OPTIMISATION OF PROCESS VARIABLES FOR VALUE ADDED PUMPKIN (*Cucurbita moschata* Poir.) PRODUCTS

By

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** is a bonafide record of research work done by me during the course of research and that this thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** is a bonafide record of research work done independently by **Miss. SHABINA B.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Introduction

1. INTRODUCTION

India, endowed with diverse agro-climatic conditions, produces wide variety of fruits and vegetables such as tropical, sub-tropical, temperate and arid, and also enjoys an enviable position in the horticulture map of the world. Fruits and vegetables are packed full of goodness and often contain a number of essential vitamins and minerals that cannot be found in other types of foods or they may contain higher levels of these nutrients than other foods.

Pumpkin is considered as 'the marvel of vegetable world' due to its unusual and extravagant characters. Among cucurbitaceous vegetables, pumpkin has been appreciated for high yield, long storage life and high nutritive value. Pumpkin fruits are sweet when ripe, with yellow or orange flesh rich in β carotene and vitamins like C, E, B_6 as well as minerals like potassium, phosphorus, magnesium, iron and selenium (Zawiska *et al*., 2009).

Pumpkin is a valuable source of functional compounds mainly carotenoids, leutein, zeaxanthin, fibre and phytosterols, which acts as antioxidants in human nutrition. Pumpkin has anti-diabetic, antioxidant, anti-carcinogenic and anti-inflammatory properties (Yadav *et al*., 2010). Huge concentration of β carotene in pumpkin protect against certain cancers, cataract, and act as an anti- ageing agent.

Pumpkins are versatile in nature with good preservation capacity. Pumpkins are utilised for the preparation of various value added products like pies, freeze, canned, dried and pickled products in foreign countries. In India, they are mostly consumed as fresh vegetable with exception of its use in vegetable sauce where the pumpkin is being added as a thickening agent.

Pumpkin has a vast scope for diversification and exploring its utilisation in commercial products like jam, pickle, beverages, candy, seed oil, bakery and confectionary products. Moreover, pumpkin is a rich source of β carotene and can also be utilised in combination with other vegetables and fruits to enrich the nutritional properties of such products.

Since, pumpkin is produced in bulk in India especially in rural areas, the processing of pumpkin into various products could commercially be explored so that they are made available to the common masses. Hence, the project entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** was undertaken with the following objectives

1. To standardise the process variables for value added dehydrated products of pumpkin
2. To evaluate the nutritional and organoleptic qualities and shelf life of the products.

Review of literature

2. REVIEW OF LITERATURE

The relevant literature available on the study entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** is briefly reviewed here. Similar works on other fruits and vegetables are also cited wherever sufficient literature is not available on pumpkin. The literature is reviewed under the following subtitles.

2.1. Importance of value addition in fruits and vegetables
2.2. Nutritional and health benefits of pumpkin
2.3. Osmotic dehydration and drying of fruits and vegetables
2.4. Pumpkin based products and quality evaluation

2.1. Importance of value addition in fruits and vegetables

Fruits and vegetables play a significant role in the human diet, through its supply of vitamins and minerals. They contain antioxidants and various phytochemicals which help to protect the body against chronic diseases (Rajeshwari, 2003). Fruits and vegetables are coined as functional foods since they not only fulfill the physiological needs, but also have prophylactic effect (Kapoor and Kaur, 2004).

Premnath *et al*. (2004) pointed out that increased awareness about sound health and quality life, coupled with increased problems of nutritional insecurity brought about a sudden shift in food grain production and consumption pattern to, diversified and value added food production and consumption.

According to Rao (1989), processing of fruits can be defined as adding value to conventional and innovative fruit items, through various permutations and combinations providing protection, preservation, packaging, convenience, carriage and disposability.

The food industry can provide processed fruit products at reasonable and steady prices throughout the year, meeting the requirements of defense forces in border area and earning foreign exchange for the country by development of exports (Shaw *et al*., 1993). Anand (2000) pointed out that a strong and vibrant food processing sector plays a significant role in economic growth, as it provides vital linkages and synergies between the two pillars of the economy namely industry and agriculture. India, a diversified country with wide range of fruits, can play an important role by providing exotically flavoured processed products (Sharma, 2004; Tandon and Kumar, 2006).

Dhankar (2001) reported that processing of fruits and vegetables for both food and non food uses will open up marketing alternatives to the sale of fresh produce, reduce post harvest losses, regulate prices during lean production and raise farm income and create employment. Product development is increasingly the life line of the food industry (Research News and Notes, 2004).

Underexploited fruits are the several less known fruit species, which have the potential for commercial exploitation (Pareek and Sharma, 1993). Kumar (1993) indicated that considerable efforts are needed to make a new product from underexploited fruits, competitive in the world market with respect to nutritional and microbial quality as well as zero level chemical residues.

According to Roy (2001), huge variety of underutilised fruits available are not easily marketable in the fresh form, and hence should be processed into value added products so that consumers all over the world get an opportunity to enjoy at least in the processed form. The underutilised fruits have the ability to grow under adverse conditions and are known for their therapeutic and nutritive values. However, some of these fruits are not acceptable in the markets in fresh form due to acidic nature, astringent taste, small fruit size, high picking frequency of fruits, distant markets etc. (Gajanana, 2006 and Hiremath *et al.,* 2006).

Choudhary *et al.* (2006) suggested that product diversification of underutilised fruits and vegetables will be an effective technological intervention. According to Thilakawardane (2009), the demand for fruit and vegetable preserves and preparations is increasing yearly.

2.2. Nutritional and health benefits of pumpkin

Pumpkin is a tasty source of carotenoids, vitamins, minerals and dietary fibres (Djutin, 1991 and Egbekun *et al*., 1998). Proximate analysis of pumpkin flesh (Sharma and Kumar, 1995) revealed that it contains protein (1.4 g), fat (0.1 g), carbohydrate (4.6 g), calcium (10 mg), phosphorus (30 mg) and iron (0.7 mg) per 100 g. See *et al*. (2007) reported that fresh pumpkin contains 92.2 per cent moisture, 0.15 per cent fat and 5.3 per cent carbohydrate.

Sirohi *et al*. (1991) reported that pumpkin is a valuable source of various functional components like carotenoids, lutein, zeaxanthin, vitamin E, ascorbic acid, phytosterols and selenium which act as antioxidants in human nutrition. According to Yadav *et al*. (2010), pumpkin had anti-diabetic, antioxidant, anti-carcinogenic and anti-inflammatory properties.

