/100 g) while, minimum ß–carotene content (3.67 mg/100 g) was observed in T_1 (Control) at initial storage.

Maximum ß–carotene content was recorded in T_3 (6.07 and 5.94 mg/100 g) followed by T_5 (5.67 and 5.56 mg/100 g) and T_2 (5.62 and 5.53 mg/100 g) while, minimum ß–carotene was recorded in T_1 (3.56 and 3.41 mg/100 g) after 1 and 2 months of storage respectively.

After 3 months of storage, maximum ß–carotene content of pumpkin candy was recorded in T_3 (5.83 mg/100 g) and it was followed by T_5 and T_2 (5.42 mg/100 g each) whereas, minimum ß–carotene content was recorded in T_1 (3.29 mg/100 g).

4.1.6 Non-enzymatic browning (OD value)

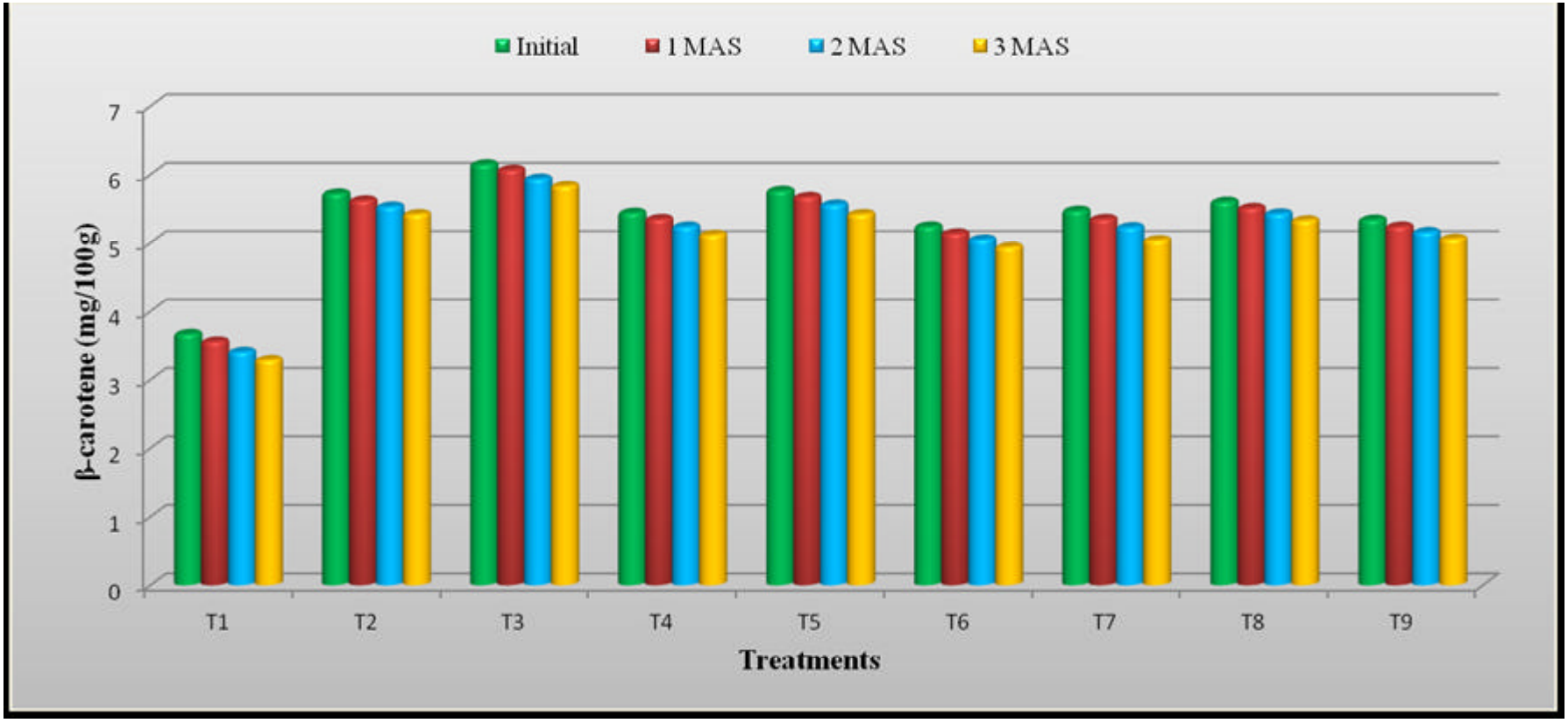
The data with respect to non-enzymatic browning of pumpkin candy as influenced by different treatments and storage period are presented in table 3. The non-enzymatic browning of pumpkin candy was found to have significant difference among the treatments initially as well as during storage period. In general, irrespective of the treatments non-enzymatic browning values found to increase slightly as the storage period increased.

Data recorded reveals that, initially minimum (0.123) non-enzymatic browning was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid) which was followed by T_4 (0.132) and T_7 (0.142), whereas, maximum non-enzymatic browning (0.223) was observed in T_1 (Control).

Table 3: Effect of treatments and storage period on ß-carotene and non-enzymatic browning of pumpkin candy

Treatments	ß–carotene (mg/100g)				Non enzymatic browning (OD)			
	Months after storage							
	Initial	**1**	**2**	**3**	**Initial**	**1**	**2**	**3**
T_1	3.67	3.56	3.41	3.29	0.223	0.240	0.285	0.303
T_2	5.72	5.62	5.53	5.42	0.160	0.165	0.170	0.175
T_3	6.15	6.07	5.94	5.83	0.123	0.125	0.135	0.146
T_4	5.44	5.35	5.24	5.12	0.132	0.139	0.144	0.150
T_5	5.76	5.67	5.56	5.42	0.151	0.154	0.160	0.168
T_6	5.24	5.14	5.05	4.94	0.200	0.208	0.215	0.222
T_7	5.47	5.35	5.23	5.04	0.142	0.150	0.156	0.160
T_8	5.60	5.51	5.43	5.33	0.171	0.180	0.192	0.210
T_9	5.34	5.24	5.16	5.06	0.191	0.197	0.214	0.220
Mean	**5.38**	**5.28**	**5.17**	**5.05**	**0.170**	**0.173**	**0.185**	**0.194**
S.Em±	0.12	0.07	0.08	0.07	0.03	0.03	0.04	0.05
C.D. @ 1%	0.48	0.27	0.34	0.27	0.07	0.09	0.14	0.15

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid



T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 4. Effect of treatments and storage period on ß-carotene (mg/100g) of pumpkin candy

After 1, 2 and 3 months of storage, minimum non-enzymatic browning of pumpkin candy was found in T_3 (0.125, 0.135 and 0.146) which was followed by T_4 (0.139, 0.144 and 0.150) and T_7 (0.150, 0.156 and 0.160) whereas, maximum non-enzymatic browning was recorded in T_1 (0.240, 0.285 and 0.303) respectively.

4.1.7 Reducing sugar (%)

The per cent reducing sugar of pumpkin candy observed initially and for 3 months storage at monthly interval is presented in table 4. With respect to reducing sugar content significant differences were noticed among treatments and also during storage.

Increasing trend was observed in reducing sugar content of pumpkin candy during storage. Maximum reducing sugar content (39.95 and 40.11%) was recorded in T_9 (Blanching for 10 minutes + covering with dry sugar + 1% citric acid), it was followed by T_7 (38.02 and 38.08%) and T_6 (37.27 and 37.39%) and minimum (30.35 and 30.43%) was found in T_1 (Control) at initial and one month after storage respectively.

After two and three months of storage maximum per cent reducing sugar of pumpkin candy was recorded in T_9 (41.05 and 41.35%) and it was followed by T_7 (39.18 and 39.58%) and T_8 (38.22 and 38.62%), while minimum per cent reducing sugar was recorded in T_1 (30.64 and 30.85%) respectively.

4.1.8 Non reducing sugar (%)

The results of non-reducing sugar of pumpkin candy as influenced by different treatments and storage period are presented in table 4. Per cent non-reducing sugar of pumpkin candy showed a significant difference among treatments and also during storage period.

Initially maximum non-reducing sugar (22.51%) percentage of pumpkin candy was recorded in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid), it was followed by T_7 (22.11%) and T_8 (21.93%), whereas minimum (15.86%) was found in T_1 (Control).

Table 4: Effect of treatments and storage period on reducing sugar and non-reducing sugar content of pumpkin candy

Treatments	Reducing sugar (%)				Non reducing sugar (%)			
	Months after storage							
	Initial	**1**	**2**	**3**	**Initial**	**1**	**2**	**3**
T_1	30.35	30.43	30.64	30.85	15.86	15.83	15.77	15.67
T_2	33.55	33.64	33.90	34.22	17.64	17.61	17.50	17.31
T_3	34.24	34.31	35.10	35.44	20.23	20.13	19.57	19.36
T_4	32.35	32.42	33.13	33.43	20.42	20.33	19.88	19.77
T_5	31.22	31.30	32.02	32.32	22.51	22.47	21.95	21.85
T_6	37.27	37.39	38.10	38.41	21.09	21.36	20.90	20.72
T_7	38.02	38.08	39.18	39.58	22.11	22.07	21.15	20.93
T_8	37.06	37.16	38.22	38.62	21.93	21.91	21.02	20.82
T_9	39.95	40.11	41.05	41.35	20.14	20.03	19.28	19.16
Mean	**34.89**	**34.98**	**35.70**	**36.02**	**20.21**	**20.17**	**19.67**	**19.51**
S.Em±	0.03	0.03	0.04	0.04	0.06	0.05	0.06	0.02
C.D. @ 1%	0.11	0.12	0.18	0.16	0.24	0.20	0.08	0.09

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup+ 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°Bsyrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°Bsyrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Per cent non-reducing sugar of pumpkin candy decreased with increasing storage period in all the treatments. After 1 month of storage, maximum per cent non-reducing sugar was recorded in T_5 (22.47%), followed by T_7 (22.07%) and T_8 (21.91%) while minimum was found in T_1 (15.83%).

After two and three months of storage, maximum per cent non-reducing sugar of pumpkin candy was observed in T_5 (21.95 and 21.85%), followed by T_7 (21.15 and 20.93%) and T_8 (21.02 and 20.82%), while minimum was noticed in T_1 (15.77 and 15.67%) respectively.

4.1.9 Total sugars (%)

The observations pertaining to per cent total sugar of pumpkin candy as influenced by treatments and storage period are presented in table 5. Total sugar content of pumpkin candy increased in all the treatments during storage period.

Maximum per cent total sugar (61.30 and 61.35%) of pumpkin candy was recorded in T_7 (Blanching for 7 minutes + covering with dry sugar + 1% citric acid), it was followed by T_9 (61.14 and 61.20%) and T_8 (60.15 and 60.22%) while minimum (47.05 and 47.10%) was found in T_1 (Control) at initial and one month after storage.

After two months of storage, maximum per cent total sugar was recorded in T_7 (61.45%), it was followed by T_9 (61.35%) and T_8 (60.33%), while minimum was noted in T_1 (47.25%) and at 3 months of storage period maximum per cent total sugar was found in T_7 (61.62%), it was followed by T_9 (61.52%) and T_8 (60.54%) and minimum was found in T_1 (47.35%).

4.1.10 Colour (*L* a* b**) values

The data on colour (*L* a* b** values) of pumpkin candy as influenced by different treatments and storage period are presented in table 6. Colour values recorded show a significant difference among the treatments and showed considerable amount of changes throughout storage of pumpkin candy.

Initially maximum *L** value (80.12) was recorded in T_7 (Blanching for 7 minutes + covering with dry sugar + 1% citric acid) which was statistically on par with T_2 (80.10) and T_9 (80.06) while minimum (79.12) was recorded in T_1 (Control).

Table 5: Effect of treatments and storage period on total sugar content of pumpkin candy

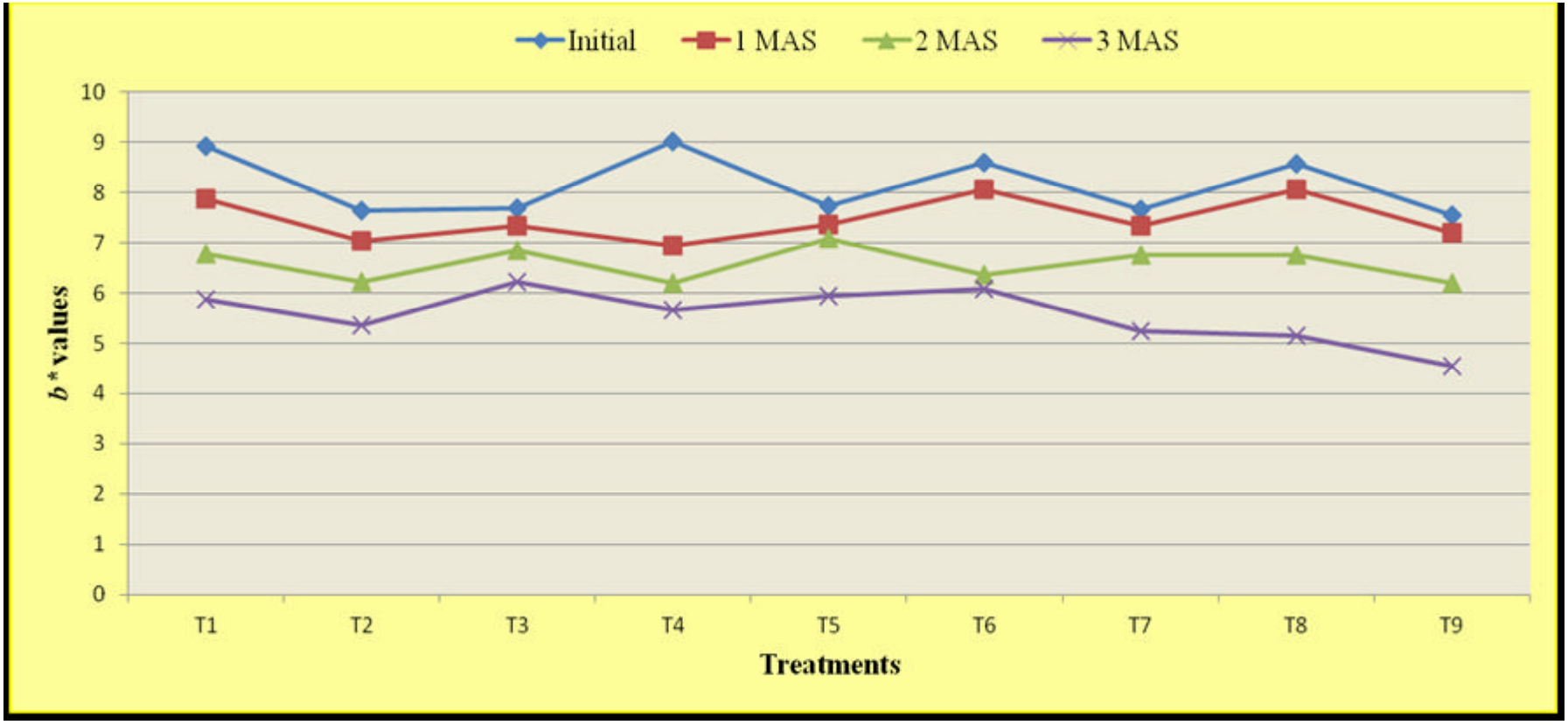
Treatments	Total sugar (%)			
	Months after storage			
	Initial	**1**	**2**	**3**
T_1	47.05	47.10	47.25	47.35
T_2	52.12	52.18	52.33	52.45
T_3	55.54	55.60	55.70	55.82
T_4	53.85	53.93	54.05	54.25
T_5	54.92	54.96	55.13	55.33
T_6	59.48	59.51	60.10	60.23
T_7	61.30	61.35	61.45	61.62
T_8	60.15	60.22	60.33	60.54
T_9	61.14	61.20	61.35	61.52
Mean	**56.21**	**56.23**	**56.41**	**56.57**
S.Em±	0.11	0.03	0.04	0.05
C.D. @ 1%	0.46	0.13	0.16	0.21