Gopalakrishnan *et al*. (1980) reported that Indian cultivars of pumpkin had 132 to 527 mg of β carotene per 100 g on dry weight basis. As reported by Danilchenko *et al*. (2000) and Wills (2001), the β carotene content of pumpkin fruits varied from 1.6 to 45.6 mg and 2.8 to 3.4 mg respectively per 100 g. Organically grown pumpkin fruits accumulated higher amount of β carotene and vitamin E as compared to conventionally grown fruits (Danilchenko *et al.,* 2003). Dhiman *et al*. (2007) reported that pumpkin has a huge concentration of β carotene which protect against certain cancers, cataract, and act as an anti-ageing agent.

The fruits of pumpkin are diuretic, tonic and calm thirst. The pulp of pumpkin fruit was considered as sedative, emollient, and refrigerant (Kirtikar and Basu, 1975). Egbekun *et al*. (1998) indicated the role of pumpkins in reducing the risk of macular degeneration, a serious eye problem leading to blindness. The authors also indicated the role of pumpkin in bowel health due to high fibre content, lowering the risk of hypertension due to high potassium and boosting immunity due to the presence of zinc.

Being rich in phytosterols, pumpkin has been associated in reducing the levels of LDL cholesterol. Danilchenko *et al.* (2000) recommended pumpkin for atherosclerosis as it helps to reduce cholesterol in people suffering from obesity. The authors also reported that the presence of magnesium, potassium and folate in pumpkin highlights its heart friendly attributes.

Jiawei *et al.* (2003) reported that pumpkin could be consumed to cure stomach and intestinal disorders since the amounts of organic acid and cellular tissue are not high in pumpkin. The authors indicated the use of pumpkin against diabetes mellitus due to its hypoglycemic characters.

Pumpkin leaves contain essential oils, vitamins and antioxidants (Iwu, 1983). Gbile (1986) reported the use of young leaves sliced and mixed with coconut water and salt for the treatment of convulsion in ethno medicine. According to Eseyin *et al*. (2005), pumpkin leaf extract was found to be useful in the management of cholesterolemia, liver problems and impaired defense immune system.

The seeds of pumpkins are useful to lower cholesterol and had antidepressant qualities due to the presence of tryptophan (Anon., 1950). One gram of pumpkin seed protein contains as much tryptophan as a full glass of milk. Murkovic *et al*. (1996) and Anon. (2008) reported that pumpkin seeds contain omega-3 and omega-6 essential fatty acids.

According to Suphakarn *et al*. (1987), pumpkin seeds provide high phosphorus and lower the risk of bladder stones. Zimmerman (1997) indicated that pumpkin seed oil is useful in promoting wellness in HIV/ AIDS patients.

Younis *et al*. (2000) found that pumpkin seeds contain cucurbitacins, which are useful against intestinal parasites and considered as a traditional remedy for tape worm and safe for children and pregnant women. According to Kreft and Kreft (2007), pumpkin seeds are rich in magnesium, manganese, phosphorus and phytosterols.

Levin and Rachel (2008) cited that pumpkin seeds promoted overall prostrate health, apart from alleviating the problem of difficult urination that is associated with an enlarged prostrate. The authors also reported various other properties of pumpkin seeds like reducing inflammation, preventing the formation of calcium oxalate stones and protection against osteoporosis. L-tryptophan present in seeds is effective against depression. The importance of pumpkin seed oil in maintaining healthy blood vessels, nerves and tissues due to the essential fatty acids was also indicated by the authors.

Dhiman *et al*. (2009) indicated that pumpkin seeds could be used to treat learning disorders and were considered to be useful in gastritis, enteritis and febrile diseases and could be used in the treatment of arthritis since it had anti- inflammatory properties.

Zhang and Guo (2011) indicated that pumpkin powder contains abundant quantities of nutrients which included 4.09 g fat, 21.06 g fibre and 301.57 mg calcium in 100 g. The authors also reported that the pumpkin powder is low in fat and high in calcium and it is an ideal food for patients suffering from diabetes mellitus and cardiovascular diseases as well as in geriatrics.

2.3. Osmotic dehydration and drying of fruits and vegetables

Osmotic dehydration represents a technological alternative to reduce post- harvest loss in fruits and vegetables. Pointing *et al.* (1966) reported that osmotic process in conventional dehydration has two major objectives- quality improvement and energy saving. Osmotic dehydration is an energy efficient method of partial dehydration by immersion in a hypertonic solution (Bolin *et al*., 1983; Rastogi *et al*., 2002 and Azoubel and Murr, 2004).

Torreggiani (1993) reported that osmotic dehydration can be used as a pretreatment to many processes used for the improvement of nutritional, sensorial, and functional properties of food without changing its integrity. The author also pointed out that osmotic dehydration was effective around ambient temperature. According to Wack (1994) and Krokida and Kouris (2003), the advantages of osmotic dehydration included minimised heat damage to colour and flavour, less discoloration by enzyme oxidative browning and improved texture, colour and flavour.

Rastogi *et al*. (2002) observed inhibition of microbial growth through osmotic dehydration by reducing the water activity of food materials. Tiwari and Jalali (2004) reported that osmotic dehydration improved the quality of final product by increasing the sugar to acid ratio. Due to the efficiency of osmotic process in achieving a wide range of water loss/ solid gain ratio, osmotic dehydration could be used for salting operations or for dehydration processes (Mayor *et al.*, 2006).

The use of sodium chloride and sucrose as osmotic agents was reported by Pointing *et al.* (1966). Apart from these, the use of glucose, trisodium citrate, fructose, high molecular weight sugar, sorbitol and celerose as osmotic agents were also reported (Alvarez *et al*., 1995; Ertekin and Cakaloz, 1996; Nieto *et al*., 2004; Marani *et al*., 2007 and Rizzolo *et al*., 2007).

Lerci *et al*. (1985) reported that, when sodium chloride was added to the osmotic solution, it increases the force of the drying process by its capacity to lower water activity. Taiwo *et al*. (2003) opined that the addition of sodium chloride attenuated sweetness of the fruit and enhanced water loss and solid gain.

Research on osmotic dehydration of foods was pioneered in 1966 by Pointing *et al*. and many review articles have already been published dealing with various parameters such as mechanism of osmotic dehydration, effect of operating variables on osmotic dehydration, modeling of water loss, solid gain etc. (Tiwari and Jalali, 2004).

Hough *et al*. (1993) observed mass transfer during osmotic treatment through semi permeable cell membranes present in biological materials which offers dominant resistance to the process. The authors also indicated that mass transfer in osmotic dehydration is a combination of simultaneous water loss and solid gain.

According to Rastogi *et al*. (2000), the state of the cell membrane changed from being partially or totally permeable and lead to significant changes in tissue architecture during osmosis. Barat *et al*. (2001) reported that the changes in volume during osmotic dehydration were due to mass fluxes and these volume changes were explained as a consequence of the variation in volume of the solid, liquid and gas phases in the material during the osmotic process. Talens *et al*. (2002) reported that structural changes such as cell alteration due to deformation and breakage of cellular elements were associated to dehydration, and gas-liquid exchanges was occurred during osmosis and these changes greatly affected the product quality.

According to Chiralt and Fito (2003), in osmotic dehydration, water loss in the cells was promoted due to the differences in water chemical potential established between the external solution and the internal liquid phase of the cells. Moreira and Sereno (2003) reported that independently of the osmotic conditions, shrinkage of samples decreased linearly with water loss and weight reduction in apple.

Various studies have been conducted to evaluate the use of osmotic processes for the development of different kinds of fruit products or food ingredients such as minimally processed or intermediate moisture fruits, or their application as a pre- treatment in freezing (Pinnavaria *et al*., 1988 and Giangiacomo *et al*., 1994) or in air- drying (Alvarez *et al*., 1995; Nieto *et al*., 1998; Sormani *et al.,* 1999 and Maestrelli *et al.,* 2001).

Kinetics of dewatering and mass transfer properties during osmotic process have been investigated for apple (Hawkes and Flink, 1978; Conway *et al*., 1983 and Videv *et al*., 1990), green beans (Biswal *et al*., 1991), pineapple (Parjoko *et al*., 1996), banana (Pokharkar and Prasad, 1998), papaya (Kaleemullah *et al*., 2002), mushrooms (Kar and Gupta, 2003), and carrot (Sodhi *et al*., 2006).

Bongirwar and Sreenivasan (1977) studied the osmotic dehydration of banana and observed 50 per cent reduction in weight by osmosis using sugar syrup of 70 per cent concentration. George (1994) evaluated the application of osmotic dehydration technique for product development in banana and found that the weight loss of the fruits after dewatering increased with increase in sugar concentration, temperature and immersion time.

Panagiotou *et al*. (1999) investigated the kinetics of mass transfer during osmotic dehydration of banana, apple and kiwi fruit using sugar concentrations of 30, 40, and 50 per cent. The authors also indicated that the concentration of the osmotic solution had a more significant effect than the process temperature on the equilibrium value of water loss and solid gain.

Fernandes *et al*. (2006) optimised the osmotic dehydration conditions of banana followed by air-drying and indicated that the temperature used in the osmotic dehydration affected the diffusivity of water during air- drying and evaluated the mass transfer rate, with an increase in the temperature of osmotic dehydration from 50 to 70^{o}C.

Barat *et al*. (2001) studied the change in volume of apple slices due to osmotic processes using sucrose solutions of different concentration. A study conducted by Sacchetti *et al.* (2001) in apple using 44.6 to 64.6 per cent sucrose and 0 to 2 per cent salt concentrations indicated an increase in the sweetness and/ or saltiness reduced the product acceptability.

Kowalska and Lenart (2001) studied the mass exchange during osmotic pre- treatment of apple, pumpkin and carrot for 180 minutes and reported that significant changes in water content, water loss and solid gain took place during the first 30 minutes of dewatering. The authors also indicated a reduction of 48 per cent water in apple while in pumpkin and carrot the reduction was found to be 50 per cent and 47 per cent respectively during the first 30 minutes of dewatering. Further, dewatering from 60 to 180 minutes resulted in a reduction of 30 per cent water in apple, while for pumpkin and carrot dewatering proceeded slowly. The authors also observed highest uptake of solids in pumpkin during first 15 minutes of osmotic dehydration whereas in apples the uptake of solids was found to be low.

Moreira and Sereno (2003) observed a simple linear relation between weight reduction and reduced shrinkage during osmotic dehydration of apple. Nieto *et al*. (2004) also observed a linear decrease in sample volume with the loss of water from apple. Agnelli *et al*. (2005) observed that water loss and solid gain were more in apple cubes of 1.5 cm as compared to 2 cm.

Rashmi *et al*. (2005) optimised sugar syrup concentration for osmo- air dehydration of 'Giant kew' variety of pineapple by subjecting pineapple slices to osmosis for 24 hours in 50°, 60° and 70° brix sugar syrups followed by draining and drying at 60 to 65°C. The authors observed maximum product yield and highest sensory scores in 60° brix sugar syrup.

Water loss, sucrose gain and variation in concentration of other natural fruit sugars like glucose and fructose were studied by Ramello and Mascheroni (2005) during osmotic dehydration of pineapple slices in sucrose solution at 30, 40 and 50°C. The authors observed an increase in apparent moisture and sucrose diffusivities by 3.8 and 2.8 times with an increase in the temperature from 30 to 50°C.

Nieto *et al*. (2001) studied the kinetics of moisture transfer during the air- drying of blanched and osmotically dehydrated mango. Giraldo *et al*. (2006) studied the osmotic dehydration process of mango fruit in vacuum and observed maximum solute gain with the more diluted solution in the beginning of the process because of vacuum.

Tsamo *et al*. (2005) studied the mass transfer during osmotic dehydration of onion slices and found that dehydration was over in one hour. Sutar and Gupta (2007) studied the mass transfer in onion slices using 5, 12.5 and 20 per cent salt solutions and observed that equilibrium moisture loss and solid gain were related to concentration of solution and its temperature.

Singh *et al*. (2007) evaluated the mass transfer kinetics and diffusivity during osmotic dehydration of carrot cubes in ternary solution of sucrose, sodium chloride and water and observed an increase in water loss and solid gain with an increase in immersion time as well as concentration of salt from 5 to 15 per cent in 50^{o} brix sucrose solution due to the synergistic effect of both sucrose and salt.

Prinzivalli *et al*. (2007) studied the effect of osmosis time on structure, texture, and pectin composition of strawberry tissues and found that solid gain was constant after four hours of osmotic dehydration. Rizzolo *et al*. (2007) studied the influence of time taken for osmotic processing of strawberry and found that changes in the volatile compounds of strawberry occurred after two hours in sucrose.

Suitability of osmotic dehydration technique for product development in jackfruit was evaluated by Oommen (1995). Khin *et al*. (2006) evaluated mass transfer in osmotic dehydration of coated potato cubes and found that the initial rates of water loss and salt uptake were at equilibrium where as in non-coated samples greater loss were noticed compared to coated samples. A study conducted by Jokic *et al*. (2007) on the osmotic dehydration of sugar beet found that water loss was linearly affected by immersion time.

Omowaye *et al.* (2002) subjected bell pepper to high intensity electric field pulse treatment and found that it enhanced the amount of water loss and solid gain.

Smitha (2008) studied the effect of osmotic dehydration on green pepper and reported that water loss was significantly influenced by concentration of the solute, time of osmosis, and sample to solution ratio.