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Table 6: Effect of treatments and storage period on colour (*L* a* b) values of pumpkin candy**

Treatments	Months after storage											
	Initial			1			2			3		
	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**	*L**	*a**	*b**
T_1	79.12	0.52	8.92	79.09	0.93	7.87	78.99	1.01	6.78	76.23	1.41	5.88
T_2	80.10	0.32	7.64	79.21	0.40	7.04	77.67	0.90	6.23	75.36	0.86	5.36
T_3	79.20	0.14	7.68	79.17	0.64	7.33	79.04	1.11	6.84	77.25	1.47	6.23
T_4	79.27	0.15	9.01	78.98	0.43	6.94	77.63	0.57	6.20	75.45	1.02	5.67
T_5	80.05	0.48	7.73	79.16	0.77	7.37	79.12	1.18	7.07	76.63	1.43	5.95
T_6	79.20	0.36	8.60	79.15	0.61	8.05	78.97	0.98	6.37	76.86	1.46	6.08
T_7	80.12	0.25	7.66	79.13	0.52	7.33	77.61	0.75	6.75	75.68	1.00	5.23
T_8	79.17	0.49	8.56	79.09	0.71	8.05	78.92	0.97	6.76	75.87	1.10	5.14
T_9	80.06	0.34	7.55	79.25	0.75	7.19	77.68	0.83	6.20	75.28	0.77	4.54
Mean	**79.59**	**0.34**	**8.15**	**79.14**	**0.64**	**7.47**	**78.40**	**0.92**	**6.56**	**76.07**	**1.18**	**5.57**
S.Em±	0.20	0.02	0.06	0.07	0.05	0.05	0.06	0.04	0.07	0.08	0.05	0.04
C.D. @ 1%	0.83	0.10	0.24	0.28	0.20	0.22	0.25	0.17	0.30	0.32	0.20	0.18

*L**-lightness, *a**- redness, *b**- yellowness
T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup+ 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid



T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 5. Effect of treatments and storage period on *b values of pumpkin candy**

Maximum *a** value was observed in T_1 (0.52) it was on par with T_8 (0.49) and T_5 (0.48) whereas, minimum was in T_3 (0.14). Maximum *b** value obtained for T_4 (9.01) it was on par with T_1 (8.92) while minimum was found in T_9 (7.55).

After one month of storage maximum *L** value (79.25) was recorded in T_9 (Blanching for 10 minutes + covering with dry sugar + 1% citric acid), it was on par with T_2 (79.21) and T_3 (79.17) and minimum (78.95) was found in T_4 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid). Maximum *a** value was observed in T_1 (0.93) it was on par with T_5 (0.77) and T_9 (0.75), while, minimum was found in T_2 (0.40). Maximum *b** value was observed in T_6 (8.05) it was on par with T_8 (8.03) and T_1 (7.87), while minimum was found in T_4 (6.94).

After two months after storage maximum *L** *a** *b** values were recorded in T_5 (79.12, 1.18, 7.07) and it was on par with T_3 (79.04, 1.11, 6.84) and T_1 (78.99, 1.01, 6.78) whereas, minimum was found in T_4 (77.63, 0.57, 6.20) respectively. At 3 months of storage, maximum *L** *a** *b** values was scored by T_3 (77.25, 1.47, 6.23) and minimum was recorded by T_9 (75.28, 0.77, 4.54) respectively.

4.1.11 Organoleptic evaluation

The prepared pumpkin candy were subjected to organoleptic evaluation by semi trained panel to assess the quality attributes like colour and appearance, texture, taste and flavour and overall acceptability using 9 point hedonic scale

4.1.11.1 Colour and appearance

Results on colour and appearance of pumpkin candy influenced by treatments and storage are presented in table 7. The data reveals that there was a significant difference with respect to colour and appearance of pumpkin candy among the treatments and also during the storage. Mean values for colour and appearance of pumpkin candy decreased from 7.32 to 6.80 during 3 months storage irrespective of treatments.

Significantly highest score for colour and appearance (8.84) of pumpkin candy was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) followed by T_2 (8.68) and T_5 (8.32) whereas, T_1 (Control) recorded least

Table 7: Effect of treatments and storage period on colour and appearance and texture (score out of 9) of pumpkin candy

Treatments	Colour and appearance				Texture			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	4.67	4.46	4.25	4.11	4.50	4.36	4.20	3.86
T_2	8.68	8.56	8.48	8.30	8.32	8.15	8.03	7.92
T_3	8.84	8.73	8.64	8.56	8.51	8.34	8.32	8.15
T_4	8.15	7.68	7.45	7.33	8.02	7.89	7.78	7.60
T_5	8.32	7.84	7.70	7.67	8.13	7.93	7.85	7.72
T_6	7.52	7.38	7.25	7.05	7.64	7.51	7.39	7.24
T_7	7.74	7.50	7.36	7.27	7.83	7.70	7.62	7.51
T_8	5.86	5.67	5.45	5.33	7.45	7.32	7.20	7.06
T_9	6.13	5.85	5.76	5.61	7.53	7.41	7.33	7.25
Mean	**7.32**	**7.07**	**6.93**	**6.80**	**7.55**	**7.40**	**7.30**	**7.15**
S.Em±	0.05	0.06	0.07	0.08	0.04	0.06	0.06	0.06
C.D. @ 1%	0.21	0.23	0.29	0.32	0.16	0.18	0.25	0.23

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

score (4.67) initially. After one and two months of storage, highest score for the colour and appearance of pumpkin candy was recorded in T_3 (8.73 and 8.64), it was followed by T_2 (8.56 and 8.48) and T_5 (7.84 and 7.70) while, least score was obtained in T_1 (4.46 and 4.25) respectively.

After three months of storage, highest score for colour and appearance of pumpkin candy was recorded by T_3 (8.56), it was followed by T_2 (8.30) and T_5 (7.67) and minimum score was recorded in T_1 (4.11).

4.1.11.2 Texture

The results of texture of pumpkin candy as affected by treatments and storage period are presented in table 7. The data on the texture of pumpkin candy indicated that there were significant differences among the treatments and values were found to decrease from 7.55 to 7.15 with the progress in storage period.

Initially highest score (8.51) for texture of pumpkin candy was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and it was followed by T_2 (8.32) and T_5 (8.13) whereas, least score (4.50) was scored by T_1 (Control). After one month of storage, significantly highest score for texture of pumpkin candy was recorded in T_3 (8.34) and it was followed by T_2 (8.15) and T_5 (7.93), while least score was recorded in T_1 (4.36).

Highest score for texture of pumpkin candy was recorded in T_3 (8.32 and 8.15) and it was followed by T_2 (8.03 and 7.92) and T_5 (7.85 and 7.72) whereas, least score was observed in T_1 (4.20 and 3.86) at 2 and 3 months after storage respectively.

4.1.11.3 Taste and flavour

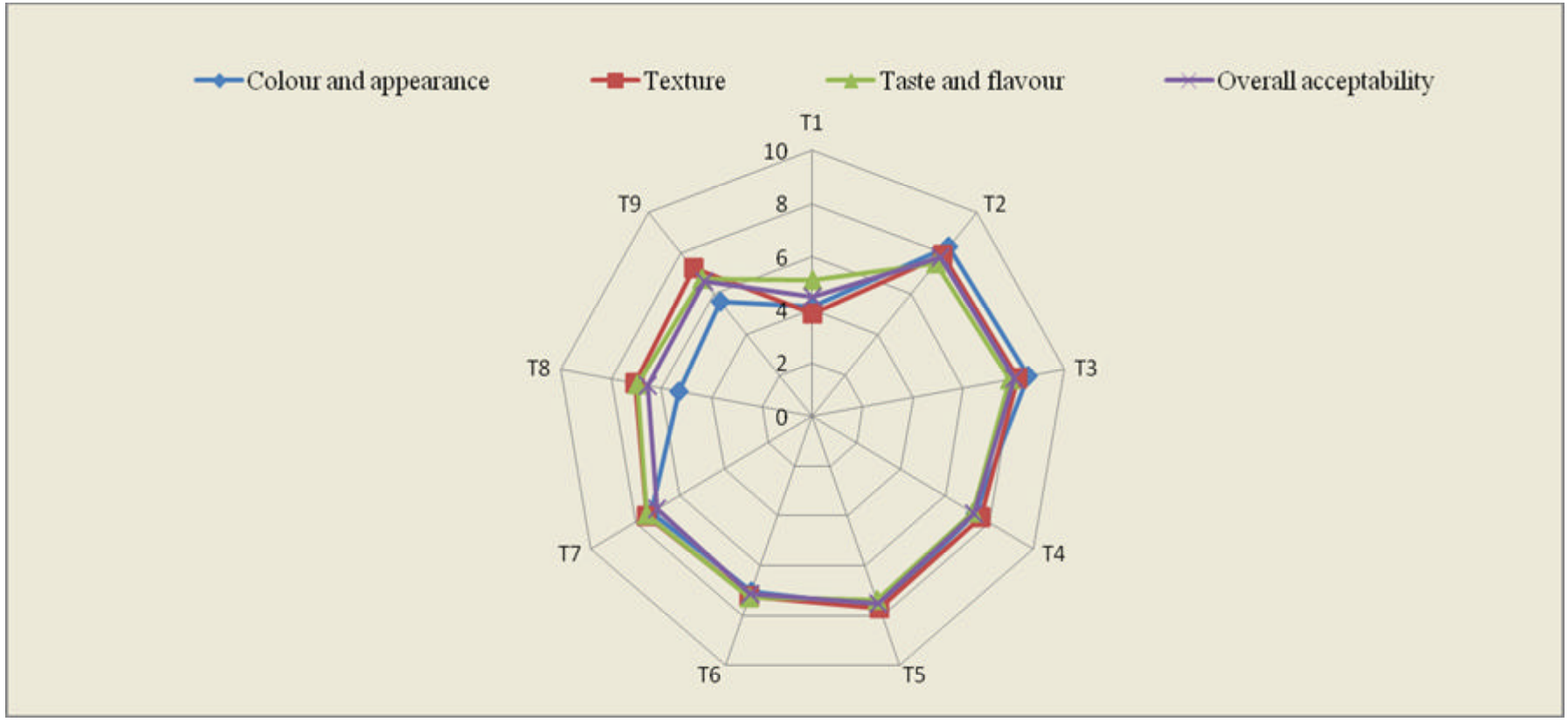
The results of taste and flavour of pumpkin candy as affected by different treatments and storage period are presented in table 8. It was evident that the score for taste and flavour of pumpkin candy exhibited decreasing trend with the increase in storage period irrespective of the treatments.

Highest score (8.32 and 8.16) for taste and flavour of pumpkin candy was obtained by T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid) and it was followed by T_2 (8.04 and 7.76) and T_5 (7.86 and 7.72) while,

Table 8: Effect of treatments and storage period on taste and flavour and overall acceptability (score out of 9) of pumpkin candy

Treatments	Taste and flavour				Overall acceptability			
	Months after storage							
	Initial	**1**	**2**	**3**	**Initial**	**1**	**2**	**3**
T_1	5.72	5.61	5.48	5.13	5.00	4.83	4.62	4.50
T_2	8.04	7.76	7.68	7.50	8.03	7.92	7.83	7.77
T_3	8.32	8.16	7.93	7.83	8.31	8.23	8.16	8.04
T_4	7.74	7.65	7.50	7.26	7.63	7.51	7.40	7.32
T_5	7.86	7.72	7.54	7.36	7.82	7.73	7.61	7.50
T_6	7.65	7.56	7.43	7.30	7.42	7.34	7.20	7.11
T_7	7.80	7.70	7.62	7.48	7.31	7.23	7.13	7.04
T_8	7.52	7.31	7.05	6.94	6.83	6.70	6.61	6.53
T_9	7.21	7.04	6.85	6.73	6.94	6.83	6.73	6.60
Mean	**7.54**	**7.39**	**7.23**	**7.06**	**7.25**	**7.15**	**7.03**	**6.93**
S.Em±	0.07	0.06	0.05	0.06	0.09	0.05	0.04	0.07
C.D. @ 1%	0.28	0.25	0.22	0.26	0.38	0.20	0.17	0.27

T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid



T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1 % citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid
T_9: Blanching for 10 minutes + covering with dry sugar + 1% citric acid

Fig. 6. Effect of treatments on organoleptic quality (9 point hedonic scale) of pumpkin candy at three months of storage

minimum (5.72 and 5.61) was scored in T_1 (Control) at initial and 1 month after storage respectively.

After 2 and 3 months of storage, highest score for taste and flavour of pumpkin candy was recorded in T_3 (7.93 and 7.83) and it was statistically followed by T_2 (7.68 and 7.50) and T_5 (7.54 and 7.36) whereas, minimum was scored in T_1 (5.48 and 5.13) accordingly. Mean values for taste and flavour decreased from 7.54 to 7.06 during three months storage period.

4.1.11.4 Overall acceptability

The data on overall acceptability of pumpkin candy reveals that there were significant differences among treatments and mean values decreased from 7.25 to 6.93 from initial to three months after storage period (Table 8).

Initially highest score (8.31) for overall acceptability of pumpkin candy was scored by T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1 % citric acid) it was followed by T_2 (8.03) and T_5 (7.82) whereas, least score (5.00) was recorded in T_1 (Control).

After one month of storage highest score for overall acceptability of pumpkin candy was recorded in T_3 (8.23) and it was followed by T_2 (7.92) and T_5 (7.73) whereas, the least score was recorded by T_1 (4.83).

Highest score for overall acceptability of pumpkin candy was obtained for T_3 (8.16 and 8.04) and it was statistically followed by T_2 (7.83 and 7.77) and T_5 (7.61 and 7.50) while, least score was scored by T_1 (4.62 and 4.50) at 2 and 3 months after storage respectively.

4.1.12 Microbial population

The perusal of data on microbial load in pumpkin candy during storage is presented in Table 9. Irrespective of treatments no microbial growth was observed at initial when product was fresh, whereas a slight presence of the microbial population was observed after 1, 2 and 3 months of storage. The mean total bacterial count increased from 0.46 to 0.72 x 10^5CFU/g in all the treatments during storage.

Table 9: Effect of treatments and storage period on total bacterial and total fungal count of pumpkin candy

Treatments	Total bacterial count ($x\ 10^5$ CFU/g)			Total fungal count ($x\ 10^3$ CFU/g)		
	Months after storage					
	1	2	3	1	2	3
T_1	1.53	1.85	2.20	1.86	2.02	2.50
T_2	0.52	0.75	0.81	0.82	0.95	1.00
T_3	0.46	0.58	0.65	0.73	0.81	0.92
T_4	0.35	0.46	0.57	0.61	0.73	0.82
T_5	0.22	0.35	0.43	0.50	0.62	0.73
T_6	0.51	0.77	0.84	0.85	0.98	1.11
T_7	0.40	0.58	0.70	0.74	0.83	0.97
T_8	0.36	0.47	0.55	0.65	0.8	0.91
T_9	0.25	0.38	0.46	0.61	0.78	0.87
Mean	**0.46**	**0.62**	**0.72**	**0.75**	**0.87**	**1.00**
S.Em±	0.06	0.06	0.08	0.06	0.08	0.09
C.D. @ 1%	0.23	0.26	0.34	0.24	0.31	0.37

*CFU- Colony forming units
T_1: Control (without blanching and citric acid)
T_2: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_3: Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_4: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid
T_5: Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid
T_6: Blanching for 7 minutes + covering with dry sugar + 0.5% citric acid
T_7: Blanching for 7 minutes + covering with dry sugar + 1% citric acid
T_8: Blanching for 10 minutes + covering with dry sugar + 0.5% citric acid

After one month of storage, minimum total bacterial count (0.22 x 10^5CFU/g) was noticed in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and it was followed by T_9 (0.25 x 10^5CFU/g) and T_4 (0.35 x 10^5CFU/g). Whereas, T_1 (Control) has shown significantly maximum total bacterial count (1.53 x 10^5CFU/g).