Mayor *et al*. (2006) conducted a study to obtain experimental data on kinetics of osmotic dehydration of pumpkin with aqueous sodium chloride/ sucrose solutions and found that sodium chloride/ sucrose solutions were suitable to dehydrate pumpkin fruits and the desired final water loss/ solid gain ratio and final moisture content will be obtained by controlling sodium chloride and sucrose in the osmotic solution and controlling the processing time.

2.4. Pumpkin based products and its quality evaluation

Pumpkin is considered to be one of the important vegetable crops where immature and mature fruits, tender leaves and flowers are processed in one or the other form (Choudhury, 1967).

Process for converting pumpkin flesh into a flavoured sweet and sour pickle product has been patented (Laping, 1972). Pickles of improved colour, texture and flavour from pumpkin also reported (Anon., 1973). Pickle of excellent quality from ripe pumpkin for commercial processing has been developed by Dhiman *et al*. (2007).

The fresh leaves of pumpkin are used as vegetable. Badifu *et al.* (1995) reported that the leaves are also used for preparing cassava salads, plantain porridge and yam pottage.

Addition of 10 per cent boiled pumpkin pulp resulted in improving the quality of bread (Popseu *et al.,* 1972). The authors also reported that processed pumpkin flour had extended shelf life, highly desirable flavour, sweetness and deep yellow- orange colour. Ptitchkina *et al.* (1998) reported that supplementation of pumpkin flour improved the nutritional quality of bread. See *et al*. (2007) recommended the pumpkin powder as a natural colourant due to its yellow colour.

Pumpkin seeds were cooked and used as an ingredient or protein supplement in a variety of local foods (Achinewhu, 1987). Agatemor (2006) reported that the pumpkin seed oil is edible due to its low acid value. Hamed *et al.* (2008) indicated that roasting significantly improves total and extractable minerals as well as physico- chemical properties of the pumpkin seed flour. Pumpkin seeds can be converted to snack rich in fibre, minerals and proteins (Caramez *et al.,* 2008).

Pawar *et al*. (1985) indicated that the halwa prepared from rehydrated pumpkin shreds was well acceptable to taste panelists. Premavalli *et al*. (1991) reported that pumpkin halwa had a shelf life of two months in polypropylene pouches and six months in laminated pouches.

According to Yoshimura *et al*. (1994), addition of the pumpkin paste in jellies prepared from carrageenan, agar, and gelatin helped to increase dynamic viscoelasticities, melting temperature, and suppression of synerysis. Ketchup prepared from pumpkin had been rated as above average in comparison with tomato (Sharma and Kumar, 1995).

Egbekun *et al*. (1998) reported that the marmalade prepared from pumpkin fruit had no significant differences in sensory attributes like taste, consistency, spreadability, and overall acceptability when compared with commercial orange marmalade.

Danilchenko *et al*. (2000) compared the jam made from pumpkin with different combinations of apple and quince and found to be highly acceptable. Samaha (2002) reported that jam prepared from fresh pumpkin pulp without adding pectin had yellow colour, elastic gel texture, flat flavour, and was well accepted by panelists.

Figueredo *et al*. (2000) cited that pumpkins were consumed in a variety of ways such as fresh or cooked, as well as stored, frozen or canned. Excellent dried vegetable leather, relishes and chutneys can be made from pumpkin (Anon., 2002).

Pumpkin can be canned as puree and the recipe for the development of instant pumpkin kofta had been standardised by Teotia *et al*. (2004). Ptitchkina *et al*. (2008) reported that pectin extracted from pumpkin and modified using an enzyme could be offered as an alternative for jam and confectionary.

In South Asian countries, especially in India, pumpkin is converted into a sweet dish called *kaddu ka halwa* eaten during fasting as a delicacy and indicated that pumpkin could also be used to flavour alcoholic and non-alcoholic beverages (Anon., 2008).

Pla *et al.* (2009) reported that pumpkin mesocarp tissue is a good fibre-rich food matrix for iron support and a promising raw material for the development of functional food in future.

Dehydration is a process of removal of moisture from the food under controlled condition like temperature, relative humidity, air flow etc. by the application of artificial heat (Gupta *et al*., 2010). There are several drying techniques; among them most commonly applied are hot air drying, freeze drying and spray drying.

Dehydrated fruit or vegetable pulp can be converted to powder. But it is difficult to convert pulp to powder because of low molecular weight sugars such as fructose, glucose, sucrose and acids such as citric acid present in the pulp (Roos and Karel, 1991; Roos, 1995).

Freeze-dried watermelon juice powder was produced by Arya *et al.* (1986). Jaya and Das (2005) developed vacuum dried mango powder from mango pulp. Singh and Kulshrestha (2008) studied the nutritional qualities of food supplements based on carrot powder and grits, and was found to be nutritious and acceptable.

Raj *et al*. (2008) developed ready to use instant custard powder from unmarketable potatoes by mixing potato starch and flour with powdered milk, coconut, sugar, cashewnut, salt, colour and vanilla flavour drops. The authors observed that the products were shelf stable for a period of six months at room temperature when it was packed in polyethylene bags.

Materials and Methods

3. MATERIALS AND METHODS

The study entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** was undertaken to standardise the process variables for value added dehydrated products of pumpkin and to evaluate the nutritional and organoleptic qualities and shelf life of the products. The materials used and the methods followed in the study are given under the following headings.

- 3.1. Collection of ingredients
- 3.2. Standardisation of value added pumpkin products
    - 3.2.1. Standardisation of dehydrated sweet and salted flakes
    - 3.2.2. Kinetics of osmotic dehydration of sweet and salted flakes
    - 3.2.3. Standardisation of ready to use custard powder
    - 3.2.4. Organoleptic evaluation of standardised pumpkin products
- 3.3. Selection of most acceptable treatment for the preparation of pumpkin products
- 3.4. Quality evaluation of selected pumpkin products on storage
    - 3.4.1. Physical qualities of custard powder
    - 3.4.2. Chemical constituents of dehydrated flakes and cutard powder
    - 3.4.3. Organoleptic evaluation of dehydrated flakes and custard powder
    - 3.4.4. Microbial enumeration of dehydrated flakes and custard powder
    - 3.4.5. Insect infestation in custard powder
- 3.5. Cost of production of pumpkin products
- 3.6. Statistical analysis of the data

3.1. Collection of ingredients

Pumpkins were collected from the local markets of Vellanikkara and Mannuthy of Thrissur district. Fruits were collected at their fully mature stage by observing the yellowish orange colour of the peel. The other ingredients like sugar, salt, corn flour, milk powder, cashew nuts, dessicated coconut powder, citric acid and potassium metabisulphite required for the study were also purchased from the local market.

3.2. Standardisation of value added pumpkin products

Fully matured pumpkins were washed thoroughly in tap water, removed the outer skin and split opened. After removing the seeds, the flesh was cut into slices of 1.5 x 1.5 cm. These slices were used for the preparation of value added pumpkin products like osmotically dehydrated flakes and ready to use custard powder.

3.2.1. Standardisation of dehydrated sweet and salted flakes

Two types of flakes, sweet and salted were standardised. The slices were soaked in the sugar syrup and brine to prepare sweet and salted flakes respectively. Different treatments were tried in three replications by immersing the slices in osmotic solutions containing citric acid and potassium metabisulphite (KMS) for one to six hours. The details of the quantity of ingredients used for different treatments for the standardisation of sweet and salted flakes are given in Table 1 and 2 respectively.

After soaking in osmotic solutions, the syrup and brine were drained and the pumpkin slices were dried at a temperature of 58 to 60°C in a cabinet drier up to a moisture level of five per cent to get sweet and salted flakes. The flow chart for the preparation of flakes is illustrated in Plate 1.

Plate 1. Flow chart for the preparation of dehydrated flakes

Table 1. Quantity of ingredients used for the standardisation of sweet pumpkin flakes

Treatments	Pumpkin (g)	Sugar solution (%)	Citric acid (%)	KMS (%)
T_0	100	-	-	-
T_1	100	30	0.3	0.1
T_2	100	30	0.4	0.1
T_3	100	40	0.3	0.1
T_4	100	40	0.4	0.1
T_5	100	50	0.3	0.1
T_6	100	50	0.4	0.1
T_7	100	60	0.3	0.1
T_8	100	60	0.4	0.1

Table 2. Quantity of ingredients used for the standardisation of salted pumpkin flakes

Treatments	Pumpkin (g)	Salt solution (%)	Citric acid (%)	KMS (%)
T_0	100	-	-	-
T_1	100	3	0.3	0.1
T_2	100	3	0.4	0.1
T_3	100	5	0.3	0.1
T_4	100	5	0.4	0.1
T_5	100	10	0.3	0.1
T_6	100	10	0.4	0.1
T_7	100	15	0.3	0.1
T_8	100	15	0.4	0.1

3.2.2. Kinetics of osmotic dehydration of sweet and salted flakes

Changes in physical characteristics like weight loss (WTL), solid gain (SG), water loss (WL), sucrose gain and sodium chloride gain during the process of osmotic dehydration were studied by soaking the pumpkin slices in different concentration of sugar and salt solution for one to six hours. Following equations as suggested by Singh *et al.* (2008) were used to calculate the percentage of WTL, SG and WL.

$$WTL = \frac{(M_o - M) \times 100}{M_o}$$

$$SG = \frac{(m - m_o) \times 100}{M_o}$$

$$WL = \frac{(M_o - m_o) - (M - m) \times 100}{M_o}$$

where, M_o= initial mass of fresh sample (g) prior to OD

M = mass of sample after time 't' of OD (g)

m = dry mass of sample after time 't' of OD (g)

m_o= dry mass of fresh sample prior to OD (g)

3.2.2.1. Sucrose gain

To estimate the sucrose gain in sweet flakes, the method suggested by Lane and Eyon (Ranganna, 1986) was used. The procedure involved three steps. First step was acid hydrolysis of non-reducing sugar. One gram of flake was powdered and taken in 250 ml volumetric flask and diluted with about 150 ml of water. Volume was made up to 250 ml. To 100 ml of this solution, 6 ml of 0.04N HCl was added. Boiled the solution and kept for 30 minutes. Neutralised the solution using 0.6N NaOH.

Standardisation of $CuSO_4$ solution was the second step. Standard invert sugar solution was prepared for standardisation of $CuSO_4$ by dissolving 0.985 g of sucrose in 500 ml of water. Added 2 ml of Conc. H_2SO_4 and boiled for 30 minutes and kept aside for 24 hours. Neutralised with Na_2CO_3 and made the volume to 1000 ml.

Pipetted 5 ml of Fehling's solution A and B in conical flask of 250 ml capacity. Heated the mixture to boil and added standard invert sugar solution taken in the burette. One ml of methylene blue indicator was added to the solution with standard invert sugar solution and completed the titration. The change in blue to reddish brown colour was the end point. From the volume of the invert sugar solution used, the strength of $CuSO_4$ was calculated by multiplying the titrated value with 0.001. This is known as Fehling's factor.

Third step was the titration of inverted solution (sample obtained after carrying out step 1). Five ml of Fehling's solution A and B was taken in a conical flask. From burette, approximately 10 ml of the inverted sugar solution was added and boiled. Methylene blue indicator was added and titrated till blue colour changed to red. Sucrose content was expressed in percentage.

3.2.2.2. Sodium chloride (salt) gain

Salt content was quantified by Mohr's titration method (Ranganna, 1986). Twenty gram sample was soaked in 200 ml distilled water for 3 minutes while stirring occasionally. Contents were filtered. Ten ml filtrate was pipetted in a 150 ml beaker. Approximately 16 drops of 5 per cent $K_2Cr_2O_7$ solution were added to filtrate. Titrated with 0.1N $AgNO_3$ solution and salt content was expressed in percentage.

3.2.3. Standardisation of ready to use custard powder

The pumpkin slices were blanched in boiling water containing 0.1 per cent potassium metabisulphite for one minute. The slices were drained and dried at a temperature of 58 to 60°C in a drier up to a moisture level of 5 to 6 per cent. Dried slices were powdered and sieved through a 100 mesh sieve to get pumpkin powder. By mixing the pumpkin powder with suitable blending materials, ready to use custard powder was prepared. The composition of each treatment is given in Table 3.

Table 3. Quantity of ingredients used for the standardisation of ready to use custard powder from pumpkin

Ingredients	T_1	T_2	T_3	T_4	T_5	T_6	T_7
Pumpkin powder (%)	5	10	15	20	25	30	35
Corn flour (%)	30	25	20	15	10	5	-
Milk powder (%)	15	15	15	15	15	15	15
Sugar (%)	40	40	40	40	40	40	40
Cashew nuts (powdered) (%)	5	5	5	5	5	5	5
Salt (%)	1	1	1	1	1	1	1
Dessicated coconut powder (%)	4	4	4	4	4	4	4

3.2.4. Organoleptic evaluation of standardised pumpkin products

The organoleptic evaluation of dehydrated sweet and salted flakes and ready to use custard powder prepared from pumpkin was conducted using score card method by a panel of 10 selected judges.

3.2.4.1. Selection of judges

A series of organoleptic trials were carried out using simple triangle test at laboratory level to select a panel of ten judges between the age group of 18 to 35 years as suggested by Jellinek (1985).

3.2.4.2. Preparation of score card

The sensory evaluation of the products was carried out using score card method (Swaminathan, 1974). Score card containing six quality attributes like appearance, colour, flavour, texture, taste and overall acceptability was prepared for the evaluation of the products. Each of the above mentioned qualities were assessed by a nine point hedonic scale. The score card used for the evaluation of pumpkin products is given in Appendix I.