After 2 and 3 months of storage, lowest bacterial count was noticed in T_5 (0.35 and 0.43 x 10^5CFU/g) and it was followed by T_9 (0.38 and 0.46 x 10^5CFU/g) and T_4 (0.46 and 0.57 x 10^5CFU/g) whereas, significantly highest total bacterial count (1.85 and 2.20 x 10^5CFU/g) was noticed in T_1 (Control).

Minimum total fungal count (0.50 x 10^3CFU/g) was recorded in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and it was statistically followed by T_9 (0.46 x 10^3CFU/g) and T_8 (0.55 x 10^3CFU/g) whereas, maximum total fungal count (1.86 x 10^3CFU/g) was recorded in T_1 (Control) at 1 month after storage.

After 2 and 3 months of storage minimum total fungal count (0.62 and 0.73 x 10^3CFU/g) was recorded by T_5 and it was statistically followed by T_4 (0.73 and 0.82 x 10^3CFU/g) and T_9 (0.78 and 0.87 x 10^3CFU/g) while, highest total fungal count (2.02 and 2.50 x 10^3CFU/g) was recorded in T_1. The mean total fungal count increased from 0.75 to 1.00 x 10^3 CFU/g in all the treatments during storage.

4.2 Experiment II: Standardization of protocol for the preparation of pumpkin fortified biscuits

4.2.1 Width and thickness (cm)

The data regarding width and thickness of pumpkin fortified biscuits as influenced by different treatments are presented in Table 10. Data reveal that there was significant difference with respect to width and thickness (cm) of pumpkin fortified biscuits among different treatments and also during storage period.

Significantly maximum width (4.66 cm) of pumpkin fortified biscuits was recorded in T_9 (20% pumpkin pulp + 80% refined wheat flour) it was followed by T_8 and T_7 (4.58 cm each), however minimum (4.31 cm) width was found in T_1 (100% refined wheat flour) at initial storage.

Table 10: Effect of treatments on width and thickness of pumpkin fortified biscuits as influenced by storage

Treatments	Width (cm)				Thickness (cm)			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	4.31	4.39	4.44	4.46	1.41	1.43	1.44	1.46
T_2	4.40	4.47	4.52	4.56	1.42	1.45	1.46	1.47
T_3	4.43	4.50	4.55	4.59	1.43	1.45	1.45	1.46
T_4	4.44	4.51	4.56	4.59	1.43	1.46	1.47	1.49
T_5	4.52	4.57	4.62	4.67	1.44	1.47	1.47	1.48
T_6	4.54	4.58	4.63	4.65	1.44	1.48	1.48	1.49
T_7	4.58	4.63	4.68	4.69	1.44	1.48	1.49	1.49
T_8	4.58	4.66	4.71	4.75	1.44	1.49	1.49	1.50
T_9	4.66	4.71	4.76	4.79	1.46	1.49	1.49	1.50
Mean	**4.49**	**4.56**	**4.61**	**4.64**	**1.43**	**1.47**	**1.47**	**1.48**
S.Em±	0.01	0.01	0.01	0.01	NS	0.01	0.01	0.01
C.D. @ 1%	0.02	0.03	0.03	0.02		0.04	0.03	0.03

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

After 1 and 2 months of storage, maximum width of pumpkin fortified biscuits was recorded in T_9 (4.71 and 4.76 cm), it was followed by T_8 (4.66 and 4.71 cm) and T_7 (4.63 and 4.68 cm), while minimum width was found in T_1 (4.39 and 4.44 cm) respectively.

After 3 months of storage, maximum width of pumpkin fortified biscuits was observed in T_9 (4.79 cm) and it was followed by T_8 (4.75 cm) and T_7 (4.69 cm), while minimum was recorded in T_1 (4.46 cm).

Initially the treatments did not show significant difference. Whereas after 1 and 2 months of storage maximum thickness of pumpkin fortified biscuits was found in T_9 and T_8 (1.49 cm each), it was on par with T_7 (1.48 and 1.49 cm) and T_6 (1.48 and 1.48 cm) respectively.

After 3 months of storage, maximum thickness of pumpkin fortified biscuits was found in T_9 and T_8 (1.50 cm each) and it was on par with T_7 and T_4 (1.49 cm each). Mean thickness of pumpkin fortified biscuits slightly increased from 1.43 to 1.48 cm during three months storage, indicating significant but very negligible change in thickness of pumpkin fortified biscuits.

4.2.2 Moisture (%)

The data showing the changes in moisture percentage of pumpkin fortified biscuits influenced by different treatments and storage periods are presented in table 11. The data reveals that there was a significant difference between the treatments and percent moisture content was found to increase throughout the storage period.

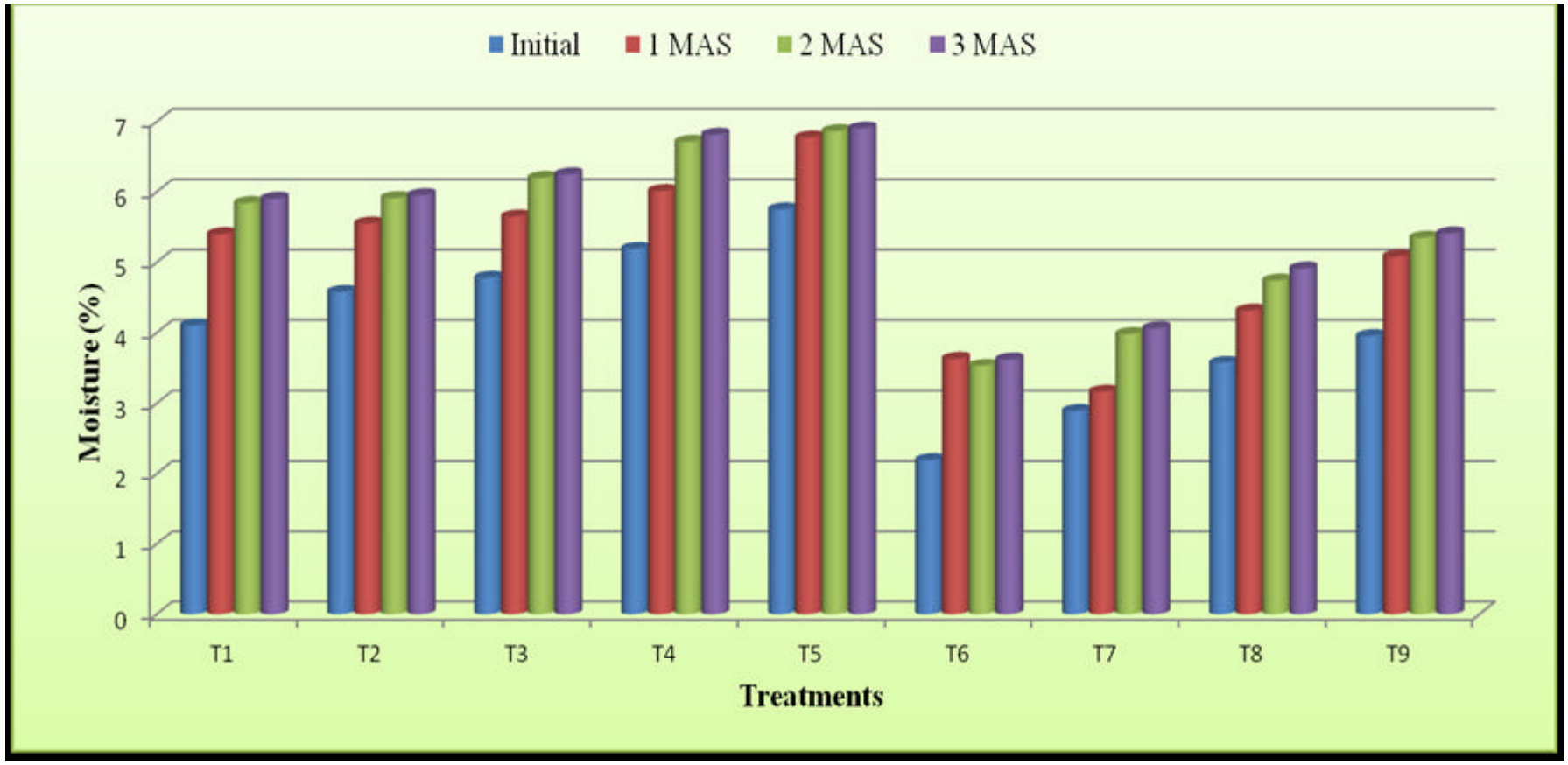
Among treatments, minimum per cent of moisture (2.19%) was recorded in T_6 (05% pumpkin pulp + 95% refined wheat flour) and it was followed by T_7 (2.89%) and T_8 (3.57%), whereas maximum per cent moisture content (5.75%) of pumpkin fortified biscuit was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) at initial storage.

Minimum per cent moisture content of pumpkin fortified biscuit was found in T_6 (3.16 and 3.53%) and it was followed by T_7 (3.63 and 3.98%) and T_8 (4.31 and 4.71%) while, maximum per cent moisture content of pumpkin fortified biscuit was recorded in T_5 (6.77 and 6.86%) at 1 and 2 months after storage respectively.

Table 11: Effect of treatments on moisture content and water activity of pumpkin fortified biscuits as influenced by storage

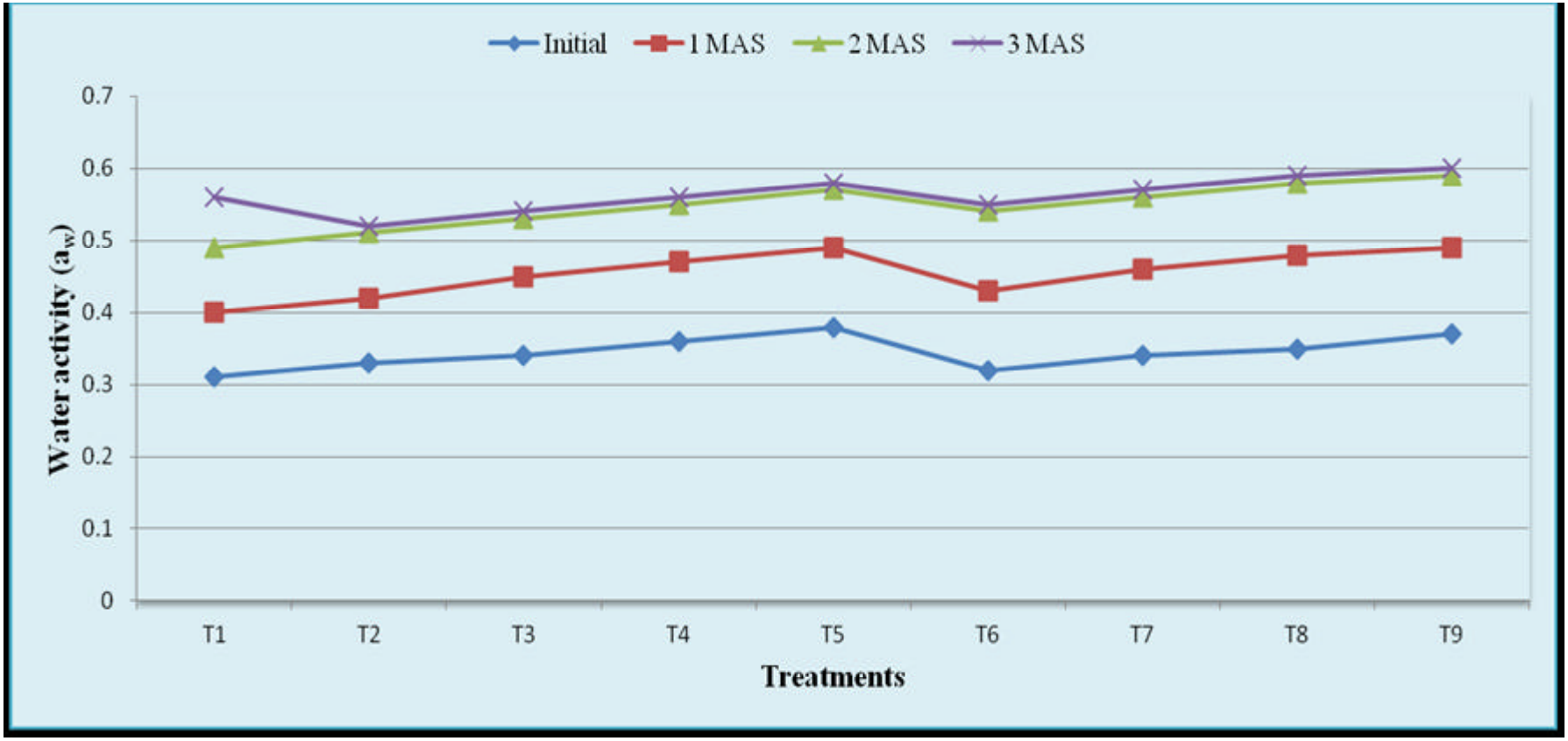
Treatments	Moisture (%)				Water activity (a_w)			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	4.10	5.40	5.84	5.90	0.31	0.40	0.49	0.56
T_2	4.58	5.55	5.91	5.95	0.33	0.42	0.51	0.52
T_3	4.78	5.65	6.20	6.25	0.34	0.45	0.53	0.54
T_4	5.19	6.01	6.71	6.81	0.36	0.47	0.55	0.56
T_5	5.75	6.77	6.86	6.90	0.38	0.49	0.57	0.58
T_6	2.19	3.16	3.53	3.62	0.32	0.43	0.54	0.55
T_7	2.89	3.63	3.98	4.06	0.34	0.46	0.56	0.57
T_8	3.57	4.31	4.74	4.91	0.35	0.48	0.58	0.59
T_9	3.95	5.08	5.35	5.41	0.37	0.49	0.59	0.60
Mean	**4.11**	**5.06**	**5.46**	**5.53**	**0.35**	**0.45**	**0.55**	**0.57**
S.Em±	0.05	0.05	0.10	0.05	0.014	0.013	0.012	0.01
C.D. @ 1%	0.18	0.21	0.41	0.21	0.05	0.03	0.05	0.04

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour



T_1: 100 % refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

Fig. 7. Effect of treatments on moisture (%) of pumpkin fortified biscuits as influenced by storage



T_1: 100 % refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

Fig. 8. Effect of treatments on water activity (a_w) of pumpkin fortified biscuits as influenced by storage

Three months after storage minimum moisture content was noticed in T_6 (3.62%) and it was followed by T_7 (4.06%) and T_8 (4.91%) whereas, maximum per cent moisture content of pumpkin fortified biscuit was recorded in T_5 (6.90%).

4.2.3 Water activity (a_w)

Observation regarding the water activity of pumpkin fortified biscuits as influenced by different treatments and storage period are tabulated in table 11.

Initially minimum (0.31) water activity was recorded in T_1 (100 % refined wheat flour) and it was followed by T_6 (0.32) and T_2 (0.33) whereas, maximum water activity (0.38) of pumpkin fortified biscuits was noticed in T_5 (20% pumpkin powder + 80% refined wheat flour).

After 1 and 2 months of storage minimum water activity was recorded in T_1 (0.40 and 0.49) and it was followed by T_2 (0.42 and 0.51) and T_6 (0.43 and 0.54) while, maximum water activity of pumpkin fortified biscuits was noticed in T_5 (0.49 and 0.57) respectively.

After 3 months of storage minimum water activity in pumpkin fortified biscuits was recorded in T_2 (0.52) and it was followed by T_3 (0.54) and T_6 (0.55) while, maximum water activity of pumpkin fortified biscuits was recorded in T_9 (0.60). Irrespective of treatments, data showed a significant increase in water activity in pumpkin fortified biscuits during three months storage period.

4.2.4 Ascorbic acid (mg/100 g)

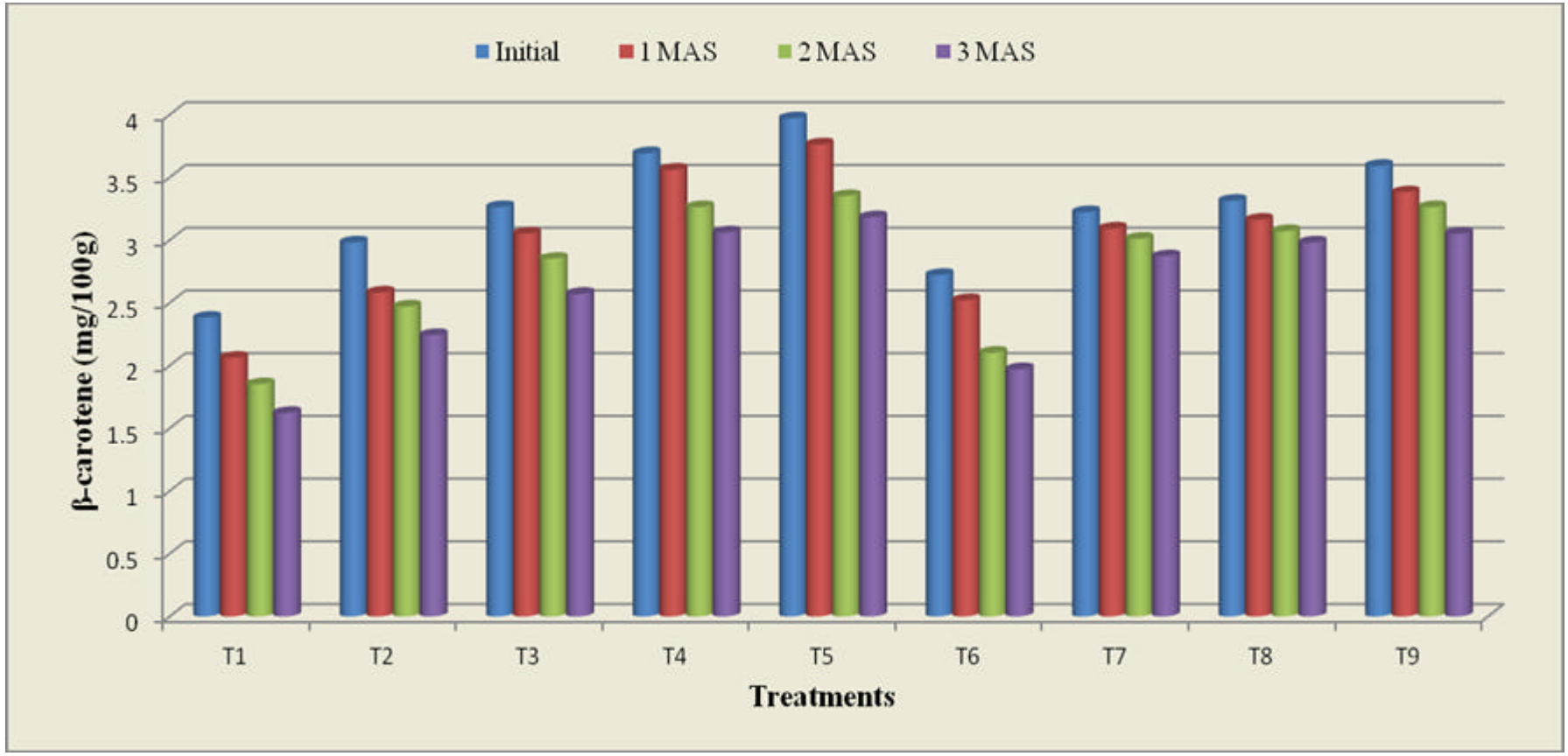
The data on the influence of different treatments and storage period on ascorbic acid content of the pumpkin fortified biscuits were presented in table 12. The data reveals that there was a significant difference in ascorbic acid content. The mean ascorbic acid content of the biscuits gradually decreased from 1.32 to 1.03 mg/100 g with the increase in storage period among all the treatments.

Initially maximum ascorbic acid content (1.73 mg/100 g) of pumpkin fortified biscuits was found in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was followed by T_4 (1.65 mg/100 g) and T_3 (1.52 mg/100 g), whereas minimum ascorbic acid content (0.98 mg/100 g) was recorded in T_1 (100 % refined wheat flour).

Table 12: Effect of treatments on ß-carotene and ascorbic acid of pumpkin fortified biscuits as influenced by storage

Treatments	Ascorbic acid (mg/100 g)				ß–carotene (mg/100 g)			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	0.98	0.93	0.90	0.70	2.38	2.06	1.85	1.62
T_2	1.31	1.25	1.16	1.07	2.98	2.58	2.47	2.24
T_3	1.52	1.41	1.30	1.22	3.26	3.05	2.85	2.57
T_4	1.65	1.50	1.41	1.32	3.69	3.56	3.26	3.06
T_5	1.73	1.62	1.54	1.41	3.97	3.76	3.35	3.18
T_6	1.01	0.98	0.87	0.76	2.72	2.52	2.10	1.97
T_7	1.13	1.01	0.91	0.83	3.22	3.09	3.01	2.87
T_8	1.22	1.15	1.02	0.94	3.31	3.16	3.07	2.98
T_9	1.35	1.23	1.11	0.98	3.59	3.38	3.26	3.05
Mean	**1.32**	**1.23**	**1.13**	**1.03**	**3.24**	**3.02**	**2.80**	**2.62**
S.Em±	0.06	0.05	0.04	0.04	0.03	0.02	0.02	0.02
C.D. @ 1%	0.24	0.21	0.17	0.16	0.11	0.09	0.07	0.08

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour



T_1: 100 % refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

Fig. 9. Effect of treatments on ß-carotene (mg/100 g) of pumpkin fortified biscuits as influenced by storage

After one month of storage, maximum ascorbic acid content of pumpkin fortified biscuits was found in T_5 (1.62 mg/100 g) and it was followed by T_4 (1.50 mg/100 g) and T_3 (1.41 mg/100 g), while minimum ascorbic acid content of pumpkin fortified biscuits was recorded in T_1 (0.93 mg/100 g).

After 2 and 3 months of storage, maximum ascorbic acid content of pumpkin fortified biscuits was found in T_5 (1.54 and 1.41 mg/100 g) and it was followed by T_4 (1.41 and 1.32 mg/100 g) and T_3 (1.30 and 1.22 mg/100 g), while minimum was recorded in T_1 (0.90 and 0.70 mg/100 g) respectively.

4.2.5 ß–carotene (mg/100 g)

The data regarding changes in the ß–carotene content of the pumpkin fortified biscuits as influenced by the different treatments and storage period are presented in table 12.

Data reveals a significant difference between treatments and there was a gradual decrease in ß–carotene content of pumpkin fortified biscuits during storage. Maximum ß–carotene content (3.97 mg/100 g) of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was followed by T_4 (3.69 mg/100 g) and T_9 (3.59 mg/100 g) while, minimum ß–carotene content (2.38 mg/100 g) was recorded in T_1 (100 % refined wheat flour) at initial storage.

After 1 and 2 months of storage, maximum ß–carotene content of pumpkin fortified biscuits was recorded in T_5 (3.76 and 3.35 mg/100 g) and it was followed by T_4 (3.56 and 3.26 mg/100 g) and T_9 (3.38 and 3.26 mg/100 g) while, minimum ß–carotene content was recorded in T_1 (2.06 and 1.85 mg/100 g) respectively.

After 3 months of storage, maximum ß–carotene content of pumpkin fortified biscuits was recorded in T_5 (3.18 mg/100 g) and it was followed by T_4 (3.06 mg/100 g) and T_9 (3.05 mg/100 g) while, minimum ß–carotene content was recorded in T_1 (1.62 mg/100 g).

4.2.6 Reducing sugar (%)

The data regarding per cent reducing sugar of pumpkin fortified biscuits recorded initially and for 3 months during storage at monthly interval is presented in

table 13. Significant differences were noticed among the treatments and also in storage intervals.

Initially maximum per cent reducing sugar (10.94%) of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was followed by T_4 (10.63%) and T_9 (10.41%) whereas, minimum per cent reducing sugar (9.33%) was found in T_1 (100 % refined wheat flour).

Increasing trend was observed in per cent reducing sugar of pumpkin fortified biscuits during storage. After 1 and 2 months of storage maximum per cent reducing sugar of pumpkin fortified biscuits was recorded in T_5 (11.14 and 11.33 %) and it was on par with T_4 (10.85 and 11.20%) whereas, minimum per cent reducing sugar was found in T_1 (9.50 and 9.72%) respectively.

Maximum per cent reducing sugar of pumpkin fortified biscuits was recorded in T_5 (11.54 %) and it was on par with T_4 (11.35%) while, minimum per cent reducing sugar was found in T_1 (9.86 %) after 3 months of storage period.

4.2.7 Non-reducing sugar (%)

The data presented in table 13 reveals the influence of different treatments and storage period on per cent non-reducing sugar of pumpkin fortified biscuits. Data indicate that there was a significant difference among treatments and also during storage.

Maximum per cent non-reducing sugar (1.52 and 1.41%) of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) it was on par with T_9 (1.37 and 1.22%) and T_4 (1.33 and 1.24%) while, minimum per cent non-reducing sugar (1.03 and 0.92%) was found in T_1 (100 % refined wheat flour) at initial and one month after storage respectively.

After 2 and 3 months of storage, maximum per cent non-reducing sugar of pumpkin fortified biscuits was recorded in T_5 (1.31 and 1.22%) and it was on par with T_9 (1.11 and 1.07%) and T_4 (1.10 and 1.00%) whereas, minimum per cent non-reducing sugar was found in T_1 (0.88 and 0.81%) respectively. Per cent non-reducing sugar of pumpkin fortified biscuits decreased with increasing storage period in all the treatments.

Table 13: Effect of treatments on reducing sugar and non-reducing sugar content of pumpkin fortified biscuits as influenced by storage

Treatments	Reducing sugar (%)				Non-reducing sugar (%)			
	Months after storage							
	Initial	**1**	**2**	**3**	**Initial**	**1**	**2**	**3**
T_1	9.33	9.50	9.72	9.86	1.03	0.92	0.88	0.81
T_2	10.01	10.23	10.45	10.68	1.16	1.05	0.92	0.91
T_3	10.23	10.44	10.65	10.82	1.22	1.12	1.00	0.97
T_4	10.63	10.85	11.20	11.35	1.33	1.24	1.10	1.00
T_5	10.94	11.14	11.33	11.54	1.52	1.41	1.31	1.22
T_6	10.00	10.25	10.46	10.63	1.07	0.94	0.85	0.76
T_7	10.11	10.33	10.54	10.72	1.18	1.06	0.94	0.90
T_8	10.34	10.62	10.84	11.00	1.24	1.16	1.06	0.98
T_9	10.41	10.64	10.87	11.11	1.37	1.22	1.11	1.07
Mean	**10.22**	**10.45**	**10.67**	**10.86**	**1.24**	**1.12**	**1.02**	**0.96**
S.Em±	0.07	0.09	0.10	0.10	0.05	0.06	0.04	0.04
C.D. @ 1%	0.28	0.38	0.39	0.41	0.22	0.25	0.18	0.17

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

4.2.8 Total sugar (%)

The data pertaining to per cent total sugar of pumpkin fortified biscuits as influenced by treatments and storage period are presented in table 14.

Total sugar content of pumpkin fortified biscuits increased in all treatments during storage period. Maximum per cent total sugar (12.54%) of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was followed by T_4 (12.03%) and T_9 (11.85%) while, minimum per cent total sugar (10.42%) was found in T_1 (100 % refined wheat flour) at initial period.

Maximum per cent total sugar of pumpkin fortified biscuits was recorded in T_5 (12.63 and 12.71%) and it was followed by T_4 (12.16 and 12.30%) and T_9 (11.93 and 12.04%) whereas, minimum was found in T_1 (10.52 and 10.65%) at 1 and 2 months after storage accordingly.

After three months of storage, maximum per cent total sugar of pumpkin fortified biscuits was recorded in T_5 (12.82%) and it was followed by T_4 (12.41%) and T_9 (12.23%) whereas, minimum per cent total sugar of was found in T_1 (10.71%).

4.2.9 Crude fibre (%)

The data related to impact of different treatments and storage period on per cent crude fibre of pumpkin fortified biscuits are tabulated in table 14.

Initially maximum crude fibre (0.96%) percentage of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was followed by T_9 (0.86%) and T_4 (0.81%) while, minimum crude fibre percentage (0.24%) was recorded in T_1 (100 % refined wheat flour).

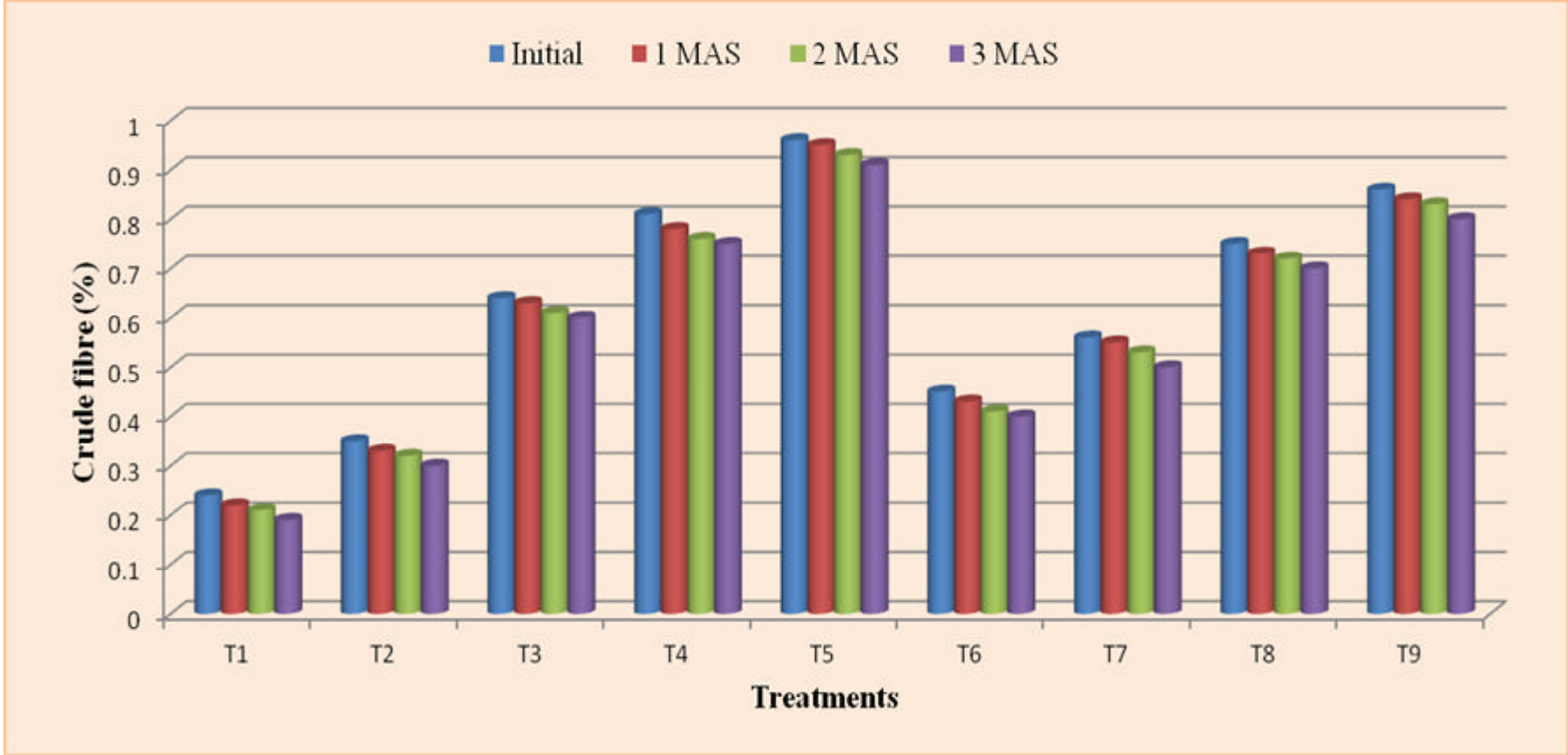
After 1 and 2 months of storage, maximum crude fibre percentage of pumpkin fortified biscuits was recorded in T_5 (0.95 and 0.93%) it was followed by T_9 (0.84 and 0.83%) and T_4 (0.78 and 0.76%) whereas, minimum crude fibre percentage was recorded in T_1 (0.22 and 0.21%).