3.2.4.3. Organoleptic evaluation of pumpkin flakes

The dehydrated sweet and salted flakes prepared from pumpkin were evaluated for various organoleptic qualities immediately after drying of flakes in a cabinet drier. The evaluation was carried out in the morning time using score card by the selected panel of ten judges.

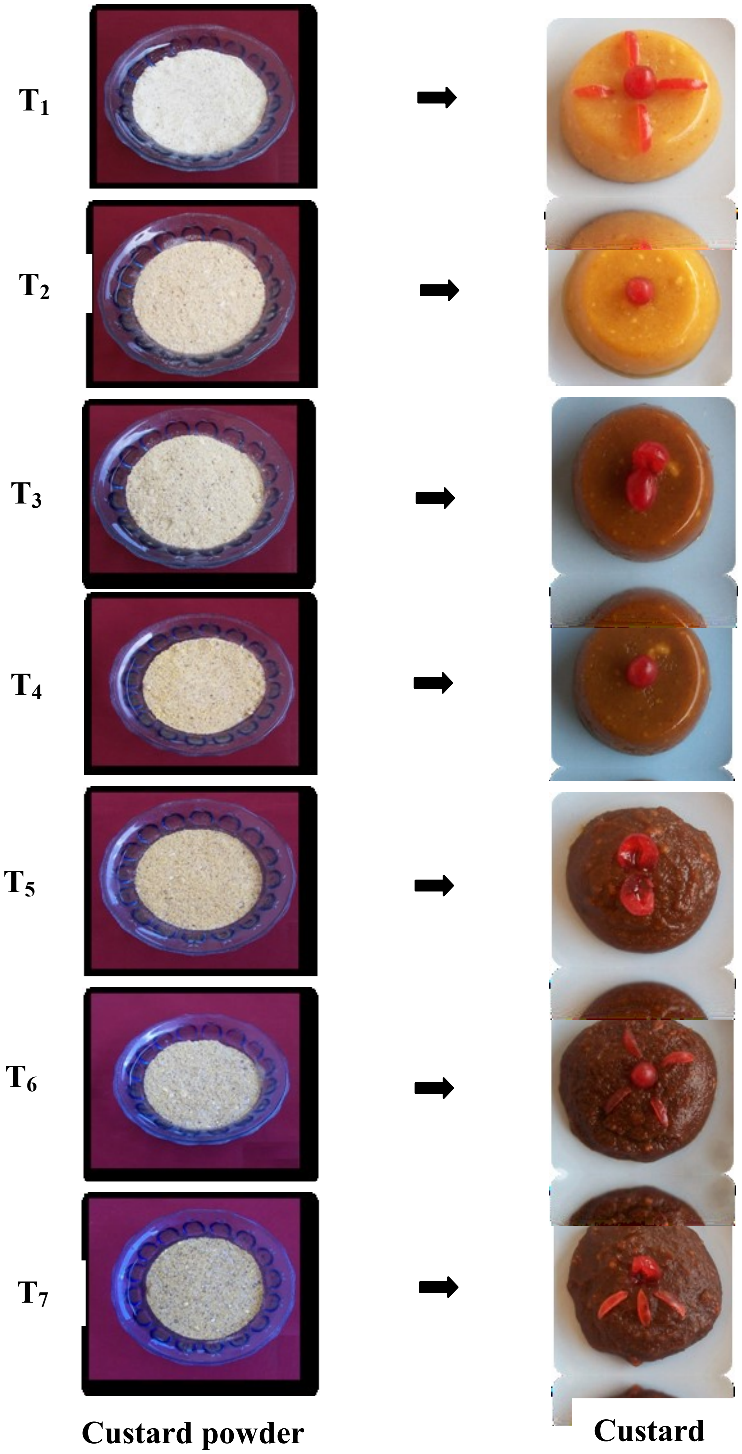
3.2.4.4. Organoleptic evaluation of pumpkin custard powder

Organoleptic evaluation of pumpkin custard powder was conducted by preparing custard. The custard prepared from each treatment is illustrated in Plate 2.

3.2.4.5. Standardisation of the quantity of water and time taken for the preparation of custard

Water and time required for making custard of acceptable consistency was standardised by repeated trials. While preparing the custard, an extra amount of 15 g sugar was added. To standardise the quantity of water to be added to prepare custard with acceptable consistency, 20 g of the custard powder was mixed with varying quantities of water. The custard powder was added to water without lumps and boiled

Plate 2. Custard prepared using various treatments



with frequent stirring and cooked till it attained the desirable consistency of custard. The time taken for each preparation was also recorded. The quantity of water and the time taken for the preparation of acceptable custard from the seven treatments under study are presented in Table 4.

Table 4. Quantity of water required and time taken for the preparation of pumpkin custard

Treatments	Water (ml/20g)	Time (minutes)
T_1	125	2
T_2	110	2
T_3	100	3
T_4	110	6
T_5	150	8
T_6	160	10
T_7	175	20

3.2.4.6. Preparation of custard and organoleptic evaluation

Custard was prepared with standardised quantity of water and organoleptic evaluation of custard was conducted using score card by the selected panel of ten judges.

3.3. Selection of most acceptable treatment for the preparation of pumpkin products

From the various treatments used for the standardisation of pumpkin products, three treatments, i.e., one each from dehydrated sweet flakes, salted flakes and ready

to use custard powder were selected for evaluation of physico chemical and shelf life qualities (Plate 3). The most acceptable treatment from each category was selected on
the basis of mean scores obtained for organoleptic qualities. All the six sensory qualities were analysed statistically using Kendall's coefficient of concordance and the most acceptable sweet flakes, salted flakes and custard powder was selected by considering the highest mean scores for majority of the quality attributes.

3.4. Quality evaluation of selected pumpkin products on storage

The selected pumpkin products were packed in metalised polyester laminate pouches (Plate 4) and stored at ambient temperature for three months. Quality evaluation of the dehydrated flakes was carried out initially and at monthly intervals till the end of three months of storage. Pumpkin custard powder was evaluated initially and at the end of three months of storage for various quality attributes.

3.4.1. Physical qualities of custard powder

The following physical qualities of pumpkin custard powder were assessed using standard techniques initially and at the end of storage.

3.4.1.1. Free flowness

Free flowing nature of custard powder was determined by visual observation.

3.4.1.2. Bulk density

The bulk density was determined by the method described by Okara and Potter (1977). Fifty gram sample was put into a 100 ml graduated cylinder. The

Plate 3. Most acceptable pumpkin products

Sweet flakes (T_7- 2 hours)

Salted flakes (T_1- one hour)

Custard powder (T_2)

Custard

Plate 4. Pumpkin products kept for storage

Sweet pumpkin flakes

Salted pumpkin flakes

Pumpkin custard powder

cylinder was tapped 50 times and the bulk density was calculated as weight per unit volume of the sample.

3.4.2. Chemical constituents of dehydrated flakes and custard powder

The following chemical constituents were analysed in the stored samples using standard procedures. Flakes were powdered to do the analysis.

3.4.2.1. Moisture

Moisture content was estimated by the method of A.O.A.C. (1980). To determine the moisture content, five gram of the sample was taken in a petri dish and dried in a hot air oven at 60 to 70°C, cooled in a desiccator and weighed. The process of heating and cooling was repeated until a constant weight was achieved. The moisture content was calculated from the loss in weight during drying and expressed in percentage.

3.4.2.2. pH

pH of the samples were determined using a pH meter.

3.4.2.3. Titrable acidity

Acidity was determined by titration with standard sodium hydroxide (0.1N) and expressed as percentage of citric acid as per Ranganna (1986). One gram of the sample was weighed accurately into a thimble and placed in 250 ml conical flask. 100 ml water was added and boiled for 15 minutes on the gas burner.

Extract was cooled under tap water and made up to 250 ml in a volumetric flask. It was mixed well and filtered through filter paper and 30 ml supernatant was collected in 250 ml volumetric flask. Few drops of phenolphthalein indicator was added and titrated with 0.1N NaOH. End point of titration was pink colour of solution in the beaker. Acidity was expressed in percentage.

3.4.2.4. β carotene

β carotene content was estimated by the method of A.O.A.C. (1980) using saturated n-butanol. To five gram of the sample, 50 ml of saturated n- butanol was added and shook for one minute and kept overnight. The supernatant was decanted and the colour intensity was noted at 435.8 nm in a spectrophotometer. The β carotene content was expressed in μg per 100g of the sample.

3.4.2.5. Reducing sugar

Reducing sugar was estimated by the method given by Lane and Eyon (Ranganna, 1986). To ten gram of the sample, 100 ml of distilled water was added and then clarified with neutral lead acetate. Excess lead was removed by adding potassium oxalate. The volume was then made up to 250 ml. An aliquot of this solution was titrated against a mixture of Fehling's solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

3.4.2.6. Total sugar

The total sugar was determined using the method given by Lane and Eyon (Ranganna, 1986). From the clarified solution used for the estimation of reducing sugar, 50 ml was taken and boiled gently after adding citric acid and water. It was later neutralized with NaOH and the volume was made up to 250 ml. An aliquot of this solution was titrated against Fehling's solution A and B. The total sugar content was expressed as percentage.

3.4.2.7. TSS

Total soluble solids were recorded using a hand refractometer (Erma, Japan) of brix ranging from 0 to 32° brix at room temperature and values were expressed in degree brix (Ranganna, 1986).

3.4.3. Organoleptic evaluation of dehydrated flakes and custard powder

Organoleptic evaluation of the selected pumpkin flakes was done initially and at monthly intervals till the end of three months of storage. The custard powder was evaluated initially and at the end of storage. The procedure was same as mentioned in **3.2.4.** and the judges were same throughout the study.

3.4.4. Microbial enumeration of dehydrated flakes and custard powder

The total microbial count of selected flakes and custard powder was enumerated using serial dilution and plate count method as described by Agarwal and Hasija (1986). One gram of sample was added to 9 ml sterile water and agitated for 20 minutes. One ml of this solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4} and 10^{-5} dilutions were also prepared.

Enumeration of total microbial count was carried out using nutrient agar media for bacteria, potato dextrose agar media for fungus and sabouraud's dextrose agar media for yeast, which was obtained from Himedia Lab, Mumbai. The dilution used for bacteria was 10^{-5} and for yeast and fungi 10^{-3} dilution were used.

3.4.5. Insect infestation in custard powder

By examining the pumpkin custard powder under the microscope, the presence of storage insects was assessed at the end of three months of storage

3.5. Cost of production of pumpkin products

Cost analysis of the products was done to assess the extent of expense incurred to prepare the products. The price was worked out based on the market prices of various commodities needed for the preparation of the product. The final product yield was computed by taking into consideration the quantity of pumpkin and other ingredients required to prepare a definite quantity of the product. The cost of fuel was also taken into account. The cost was expressed per 500 g for dehydrated flakes and 100 g for ready to use custard powder and the developed products were compared with the market price of similar popularly available products. Details of computation are given in Appendix II.

3.6. Statistical analysis

The observations were tabulated and the data was analysed statistically as Completely Randomised Design (CRD). The scores of organoleptic evaluation were assessed by Kendall's coefficient of concordance, Wilcoxon signed 'Z' test and Kruskal wallis test. Quality evaluation of the products during storage was analysed statistically using paired 't' test.

Result

4. RESULT

The results of the study entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** are presented under the following headings.

4.1. Standardisation of dehydrated pumpkin flakes
    4.1.1. Kinetics of osmotic dehydration in sweet and salted flakes
    4.1.2. Organoleptic qualities of dehydrated flakes
4.2. Standardisation of ready to use pumpkin custard powder
    4.2.1. Organoleptic qualities of custard powder
4.3. Selection of the most acceptable treatment for the preparation of pumpkin products
4.4. Quality evaluation of selected pumpkin products on storage
    4.4.1. Physical qualities of stored custard powder
    4.4.2. Chemical composition of stored dehydrated flakes and custard powder
    4.4.3. Organoleptic qualities of stored dehydrated flakes and custard powder
    4.4.4. Microbial enumeration of stored dehydrated flakes and custard powder
    4.4.5. Insect infestation in stored custard powder
4.5. Cost of production of pumpkin products

4.1. Standardisation of dehydrated pumpkin flakes

Sweet and salted flakes were standardised from pumpkin in nine different treatments (including control, T_0). Kinetics of osmotic dehydration of pumpkin flakes with aqueous sucrose and sodium chloride solution were assessed. The different treatments were evaluated organoleptically for various sensory attributes. The results are as follows.

4.1.1. Kinetics of osmotic dehydration of sweet and salted flakes

Changes in physical characteristics like weight loss, solid gain, water loss, sucrose gain and sodium chloride (salt) gain during the process of osmotic dehydration were studied by soaking the pumpkin slices in different concentrations of sugar and salt for one to six hours.

4.1.1.1. Kinetics of osmotic dehydration of sweet flakes

4.1.1.1.1. Weight loss

Percentage of weight loss in sweet flakes is presented in Table 5. Flakes prepared from 30 per cent sugar solution (T_1 and T_2) had a weight loss varying from 1.40 to 5.60 per cent among different durations of soaking. The weight loss in flakes prepared from 40 per cent and 50 per cent sugar solution varied from 4.20 to 8.30 per cent and 5.60 to 8.30 per cent respectively. The flakes dehydrated with 60 per cent sugar solution (T_7 and T_8) had a weight loss varying from 7.00 to 11.10 per cent.