Maximum crude fibre percentage of pumpkin fortified biscuits was recorded in T_5 (0.91%) and it was followed by T_9 (0.80%) and T_4 (0.75%) whereas, minimum

Table 14: Effect of treatments on total sugar and crude fibre content of pumpkin fortified biscuits as influenced by storage

Treatments	Total sugar (%)				Crude fibre (%)			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	10.42	10.52	10.65	10.71	0.24	0.22	0.21	0.19
T_2	11.23	11.34	11.42	11.64	0.35	0.33	0.32	0.30
T_3	11.51	11.62	11.71	11.84	0.64	0.63	0.61	0.60
T_4	12.03	12.16	12.30	12.41	0.81	0.78	0.76	0.75
T_5	12.54	12.63	12.71	12.82	0.96	0.95	0.93	0.91
T_6	11.13	11.24	11.35	11.43	0.45	0.43	0.41	0.40
T_7	11.35	11.45	11.53	11.67	0.56	0.55	0.53	0.50
T_8	11.64	11.84	11.96	12.04	0.75	0.73	072	0.70
T_9	11.85	11.93	12.04	12.23	0.86	0.84	0.83	0.80
Mean	**11.52**	**11.64**	**11.74**	**11.86**	**0.63**	**0.61**	**0.59**	**0.58**
S.Em±	0.07	0.08	0.09	0.08	0.01	0.01	0.02	0.01
C.D. @ 1%	0.29	0.32	0.37	0.33	0.06	0.05	0.06	0.05

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour



T_1: 100 % refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

Fig. 10. Effect of treatments on crude fibre (%) of pumpkin fortified biscuits as influenced by storage

crude fibre percentage was recorded in T_1 (0.19%) during three months of storage. Per cent crude fibre of pumpkin fortified biscuits showed decreasing trend throughout the storage period.

4.2.10 Organoleptic evaluation

The prepared pumpkin fortified biscuits were subjected to organoleptic evaluation to assess the quality attributes like colour and appearance, texture or crispness, taste and overall acceptability using 9 point hedonic scale.

4.2.10.1 Colour and appearance

Table 15 reveals the data on colour and appearance of pumpkin fortified biscuits as influenced by different treatments during three months storage. The data reveals a significant difference among the treatments and also during the storage.

Significantly highest score for the colour and appearance (8.73) of pumpkin fortified biscuits was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) and it was on par with T_4 (8.61) and T_3 (8.53) whereas, T_9 (20% pumpkin pulp + 80% refined wheat flour) scored least score (7.83) at initial period.

After 1 and 2 months of storage, significantly highest score for the colour and appearance of pumpkin fortified biscuits was recorded in T_5 (8.62 and 8.53), it was on par with T_4 (8.50 and 8.44) and T_3 (8.42 and 8.30) whereas, least score was recorded in T_9 (7.65 and 7.42) respectively.

After 3 months of storage, highest score for the colour and appearance of pumpkin fortified biscuits was found in T_5 (8.42) and it was on par with T_4 (8.31) and T_3 (8.22) whereas, T_9 (7.36) scored least score. Mean values for colour and appearance of pumpkin fortified biscuits decreased from 8.30 to 7.94 during 3 months storage.

4.2.10.2 Texture / crispness

The data on the texture of pumpkin fortified biscuits indicated that there was a significant difference among the treatments and mean values were found to decrease with the progress in storage period (Table 15).

Table 15: Effect of treatments on colour and appearance and texture (score out of 9) of pumpkin fortified biscuits as influenced by storage

Treatments	Colour and appearance				Texture/crispness			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	8.22	8.13	8.00	7.91	8.00	7.91	7.82	7.73
T_2	8.42	8.31	8.20	8.13	8.26	8.11	8.01	7.91
T_3	8.53	8.42	8.30	8.22	8.34	8.25	8.11	8.02
T_4	8.61	8.50	8.44	8.31	8.45	8.31	8.24	8.13
T_5	8.73	8.62	8.53	8.42	8.40	8.28	8.15	8.03
T_6	8.24	8.13	8.02	7.83	8.20	8.12	8.04	7.84
T_7	8.15	8.01	7.85	7.71	8.12	8.04	7.83	7.65
T_8	8.02	7.85	7.74	7.60	8.02	7.91	7.64	7.51
T_9	7.83	7.65	7.42	7.36	7.81	7.62	7.50	7.41
Mean	**8.30**	**8.18**	**8.06**	**7.94**	**8.18**	**8.06**	**7.93**	**7.80**
S.Em±	0.10	0.09	0.08	0.06	0.10	0.10	0.09	0.08
C.D. @ 1%	0.39	0.35	0.34	0.24	0.32	0.40	0.35	0.28

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

At initial day of storage, highest score for texture (8.45) of pumpkin fortified biscuits was recorded in T_4 (15% pumpkin powder + 85% refined wheat flour) and it was followed by T_5 (8.40) and T_3 (8.34) whereas, least score for texture (7.81) of pumpkin fortified biscuits was scored by T_9 (20% pumpkin pulp + 80% refined wheat flour).

After 1 and 2 months of storage, highest score for texture of pumpkin fortified biscuits obtained was for T_4 (8.31 and 8.24) and it was on par with T_5 (8.28 and 8.15) and T_3 (8.25 and 8.11) while, least score for texture of biscuits was recorded in T_9 (7.62 and 7.50) respectively.

After 3 months of storage, highest score for texture of pumpkin fortified biscuits was recorded in T_4 (8.13) and it was on par with T_5 (8.03) and T_3 (8.02), least score was obtained in T_9 (7.41). Mean values for texture of pumpkin fortified biscuits showed decreasing trend from 8.18 to 7.80 during three months storage.

4.2.10.3 Taste

Data related to taste of pumpkin fortified biscuits as influenced by the different treatments and storage period are presented in table 16. It was evident from the table that irrespective of the treatments, the score for taste exhibited decreasing trend with the increase in storage period. Highest score for taste of pumpkin fortified biscuits was obtained for T_4 (8.71) and it was on par with T_3 (8.53), while minimum was scored in T_9 (7.60) at initial period.

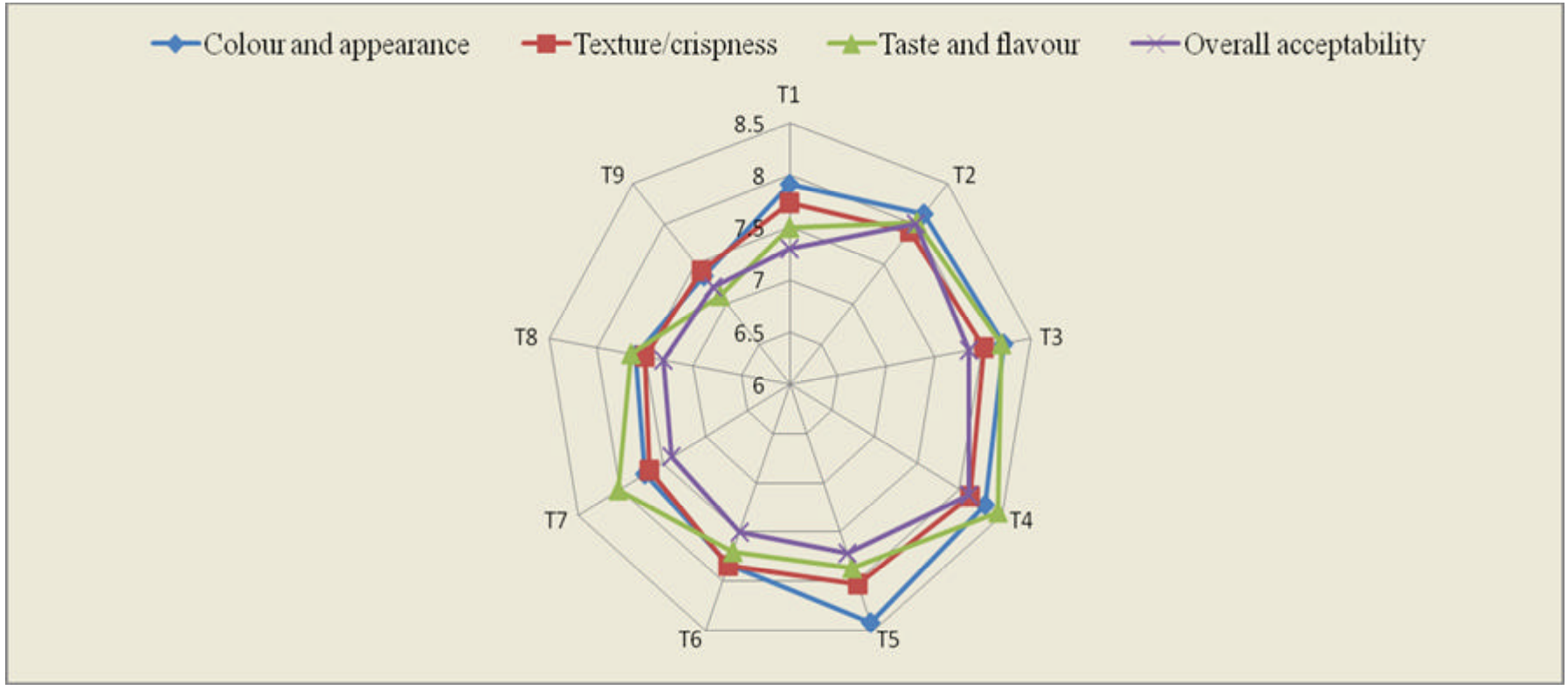
After one month of storage, maximum taste score (8.60) for pumpkin fortified biscuits was obtained in T_4 (15% pumpkin powder + 85% refined wheat flour) and it was on par with T_3 (8.40) and T_2 (8.25) while, minimum score (7.40) was scored in T_9 (20% pumpkin pulp + 80% refined wheat flour).

After 2 and 3 months of storage, highest score for taste of pumpkin fortified biscuits was recorded in T_4 (8.52 and 8.45) and it was on par with T_3 (8.31 and 8.20) while, minimum score was found in T_9 (7.25 and 7.10) respectively. Mean values for taste of pumpkin fortified biscuits was decreased from 8.22 to 7.83 during three months of storage period.

Table 16: Effect of treatments taste and overall acceptability (score out of 9) of pumpkin fortified biscuits as influenced by storage

Treatments	Taste				Overall acceptability			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	8.02	7.85	7.65	7.50	7.77	7.52	7.41	7.30
T_2	8.36	8.25	8.16	8.02	8.32	8.20	8.08	8.00
T_3	8.53	8.40	8.31	8.20	8.23	8.11	8.01	7.86
T_4	8.71	8.60	8.52	8.45	8.44	8.32	8.21	8.11
T_5	8.25	8.14	8.03	7.87	8.16	8.01	7.83	7.71
T_6	8.12	8.00	7.85	7.70	7.94	7.81	7.64	7.50
T_7	8.33	8.22	8.11	8.02	7.75	7.62	7.50	7.39
T_8	8.10	7.92	7.83	7.65	7.61	7.52	7.40	7.31
T_9	7.60	7.40	7.25	7.10	7.53	7.40	7.31	7.22
Mean	**8.22**	**8.09**	**7.97**	**7.83**	**7.97**	**7.84**	**7.71**	**7.60**
S.Em±	0.09	0.11	0.09	0.08	0.08	0.09	0.07	0.06
C.D. @ 1%	0.35	0.44	0.36	0.33	0.26	0.30	0.29	0.25

T_1: 100% refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour



T_1: 100 % refined wheat flour
T_2: 05% Pumpkin powder + 95% refined wheat flour
T_3: 10% Pumpkin powder + 90% refined wheat flour
T_4: 15% Pumpkin powder + 85% refined wheat flour
T_5: 20% Pumpkin powder + 80% refined wheat flour
T_6: 05% Pumpkin pulp + 95% refined wheat flour
T_7: 10% Pumpkin pulp +90% refined wheat flour
T_8: 15% pumpkin pulp+ 85% refined wheat flour
T_9: 20% pumpkin pulp + 80% refined wheat flour

Fig. 11. Effect of treatments on organoleptic quality (9 point hedonic scale) of pumpkin fortified biscuits at three months of storage

4.2.10.4 Overall acceptability

The data on overall acceptability of pumpkin fortified biscuits as influenced by different treatments and storage period are presented in table 16. Data recorded reveals that there was a significant difference among the treatments and mean values decreased from 7.97 to 7.60 from initial to 3 months of storage period.

Highest score for overall acceptability (8.44) of pumpkin fortified biscuits was scored by T_4 (15% pumpkin powder + 85% refined wheat flour) and it was on par with T_2 (8.32) and T_3 (8.23) whereas, least score for overall acceptability (7.53) was recorded in T_9 (20% pumpkin pulp + 80% refined wheat flour) at initial storage.

After 1 and 2 months of storage, highest score for overall acceptability of pumpkin fortified biscuits was scored by T_4 (8.32 and 8.21 respectively) and it was on par with T_2 (8.20 and 8.08 respectively) and T_3 (8.11 and 8.01 respectively respectively), whereas least score for overall acceptability was recorded in T_9 (7.40 and 7.31). Whereas after 3 months of storage highest score for overall acceptability of pumpkin fortified biscuits was scored by T_4 (8.11) and it was on par with T_2 (8.00), least score for overall acceptability of pumpkin fortified biscuits was recorded in T_9 (7.22).

4.2.11 Microbial population

Microbial evaluation of pumpkin fortified biscuits for total bacterial count and total fungal count was carried out at initial and at monthly intervals. Irrespective of the treatments, no microbial growth was observed throughout storage period. Hence the results are not tabulated. Product was found safe for consumption and was stable throughout the storage.

5. DISCUSSION

Pumpkin is highly nutritious seasonal vegetable; it is rich source of nutrients including various vitamins and minerals and referred as vegetable of immense value. Pumpkin has a great potential for processing into various products of domestic as well as international demand.

By reviewing the literature on the studies done so for regarding the processing, it was evident that not much of attention has been given to develop and standardize the protocol for the processed products from pumpkin. Therefore, in order to explore the possibilities of utilizing the pumpkin for development of processed products like candy and fortified biscuits. An attempt has been made to find out the standard protocol for processed products and their storage stability under ambient condition was studied for three months.

5.1 Experiment 1: Standardization of protocol for the preparation of pumpkin candy

5.1.1 Recovery (%)

Recovery percentage of the final product is very important from the point of cost effectiveness in the commercial production. In this investigation, highest per cent recovery (80.10%) of pumpkin candy among different treatments was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) it was followed by T_2 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid) with recovery of 74.50 per cent and minimum per cent recovery (36.57) was noticed in T_1 (Control).

The results obtained in this experiment were in comparison with the findings of Kukanoor *et al.* (2015). The highest recovery obtained in this experiment was due to blanching (7 minutes) and citric acid (1%) which attributed in reducing the shrinkage of the pumpkin slices during drying and enhanced absorption of syrup also helped in getting maximum recovery of pumpkin candies with good quality.

5.1.2 Moisture (%)

Moisture percentage of the product is most important character with respect to its storage and microbial stability. In this study maximum per cent of moisture (12.01) was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and minimum was recorded in T_1 (10.01%) during initial period of storage.

Mean moisture percentage showed an increasing trend (11.02 to 11.44%) in candies throughout the storage period irrespective of the treatments (Table 1). The increase in moisture content may be due to absorption of moisture by candy, it is because of the permeability of polyethylene pack to moisture. Similar increase in per cent moisture in osmo dehydrated mango slices was observed during storage period by Sagar and Kumar (2009) and it can be attributed to the permeability of packaging material to moisture. Similar results were reported by Sharma *et al.* (2004) in osmo dehydrated apricot, Swain *et al.* (2013) in osmo dehydrated sweet pepper, Kumar (2013) in osmo dried plum and Patil *et al.* (2014) in dehydrated jack fruit chips.

5.1.3 Titratable acidity (%)

In the present investigation titratable acidity of pumpkin candy was expressed as percent of citric acid. At the end of the 3 months storage, maximum retention of per cent titratable acidity was found in T_3 (0.68%) followed by T_2 (0.54%), whereas minimum was found in T_1 (0.22%). High per cent of acidity observed in pumpkin candies were may be due to the addition of citric acid.

Titratable acidity mean values of the pumpkin candy decreased from 0.53 to 0.42 per cent gradually with increase in storage period (Table 2). Similar trend was observed by Mehta and Bajaj (1984) in citrus peel candy, Sagar and Khurdiya (1999) in dehydrated mango slices, Sharma *et al.* (2000) in osmo dried apricot, Sagar and Kumar (2009) in osmo dehydrated mango slices, Ahmed *et al.* (2014) in osmo dried peach slices, Divya *et al.* (2014) in sapota candy, Devi (2014) in osmo dried wild pear halves, Patil *et al.* (2014) in karonda candy, Hasanuzzaman *et al.* (2014) in tomato candy and Aggarwal and Michael (2014) in kinnow candy. The decrease in titratable acidity during storage might be due to utilization of acids for conversion of non-reducing sugars to reducing sugars and in non-enzymatic reactions (Sharma *et*

al., 2004) and also due to permeability of packaging material to gas and water (Sra *et al.*, 2014).

5.1.4 Ascorbic acid (mg/100 gm)

Ascorbic acid is one of the major constituent of the pumpkin. It is very susceptible to heat and light, which is evident by the result of the present investigation that there was a decrease in ascorbic acid content of pumpkin candies from 7.17 to 5.24 mg/100 g as the storage period prolonged (Table 2). The decrease in ascorbic acid during storage might be due to its oxidation and more loss in polyethylene packed samples might have been due to more availability of oxygen during storage (Sharma *et al.*, 2000).

Maximum retention of ascorbic acid was found in T_1 (8.20, 7.35, 6.72 and 6.52 mg/100 g) where no blanching and citric acid addition was carried out, it was followed by T_3 (7.63, 6.45, 5.91 and 5.75 mg/100 g) where pumpkin candies were blanched for 7 minutes and 1 per cent citric acid was added during initial, 1, 2 and 3 months of storage. Similar results were noticed by Muzzaffar (2006) in pumpkin candy, Ahmed *et al.* (2014) in osmo dried peach slices, Ankita *et al.* (2014) in osmo dehydrated papaya cubes, Devi (2014) in osmo dried wild pear slice, Rashmi *et al.* (2005) in osmo-dehydrated pineapple and Sharma *et al.* (2006) in dehydrated apple rings.

5.1.5 ß–carotene (mg/100 g)

Pumpkin is rich source of ß–carotene and so its candy, among different treatments maximum ß-carotene was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) that is (6.15, 6.07, 5.94 and 5.83 mg/100 g) whereas minimum was recorded in T_1 (3.67, 3.56, 3.41 and 3.29 mg/100 g) where no blanching and citric acid were added at initial, 1, 2 and 3 months after storage respectively (Table 3).

By the data it is evident that ß–carotene content of pumpkin candy showed decreasing trend throughout storage irrespective of treatments (5.38 - 5.05 mg/100 g). This decrease in carotene content may be due to the thermo labile and photosensitive nature of ß–carotene and oxidation of carotenoids during storage.Similar results were

reported by Muzzaffar (2006) in pumpkin candy and same decreasing trend in carotene content has also been observed by Sagar and Kumar (2009) in osmo dehydrated mango slices, Swain *et al.* (2013) in osmo dehydrated sweet pepper, Sharma *et al.* (2004) in osmo dehydrated apricot, Durrani *et al.* (2011) in carrot candies, Sharma *et al.* (2006) in dehydrated apple rings and Sra *et al.* (2014) in dehydrated carrot slices.

5.1.6 Non-enzymatic browning (OD)

Several factors such as temperature, moisture, organic acids, water activity, oxygen and sugars have been reported to be responsible for causing non-enzymatic browning in stored fruits (Sharma *et al.*, 2000). In the present investigation non-enzymatic browning of pumpkin candy was found maximum (0.303) in T_1 (Control) and minimum (0.146) was in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) at 3 months after storage (Table 3). Addition of citric acid in some treatments showed minimum OD values, being antioxidant citric acid reduced the browning of pumpkin candy during storage.

Irrespective of treatments non-enzymatic browning (NEB) was increased with the increase in storage period. Mean values for NEB of pumpkin candy increased from 0.170 to 0.194 during storage. A significant increase in NEB during storage may be due to more degradation of ascorbic acid and formation of brown colour in products (Sagar and Kumar, 2009). Similar findings were noticed by Sagar and Kumar (2009) in osmo dehydrated mango slices, Ahmed *et al.* (2014) in osmo dried peach slices, Sharma *et al.* (2004) in osmo dehydrated apricot, Kumar (2013) in osmo dried plum, Sharma *et al.* (2006) in dehydrated apple rings and Sra *et al.* (2014) in dried carrot slices.

5.1.7 Sugars (%)

All the treatments showed significant difference in reducing, non-reducing and total sugar of pumpkin candy throughout the storage period.

The maximum reducing sugar (41.35%) was recorded in T_9 (Blanching for 10 minutes + covering with dry sugar + 1% citric acid), whereas minimum (30.85%) was recorded in T_1 (Control) at the end of 3 months storage. Among all the treatments

mean values of reducing sugar increased from 34.89 to 36.02 per cent during storage (Table 4). Total sugars also shown an increasing trend in all the treatments, mean values increased from 56.21 to 56.57 per cent during storage of pumpkin candy.

Non-reducing sugar was decreased from mean value of 20.21 to 19.51 per cent during three months storage, maximum non-reducing sugar (21.85%) was found in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B + 1% citric acid) and minimum (15.67%) was in T_1 (Control) at the end of the three months storage period.

The increase in reducing sugars, total sugar and decrease in non-reducing sugar during storage might be due to slow inversion of non-reducing sugars and starch in to reducing sugars. The results are in accordance with the findings of Dar *et al.* (2011) in cherry candy and Ahmed *et al.* (2014) in osmo dried peach slices, both observed an increase in reducing sugars during 6 months of storage. Similar results were also found by Sagar and Kumar (2009) in osmo dehydrated mango slices, Kumar (2013) in osmo dried plum, Devi (2014) in osmo dried wild pear, Khan *et al.* (2014) in osmo dehydrated strawberry, Sagar and Neelavathi (2005) in dehydrated carrot shreds and Sharma *et al.* (2006) in dehydrated apple rings.

5.1.8 Colour (*L* a* b**) values

The data on *L** *a** and *b** values of pumpkin candy as influenced by different treatments and storage were presented in Table 6. The colour values of pumpkin candy showed significant difference among treatments and during storage period. At 3 months after storage maximum *L** was recorded in T_3 (77.25) whereas minimum was recorded in T_9 (7.58). Similarly maximum *a* and b** were observed in T_3 (1.47 and 6.23) while minimum was in T_9 (0.77 and 4.54) respectively.

Mean *L** value (lightness) showed a decreasing range from 79.59 to 76.07, mean *a** value (redness) showed an increasing pattern values ranged from 0.34 to 1.18 and mean *b** value (yellowness) decreased from 8.15 to 5.57 during storage. The change in colour values might be due to enzymatic and non-enzymatic oxidation process (Sagar and Kumar, 2009). Similar results were obtained by Muzzaffar (2006) in pumpkin candy and Ankita *et al.* (2014) in osmo dehydrated papaya cubes.

5.1.9 Organoleptic evaluation

Evaluation of sensory qualities of the product is an important tool for deciding the consumer acceptability. Quality aspects of pumpkin candy such as colour and appearance, flavour and texture generally reduces with increase in storage period. In the present investigation, semi-trained panelists comprising teachers and post graduate students of Kittur Rani Channamma College of Horticulture, Arabhavi were involved in the organoleptic evaluation of pumpkin candies.

5.1.9.1 Colour and appearance

The mean score for colour and appearance varied from 7.32 at initial to 6.80 at the end of the storage period indicating decrease in score over time. The maximum score was obtained in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and T_2 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid) which varied from 8.84 to 8.56 and 8.68 to 8.30 respectively. Whereas, minimum was obtained in T_1 (Control) which varied from 4.67 to 4.11 during storage period of three months (Table 7). The decreasing trend in scores of colour might be due to enzymatic and non-enzymatic oxidation process (Sagar and Kumar, 2009).

Similar decreasing trend in colour during storage was reported by Muzzaffar (2006) in pumpkin candy, Sharma *et al.* (2004) in osmo dehydrated apricot, Ankita *et al.* (2014) in osmo dehydrated papaya cubes, Devi (2014) in osmo dried wild pear slices and Khan *et al.* (2014) in osmo dehydrated strawberry.

5.1.9.2 Texture, taste and flavour

Maximum score for texture of pumpkin candy was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and T_2 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid) which varied from 8.51 to 8.15 and 8.32 to 7.92 respectively, while minimum (4.50 to 3.86) was obtained in T_1 (Control) when fresh and at end of the storage respectively. The mean score for texture varied from 7.55 to 7.15 and for taste showed decreasing trend throughout storage (Table 7).

Highest score for taste and flavour of pumpkin candy was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and T_2 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 0.5% citric acid) which varied from 8.32 to 7.83 and 8.04 to 7.50 respectively, while minimum (5.72 to 5.13) range was obtained in T_1 (Control) when fresh and at end of the storage respectively. The mean score for texture varied from 7.54 to 7.06 and for taste showed decreasing trend throughout storage (Table 8). Change in the texture upon storage may be attributed to the degradation of pectic substances and picking of moisture by the polyethylene pouches (Sharma *et al.*, 2004).

Similar findings were reported by Sagar and Kumar (2009) in osmo dried mango slices, Pereira *et al.* (2010) in osmo dehydrated guava slices, Ankita *et al.* (2014) in osmo dehydrated papaya cubes, Devi (2014) in osmo dried wild pear slices, Khan *et al.* (2014) in osmo dehydrated strawberry and Sra *et al.* (2014) in dried carrot slices.

5.1.9.3 Overall acceptability

The mean score for overall acceptability was decreased from 7.25 to 6.93 and among the treatments highest score was obtained for T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) which ranged from 8.31 to 8.04, followed by T_2 (Blanching for 7 minutes + steeping in 40 to 70°B + 0.5% citric acid) ranged from 8.03 to 7.77 and least score was obtained in T_1 (Control) which varied from 5.00 to 4.50 at initial and end of three months storage (Table 8).

Overall acceptability scores showed a decreasing trend with advancement in storage period, might be due to enzymatic and non-enzymatic oxidation process within the candy. Results obtained were in accordance with reports done by Sagar and Kumar (2009) in osmo dried mango slices, Pereira *et al.* (2010) in osmo dehydrated guava slices, Kumar (2013) in osmo dried plum, Ankita *et al.* (2014) in osmo dehydrated papaya cubes, Khan *et al.* (2014) in osmo dehydrated strawberry and Sra *et al.* (2014) in dried carrot slices.

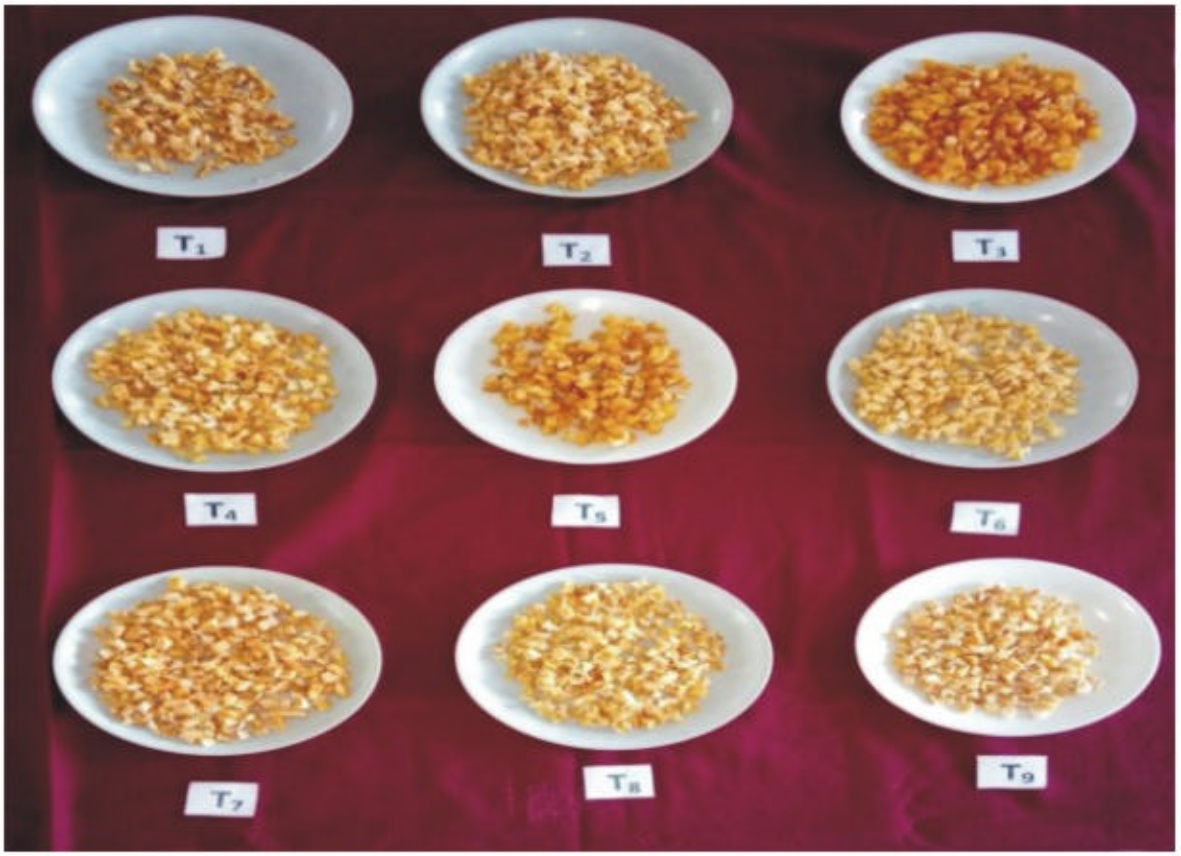


Plate 3a. Pumpkin Candies prepared with different treatments

Plate 3b. Sensory evaluation of pumpkin candies

5.1.10 Microbial population

The quality of the product may deteriorate during storage period due to many reasons. At initial when pumpkin candy was fresh no microbial growth was observed but microbial population showed a slight increase in their number after 1, 2 and 3 months after storage.

Total bacterial count was recorded maximum (2.20 x 10^5 CFU/g) in T_1 (Control) and minimum (0.43 x 10^5 CFU/g) in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid) and total fungal count was recorded maximum (2.50 x 10^3 CFU/g) in T_1 (Control) and minimum (0.73 x 10^3 CFU/g) in T_5 (Blanching for 10 minutes + steeping in 40 to 70°B syrup + 1% citric acid) after 3 months of storage (Table 9).

Irrespective of treatments the mean total bacterial count increased from 0.46 to 0.72 x 10^5 CFU/g and mean total fungal count increased from 0.75 to 1.00 x 10^3 CFU/g during storage. Similar results were reported by Muzzaffar (2006) in pumpkin candy and candies were in safe condition for consumption even after three months of storage. This may be due to the presence high sugar content and citric acid in candies prevented the spoilage of the product, may also due to the anti-microbial property of pumpkin which regulated the spoilage, in turn increasing storage stability of the candies.

5.2 Experiment II: Standardization of protocol for the preparation of pumpkin fortified biscuits

5.2.1 Width and thickness (cm)

The effect of storage on width and thickness of pumpkin fortified biscuits supplemented with pumpkin powder and pulp is presented in table 10. The data indicated an increase in width and thickness of biscuits of different treatments with the advancement of storage. The mean value for thickness during storage up to three months ranged from 4.49 to 4.64 cm and for width ranged from 1.43 to 1.48 cm.

Maximum recorded width (4.79 cm) and thickness (1.50 cm) was found in T_9 (20% pumpkin pulp + 80% refined wheat flour) and minimum was found in T_1 (100% refined wheat flour).Width and thickness of pumpkin fortified biscuits increased slightly as the level of substitution of pumpkin powder and pulp increased, because of presence of high crude fibre and carotene in pumpkin and increased moisture absorption by biscuits during storage also contributes a little to the increased width and thickness. Similar results were noticed by Joel *et al.* (2014) in full fat soya fortified cookies, Handa *et al.* (2012) in cookies fortified with fructoligosaccharide and Mahmood *et al.* (2008) in cookies fortified with vitamin A.

5.2.2 Moisture (%)

Moisture content is the most important criteria to look after in biscuit preparation as it affects the rheological properties, acceptability, microbial spoilage and storage stability of biscuits.

A significant increase in moisture content with the advancement of storage was observed in pumpkin fortified biscuits. Minimum (3.62%) was found in T_6 (05% pumpkin pulp + 95% refined wheat flour) and maximum moisture content (6.90%) was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) at end of 3 months of storage (Table 11). As incorporation of pumpkin powder increased, moisture content of biscuits also increased, this is because of increase in surface area of pumpkin powder which has high moisture holding capacity resulted in increase in moisture content as the level of incorporation of pumpkin powder increased. Irrespective of the treatments during storage also there was increase in moisture content which may be because of absorption of moisture by the polyethylene pouches.

The mean values for moisture content of pumpkin fortified biscuits increased from 4.11 to 5.53 per cent. Similar increasing trend for moisture content during storage was also revealed by Islam *et al.* (2017) in whey protein and curry leaves fortified biscuits, Joel *et al.* (2014) in full fat soya fortified cookies, Handa *et al.* (2012) in cookies fortified with fructoligosaccharide and Pasha *et al.* (2002) in cookies enriched with dietetic sweetener. The increase in moisture may be correlated to the hygroscopic nature of sucrose used in the preparation of product (Bond and Dunning, 2006).

5.2.3 Water activity (a_w)

Water activity is the ratio of the vapor pressure of water in a material to the vapor pressure of pure water, which plays a major role in stability of biscuits during storage, in particular resistance against microorganisms and rheological properties of biscuits.

The mean water activity of pumpkin fortified biscuits increased from 0.35 to 0.57 throughout the storage, minimum (0.52) was found in T_2 (05% pumpkin powder + 95% refined wheat flour) and maximum water activity (0.58) was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) at the end of 3 months of storage (Table 11). As the moisture content of biscuits increased, slight increase in water activity was observed, though there was a significant difference among the treatments, the moisture and water activity values of the biscuits indicate that the values are in the safe range of keeping quality.

The water activity values of biscuits are below the recommended water activity range for growth of bacteria (a_w<0.91) and moulds (a_w<0.81), besides which water activity plays a major role in influencing activity of enzymes and vitamins and have a major impact on colour, taste and aroma of the foods (Chirife and Buera, 1999). Similar findings were recorded by Islam *et al.* (2017).

5.2.4 Ascorbic acid (mg/100 g)

The effect of storage and level of incorporation of pumpkin powder and pulp in biscuits was presented in table 12, which indicated an increase in ascorbic acid content as the level of fortification increased.

Maximum ascorbic acid (1.73 mg/100 g) retention was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour), followed by T_4 (20% pumpkin powder + 80% refined wheat flour) that is 1.65 mg/100 g, whereas minimum (0.98 mg/100 g) was recorded in T_1 (100% refined wheat flour). Ascorbic acid values of pumpkin fortified biscuits showed a decreasing trend, mean values decreased from 1.32 to 1.03 mg/100 g during storage period. Similar results were noticed by Kumar *et al.* (2015) in pumpkin powder fortified cookies. Decrease in ascorbic acid may be due to oxidation process and some amount of acids lost due to various chemical reactions during storage.

5.2.5 ß–carotene (mg/100 g)

ß -carotene content of pumpkin fortified biscuits increased with the increased level of incorporation of pumpkin powder and pumpkin pulp, maximum (3.97 mg/ 100 g) ß–carotene was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour), whereas minimum (2.38 mg/100 g) was recorded in T_1 (100% refined wheat flour) when fresh (Table 12).

The data clearly reflect a significant variation in ß-carotene content of biscuits was due to supplementation of pumpkin powder and pulp in different proportions. The mean values for ß–carotene decreased from 3.24 to 2.62 mg/100 g with increase in storage time. The results were in correlation with the observations of Chandler and Achwartz (1998) and Speek *et al.* (1988) who suggested that changes occur in carotenoids through oxidation, isomerization and free radical formation due to the involvement of light and heat. Similar changes for ß-carotene have been noticed by Kulkarni and Joshi (2013) in pumpkin fortified cookies, Kumar *et al.* (2015) in pumpkin powder fortified cookies, Sudipta and Sumithra (2015) in bakery products enriched with pumpkin powder, Butt *et al.* (2004) and Mahmood *et al.* (2008) in cookie studies.

5.2.6 Sugars (%)

In the present experiment all the treatments showed significant difference in reducing, non-reducing and total sugar percentage in pumpkin fortified biscuits throughout storage period (Table 13 and Table 14).

The maximum reducing sugar (11.54%) recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) whereas, minimum (9.86%) was recorded in T_1 (100% refined wheat flour) at the end of 3 months storage. Among all the treatments mean values of reducing sugar increased from 10.22 to 10.86 per cent during storage.

Non-reducing sugar was decreased from mean value of 1.24 to 0.96 per cent during three months storage, maximum of non-reducing sugar (1.22%) was found in T_5 (20% pumpkin powder + 80% refined wheat flour) and minimum (0.76%) was recorded in T_6 (05% pumpkin pulp + 95% refined wheat flour) at the end of the storage period.

Total sugars also shown an increasing trend in all the treatments, mean values increased from 11.52 to 11.86 per cent during storage of pumpkin fortified biscuits, maximum total sugar (12.82%) recorded in T_5 (20% pumpkin powder + 80% refined wheat flour), whereas minimum (10.71) was recorded in T_1 (100% refined wheat flour) at the end of 3 months storage.

The increase in reducing sugars and decrease in non-reducing sugar during storage might be due to slow inversion of non-reducing sugars and starch in to reducing sugars. Findings were in comparison with Kumar *et al.* (2015) in pumpkin powder fortified cookies and Temesgen *et al.* (2015) in orange fleshed sweet potato enriched cookies showing increase in total sugar and reducing sugar content. This might have occurred due to hydrolysis of sucrose (Penfield and Campbell, 1990) or may be due to the inversion of sucrose or partial hydrolysis of starch during storage (Heikal *et al.*, 1964 and Sarhan *et al.*, 1971).

5.2.7 Crude fibre (%)

Crude fibre content of pumpkin fortified biscuits increased with increased level of substitution of pumpkin powder and pumpkin pulp. Maximum (0.96 and 0.91%) was found in T_5 (20% pumpkin powder + 80% refined wheat flour) whereas, minimum (0.24 and 0.19%) was found in T_1 (100% refined wheat flour) at initial and at the end of 3 months storage respectively. This could be due to initial high fibre content of pumpkin powder and pulp (Gopalan *et al.*, 2000), on the other hand refined wheat flour is a poor source of fibre in comparision to fruit and vegetable powders (Peter and John, 2012) Mean values decreased from 0.63 to 0.58 per cent during 3 months storage (Table 14).

Similar decreasing trend in crude fibre was reported by Islam *et al.* (2017) in whey protein and curry leaves fortified biscuits, Joel *et al.* (2014) in cookies enriched with full fat soya and Temesgen *et al.* (2015) in orange fleshed sweet potato enriched cookies. A non-significant decreasing trend in fibre content of legume fortified biscuits due to moisture absorption has also been executed by Ahmad (1996).

5.2.8 Organoleptic evaluation

Sensory quality is combination of different senses of perception coming in to play while choosing and eating a food and it is the ultimate criterion for the acceptability of any food product by the consumer. In this experiment, pumpkin fortified biscuits were evaluated for colour and appearance, texture or crispness, taste and overall acceptability at monthly interval.

The data on the effect of different storage period on sensory attributes of pumpkin fortified biscuits supplemented with pumpkin powder and pulp is shown in Table 15 and 16. The results indicated that the highest score was awarded to T5 (20% pumpkin powder + 80% refined wheat flour) for colour and appearance (8.42) and T_4 (15% pumpkin powder + 85% refined wheat flour) for texture (8.13), taste (8.45) and overall acceptability (8.11) whereas, least score for sensory parameters are recorded in T_9 (20% pumpkin pulp + 80% refined wheat flour) at the end of the storage. The scores showed a decreasing trend in all the treatments for different sensory parameters during storage. However, the mean scores significantly decreased from 8.30 to 7.94 for colour and appearance, 8.18 to 7.80 for texture or crispness, 8.22 to 7.83 for taste and 7.97 to 7.60 for overall acceptability.

The treatments like T_7, T_8 and T_9 were least accepted by the judges compared to other treatments, this may be due to the charring and browning of pulp during baking but all the treatments were found to be well above the acceptable limits even after three months of storage. The results showed that treatments as well as storage conditions has affected the sensory attributes of biscuits supplemented with pumpkin powder and pulp. Similar decreasing trend in organoleptic attributes in biscuits during storage was reported by Elahi (1997). This may be attributed to moisture absorption, increase in peroxide value and increase in fatty acids (Mushtaq *et al.*, 2010 and Borneo *et al.*, 2007). These results are also in conformity with the studies of Kulkarni and Joshi (2013) and Kumar *et al.* (2015) in pumpkin powder fortified biscuits, Pongjanta *et al.* (2006) and Sudipta and Sumithra (2015) in bakery product enriched with pumpkin powder.

Plate 4a. Fortified biscuits prepared with pumpkin powder and pulp

Plate 4b. Sensory evaluation of pumpkin fortified biscuits.

5.2.9 Microbial population

No microbial growth was found in the biscuits supplemented with pumpkin powder and pulp packed in polyethylene bags during the entire period of storage. This may be due to the reason that water activity of these products was in the range of 0.35 to 0.57 (Table 11) for different treatments. The water activity values of biscuits are below the recommended range for growth of bacteria (a_w<0.91) and moulds (a_w<0.81) and the range is not favorable for the growth of micro-organisms (Chirife and Buera, 1999). Therefore, it can be concluded that the pumpkin fortified biscuits remained safe for consumption up to a period of three months.

6. SUMMARY AND CONCLUSIONS

The research entitled "Standardization of protocol for the preparation of pumpkin (*Cucurbita moschata* D.) candy and biscuits" was done during the year 2017-2018 at the Department of Post Harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi (University of Horticultural Sciences, Bagalkot), Karnataka. The present study was carried out to standardize the protocol for the preparation of pumpkin candy and pumpkin fortified biscuits and to study their physico-chemical, nutritional, sensory properties and storage stability of products. The salient features of the present study are summarized here under.

6.1 Experiment No. 1: Standardization of protocol for the preparation of pumpkin candy

Pumpkin candies were prepared with slight modification in the procedure such as blanching time (7 and 10 minutes), steeping in 40 to 70°B syrup and covering with dry sugar, addition of citric acid (0.5 and 1%) and their combinations. Physico-chemical, nutritional and sensory qualities of pumpkin candy were recorded at fresh and during monthly interval up to three months to study product characteristics and its storage stability.

Results showed significant differences with respect to various parameters of pumpkin candy. It was evident from the results that blanching time, citric acid concentration and method of preparation of pumpkin candy does affect the final quality of the product.

During the storage, pumpkin candy showed increasing trend with respect to parameters like per cent moisture (11.02–11.44%), non-enzymatic browning (0.170-0.194), reducing sugar (34.89-36.02%), total sugar (56.21-56.57%), total bacterial count (0.46 - 0.72 x 10^5CFU/g) and total fungal count (0.75 - 1.00 x 10^3CFU/g) whereas, decreasing trend was observed in ascorbic acid (7.17-5.24 mg/100 g), titratable acidity (0.53-0.42%), ß–carotene content (5.38-5.05 mg/100 g), non-reducing sugar (20.21-19.51%) and also in sensory score like colour and appearance (7.32-6.80), texture (7.55-7.15), taste and flavour (7.54-7.06) and over all acceptability (7.25-6.93) during three months storage.

Among different treatments T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid) recorded maximum recovery percentage (80.10%), highest per cent moisture (12.47%), highest *L* a* b** values (79.04, 1.11, 6.84 respectively), maximum titratable acidity (0.68%), ß–carotene content (5.83 mg/100 g) and least non-enzymatic browning (0.146).

Sensory evaluation of pumpkin candy revealed that maximum score for colour and appearance (8.56), texture (8.15), taste and flavour (7.83) and overall acceptability (8.04) was recorded in T_3 (Blanching for 7 minutes + steeping in 40 to 70°B syrup + 1% citric acid). Even after 3 months of storage, this treatment remained high scoring throughout the storage period. Lowest score for colour and appearance, texture, taste and flavour and overall acceptability was scored by T_1 (Control: without blanching and citric acid) throughout the storage period.

6.2 Experiment No. 2: Standardization of protocol for the preparation of pumpkin fortified biscuits

The biscuits were prepared by substituting pumpkin powder and pumpkin pulp to refined wheat flour in standard recipe at different proportions like 5, 10, 15 and 20 per cent. The physical parameters like width and thickness showed a slight increasing trend from 4.49 to 4.64 cm and from 1.43 to 1.48 cm respectively. Moisture percentage and water activity found to increase from 4.11 to 5.53 per cent and 0.35 to 0.57 respectively.

Decreasing trend was observed in chemical constituents of pumpkin fortified biscuits like ß–carotene (3.24-2.62 mg/100 g), ascorbic acid (1.32-1.03 mg/100 g), non-reducing sugar (1.24-0.96%) and crude fibre (0.63-0.58%) whereas, increasing trend was noticed in reducing sugar (10.22-10.86%) and total sugar (11.52-11.86%) during three months storage.

Results of the organoleptic evaluation of pumpkin fortified biscuits reveals that the score for different parameters showed a decreasing trend during storage *viz.*, colour and appearance (8.30-7.94), texture or crispness (8.18-7.80), taste (8.22-7.83) and overall acceptability (7.97-7.60).

Among the different treatments maximum ß–carotene content (3.18 mg/100 g), ascorbic acid content (1.41 mg/100 g), reducing sugar (11.54%), non-reducing sugar (1.22%), total sugar (12.82%) and crude fibre (0.91%) at three months after storage was recorded in T_5 (20% pumpkin powder + 80% refined wheat flour) whereas, minimum was recorded in T_1 (100% refined wheat flour).

Biscuits fortified with pumpkin powder scored high overall acceptability than pumpkin pulp enriched biscuits by the judges at initial as well as during storage period. The maximum organoleptic scores for colour and appearance was recorded in T_5 (8.42) and T_4 (8.31), whereas maximum score for texture or crispness (8.13), taste (8.45) and overall acceptability (8.11) was recorded in T_4 (15% pumpkin powder + 85% refined wheat flour) at three months after storage. Irrespective of the treatments no microbial growth was observed in biscuits samples throughout the storage period indicating it's stable and safe product for consumption.

Conclusion

- Nutritionally as well as organoleptically superior pumpkin candy can be prepared by blanching pumpkin cubes for 7 minutes and steeping them in 40 to 70°B syrup with 1 per cent citric acid (T_3) and it was followed byblanching pumpkin cubes for 7 minutes and steeping them in 40 to 70°B syrup with 0.5 per cent citric acid (T_2).

- Organoleptically acceptable pumpkin fortified biscuits can be prepared by the combination of 15 per cent pumpkin powder and 85 per cent refined wheat flour (T_4) and it is followed by T_5 (20% pumpkin powder + 80% refined wheat flour). Whereas nutritionally superior quality pumpkin fortified biscuits can be prepared by the combination of 20 per cent pumpkin powder and 80 per cent refined wheat flour (T_5) followed by T_4.

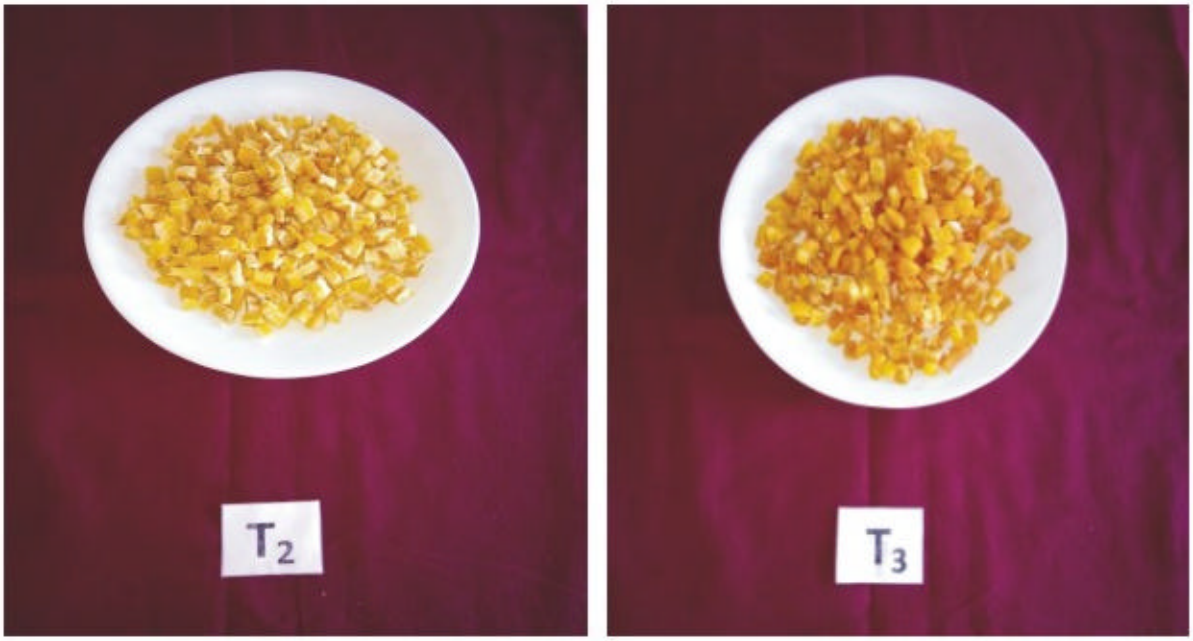


Plate 5a. Best treatments among candies prepared from pumpkin

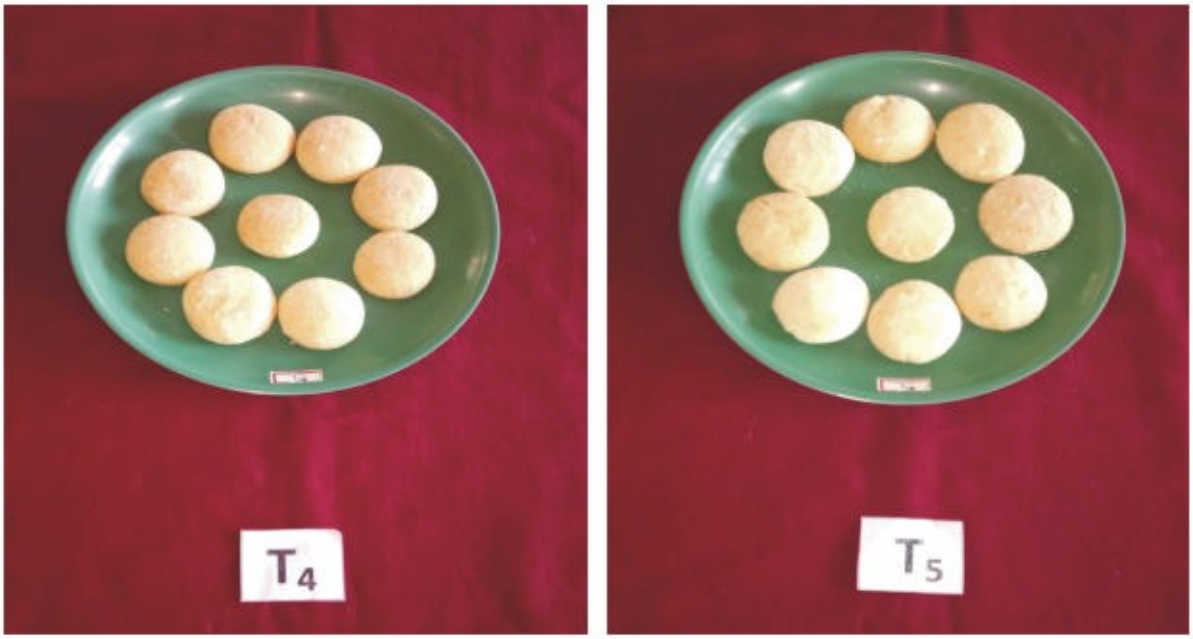


Plate 5b. Best treatments among fortified biscuits prepared from pumpkin powder and pulp

Future line of work

- Pumpkin being cheap and huge source of nutritional and health benefits, has vast scope in food processing industry, so more and more research should be done in this manner to exploit all the benefits.

- Pumpkin can be exploited potentially in food fortification. Pumpkin powder and pulp can be used for the fortification of bakery and snack foods which are having high demand in present scenario.

- Protocols for the preparation of varieties of processed pumpkin products like extruded snacks, bakery, confectionaries and fortified foods can be standardized.

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STANDARDIZATION OF PROTOCOL FOR THE PREPARATION OF PUMPKIN (*Cucurbita moschata* D.) CANDY AND BISCUITS

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ABSTRACT

An investigation to standardize the protocol for the preparation of pumpkin candy and pumpkin fortified biscuits and to study their storage stability was carried out in the Department of Post Harvest Technology, KRC College of Horticulture, Arabhavi during 2017-2018. Physicochemical and sensory qualities of both the products were studied during three months of storage.

Pumpkin candy was prepared with modification in the procedure such as blanching time (7 and 10 minutes), steeping cubes in sugar syrup and covering with dry sugar (40-70°B), addition of citric acid (0.5 and 1.0%) and their combinations. Among the treatments blanching pumpkin cubes for 7 minutes and steeping them in sugar syrup of 40-70°B with addition of 1 per cent citric acid had scored the maximum recovery (80.10%), highest *L** *a** *b** values (79.04, 1.11, 6.84 respectively), maximum titratable acidity (0.68%), ß–carotene content (5.83 mg/100 g), least non-enzymatic browning (0.146), total bacterial (0.65 x 10^5 CFU/g) and total fungal count (0.92 x 10^3 CFU/g) and highest overall acceptability (8.04) at three months of storage. The result of three months storage under ambient condition reveals that chemical constituents *viz.*, moisture percentage, reducing sugar, total sugar, *a** value, non- enzymatic browning, microbial population found to increase whereas titratable acidity, ascorbic acid, ß–carotene, non-reducing sugar, *L** and *b** values and organoleptic scores were decreased.

Pumpkin fortified biscuits were prepared by incorporating pumpkin powder and pulp into the standard recipe to replace wheat flour at levels of 5, 10, 15 and 20 per cent. Physicochemical analysis reveals that combination of 20 per cent pumpkin powder and 80 per cent refined wheat flour was found to be better with respect to nutritional quality compared to other treatments. Whereas, the result of sensory evaluation revealed that 15 per cent pumpkin powder has shown higher score for taste, texture and overall acceptability. Product was found to be stable and safe for the consumption without any microbial growth up to 90 days of storage.

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PÀÄA§¼ÀPÁ¬Ä vÀÄAqÀÄUÀ¼À£ÀÄß ««zÀ G¥ÀZÁgÀUÀ¼À ¸ÀAAiÉÆÃd£ÉUÀ¼ÉÆA¢UÉ (7 ªÀÄvÀÄÛ 10 ¤«ÄµÀUÀ¼À PÁ® ©¹ ¤Ãj£À°è CzÀÄÏªÀÅzÀÄ, ¸ÀPÀÌgÉ ¥ÁPÀzÀ°è £É£É¸ÀÄªÀÅzÀÄ (40-70⁰ ©ºPÀÌ), Mt ¸ÀPÀÌgÉ¬ÄAzÀ ªÀÄÄZÀÄÏªÀÅzÀÄ, £Ã. 0.5 ªÀÄvÀÄÛ 1 gÀµÀÄß ¹nºï DªÀÄé¢zÀ°è CzÀÄÏªÀÅzÀÄ) PÁåAr AiÀÄ£ÀÄß vÀAiÀÄÁj¸À¯Á¬ÄvÀÄ. GvÀÛªÀÄ UÀÄtªÀÄlÖzÀ PÀÄA§¼À PÁåAr AiÀÄ£ÀÄß G¥ÀZÁgÀ 3 (7 ¤«ÄµÀ ©¹ ¤Ãj£À°è CzÀÄÏªÀÅzÀÄ + 40-70⁰ ©ºPïì ¸ÀPÀÌgÉ ¥ÁPÀ + ±ÉÃ. 1.00 ¹nºï DªÀÄé¢zÀ°è CzÀÄÏªÀÅzÀÄ) jAzÀ PÁåAr vÀAiÀÄÁj¸À¯Á¬ÄvÀÄ. ¥À¸ÀÄÛvÀ «zÁ£ÀªÀÅ UÀjµÀ× E¼ÀÄªÀj (80.10%), J¯ï*, J*, ©* ªÀiËÖ®åUÀ¼ÀÄ (C£ÀÄPÀªÀÄªÁV 79.04, 1.11, 6.84), DªÀÄévÉAiÀÄ ¥ÀªÀiÁt (0.68%), ß-PÁågÉÆnÃ£ï (5.83 «ÄUÁA/100 UÁA), PÀ¤µÀ× £Á£ï JAeÉÉªÉÄnºï ¨Ëé¤AUï (0.146), ¨ÁåQÛÃjAiÀÄÁ (0.65 x 10^5 ¹.J¥ï.AiÀÄÄ/UÁA) ºÁUÀÆ MlÄÖ ²°ÃAzÀ (0.92 x 10^3 ¹.J¥ï.AiÀÄÄ/UÁA) ªÀÄvÀÄÛ ºÉaÑ£À ¸Áé¢zÀUÀÄtªÀ£ÀÄß (8.04) UÀ½¹zÉ. ªÀÄÄÆgÀÄ wAUÀ¼À ±ÉÃRgÀuÉ ¥À°vÁA±ÀUÀ¼À ¥ÀºÁgÀ ±ÉÃPÀqÀ ¤Ãj£À CA±À, QëÃtÂ¸ÀÄªÀ ¸ÀPÀÌgÉ, MmÁÖgÉ ¸ÀPÀÌgÉ, J* ªÀiËÖ®å, £Á£ï JAeÉÉªÉÄnºï ¨Ëé¤AUï, MlÄÖ ¸ÀÆPÀëöäfÃ«UÀ¼À ¸ÀASÉå ºÉZÀÄÏªÀÅzÀÄ PÀAqÀÄ§A¢zÉ. DzÀgÉ DªÀÄévÉAiÀÄ ¥ÀªÀiÁt, C¸ÉÆÌÃ©ðºï DªÀÄé, ß-PÁågÉÆnÃ£ï, QëÃtÂ¸ÀzÀ ¸ÀPÀÌgÉ, J¯ï* ªÀÄvÀÄÛ ©* ªÀiËÖ®å ºÁUÀÆ gÀ¸À¸Áé¢zÀ UÀÄtUÀ¼ÀÄ ªÀÄÄÆgÀÄ wAUÀ¼À ±ÉÃRgÀuÉ CªÀ¢AiÀÄ°è E½PÉAiÀÄÁUÀÄªÀÅzÀÄ PÀAqÀÄ§A¢zÉ.

©¸ÀÌmï vÀAiÀÄÁj¸ÀÄªÀ «zÁ£ÀzÀ°è UÉÆÃ¢Ã¢ »nÖ£À §zÀ¯ÁV ±ÉÃ. 5, 10, 15 ªÀÄvÀÄÛ 20 gÀµÀÄß ¥ÀªÀiÁtzÀ°è PÀÄA§¼ÀPÁ¬Ä ¥ÀÄr ªÀÄvÀÄÛ wgÀÄ¼À£ÀÄß ¸ÉÃj¹ PÀÄA§¼ÀPÁ¬Ä ©¸ÀÌmï vÀAiÀÄÁj¸À¯Á¬ÄvÀÄ. ±ÉÃ. 20 gÀµÀÄß PÀÄA§¼ÀPÁ¬Ä »lÄÖ ªÀÄvÀÄÛ ±ÉÃ. 80 gÀµÀÄß UÉÆÃ¢Ã¢ »nÖ¤AzÀ vÀAiÀÄÁj¹zÀ ©¸ÀÌmï GvÀÛªÀÄ ¥Ë¶ÖPÁA±ÀªÀÄß ºÉÆA¢gÀÄªÀÅzÀÄ ¨ÉÊvÀ gÁ¸ÁAiÀÄ¤PÀ «±ÉßÃµÀuÉ¬ÄAzÀ w½zÀÄ§A¢zÉ. DzÀgÉ ±ÉÃ. 15 gÀµÀÄß PÀÄA§¼ÀPÁ¬Ä »lÄÖ ªÀÄvÀÄÛ ±ÉÃ. 85 gÀµÀÄß UÉÆÃ¢Ã¢ »nÖ¤AzÀ vÀAiÀÄÁj¹zÀ ©¸ÀÌmï GvÀÛªÀÄ gÀ¸À¸Áé¢zÀzÀ UÀÄtUÀ¼À£ÀÄß UÀ½¹gÀªÀÅzÀÄ PÀAqÀÄ§A¢zÉ. ªÀÄÄÆgÀÄ wAUÀ¼À ±ÉÃRgÀuÉ CªÀ¢AiÀÄ°è AiÀÄÁªÀÅzÉÃ jÃwAiÀÄ ¸ÀÆPÀëöäfÃ«AiÀÄ ¨É¼ÀªÀtÚÉ PÀAqÀÄ§A¢gÀªÀÅ¢®è. vÀAiÀÄÁj¹zÀ ©¸ÀÌmï ±ÉÃRgÀuÉAiÀÄ°è ¹ÜgÀªÁVzÀÄÝ §¼ÀPÉUÉ ªÀÄÄÆgÀÄ wAUÀ¼ÀªÀgÉUÉ ¸ÀÄgÀQëvÀªÁVzÉ JAzÀÄ PÀAqÀÄ§A¢zÉ.