In T_1 to T_4, the weight loss increased gradually with advancement in duration of soaking. The weight loss was constant in T_5 for first three hours of soaking (5.60%) and it increased to 8.30 per cent in five hour soaked sample. A decrease in percentage of weight loss (5.60%) was observed in T_5 in six hours of soaking. In T_6, the weight loss was 5.60 per cent till the end of three hours. Later the weight loss in flakes decreased to 4.20 per cent (fourth hour) and 2.80 per cent (fifth and sixth hours).

The weight loss in T_7 was 7.00 per cent in the first two hours, which increased to 8.30 per cent in four hours. Later it decreased to 2.80 and 1.40 per cent respectively in four, five and six hour soaked flakes. The percentage of weight loss in T_8 was 7.00 per cent upto two hours and it increased to 8.30 per cent in three hours. Further, a decrease in percentage of weight loss (5.60%) was noticed in samples soaked for five hours which increased to 11.10 per cent in the sixth hour.

Table 5. Weight loss (%) in dehydrated sweet flakes

Treatments	**Sugar (%)**	**Citric acid (%)**	**Duration of soaking (hours)**					
			1	**2**	**3**	**4**	**5**	**6**
T_1	30	0.3	1.40	1.40	2.80	4.20	5.60	5.60
T_2	30	0.4	1.40	1.40	2.80	4.20	4.20	5.60
T_3	40	0.3	4.20	5.60	5.60	7.00	8.30	8.30
T_4	40	0.4	5.60	5.60	5.60	7.00	7.00	8.30
T_5	50	0.3	5.60	5.60	5.60	8.30	8.30	5.60
T_6	50	0.4	5.60	5.60	5.60	4.20	2.80	2.80
T_7	60	0.3	7.00	7.00	8.30	2.80	2.80	1.40
T_8	60	0.4	7.00	7.00	8.30	5.60	5.60	11.10

Maximum weight loss was noticed in flakes prepared from slices soaked for six hours in 60 per cent sugar solution and 0.4 per cent citric acid (T_8). Minimum weight loss was noticed in T_1 and T_2 which were soaked in 30 per cent sugar solution for one to two hours.

4.1.1.1.2. Solid gain

The percentage of solid gain in dehydrated sweet flakes during osmotic process is presented in Table 6. In T_1 and T_2, which were dehydrated with 30 per cent sugar solution, solid gain increased with advancement in duration of soaking. The solid gain in T_1 and T_2 varied from 1.40 to 5.60 per cent. The lowest solid gain of 1.40 per cent was observed in flakes from T_1 and T_2, prepared by one hour soaking. Flakes from slices treated with 40 per cent sugar solution (T_3 and T_4) had solid gain varying from 3.30 to 7.00 per cent.

The solid gain in flakes prepared from 50 per cent and 60 per cent sugar solution varied from 4.20 to 7.00 per cent and 5.60 to 7.00 per cent respectively.

Table 6. Solid gain (%) in dehydrated sweet flakes

Treatments	Sugar (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	30	0.3	1.40	2.80	3.30	4.20	5.60	5.60
T_2	30	0.4	1.40	2.20	3.80	4.20	5.60	5.60
T_3	40	0.3	3.30	3.30	4.20	5.60	5.60	6.10
T_4	40	0.4	3.30	3.30	3.80	5.60	6.10	7.00
T_5	50	0.3	4.20	4.20	5.60	6.10	7.00	7.00
T_6	50	0.4	4.20	4.20	5.60	7.00	2.80	4.20
T_7	60	0.3	5.60	5.60	5.60	7.00	5.60	5.60
T_8	60	0.4	5.60	5.60	5.60	7.00	5.60	5.60

The treatments T_1 to T_5 showed slow rise in solid gain with increase in concentration of the syrup and advancement in duration of soaking. In T_6, during the first two hours of soaking, the solid gain was 4.20 per cent which increased to 5.60 per cent and 7.00 per cent in flakes from samples soaked for three and four hours respectively. In the fifth hour, a decrease in solid gain (2.80%) was also noticed. The percentage of solid gain in T_7 and T_8 was 5.60 per cent throughout the duration of soaking except in sample soaked for four hours in which the solid gain was found to be 7.00 per cent.

4.1.1.1.3. Water loss

The percentage of water loss in dehydrated sweet flakes is given in Table 7. The water loss in T_1 and T_2, which were treated with 30 per cent sugar solution varied from 2.80 to 11.20 per cent. In flakes prepared with 40 per cent sugar solution (T_3 and T_4), the water loss was found to be in the range of 7.50 to 15.30 per cent. The treatments T_5 and T_6 had a water loss varying from 9.80 to 15.30 per cent and in T_7 and T_8, it varied from 12.60 to 16.70 per cent.

Table 7. Water loss (%) in dehydrated sweet flakes

Treatments	Sugar (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	30	0.3	2.80	4.20	6.10	8.40	11.20	11.20
T_2	30	0.4	2.80	3.60	6.60	8.40	9.80	11.20
T_3	40	0.3	7.50	8.90	9.80	12.60	13.90	14.40
T_4	40	0.4	8.90	8.90	9.40	12.60	13.10	15.30
T_5	50	0.3	9.80	9.80	11.20	14.40	15.30	12.60
T_6	50	0.4	9.80	9.80	11.20	11.20	5.60	7.00
T_7	60	0.3	12.60	12.60	13.90	15.30	8.40	7.00
T_8	60	0.4	12.60	12.60	13.90	15.30	11.20	16.70

In T_1, the percentage of water loss increased steadily with progress in hours of soaking upto five hours and remained unchanged in six hours. The water loss increased in T_2 and T_3 with advancement in hours of soaking.

In T_4, the percentage of water loss was 8.90 upto two hours. Thereafter, it showed a steady increase in every succeeding hour. The percentage of water loss increased in T_5 upto five hours and it decreased to 12.60 per cent in sixth hour.

In first two hours, the percentage of water loss in T_6 was 9.80 per cent and it increased to 11.20 per cent in next two hours. Further, it decreased to 5.60 per cent in five hours and again increased to 7.00 per cent in six hours.

In T_7 and T_8, the percentage of water loss was 12.60 in first two hours. Water loss of 13.90 per cent and 15.30 per cent was noticed in flakes of T_7 and T_8 soaked for three and four hours respectively. In fifth hour, the water loss decreased in both treatments to 8.40 and 11.20 per cent respectively. In T_7, the percentage of water loss decreased further in six hours (7.00%) but in T_8, it increased to 16.70 per cent in six hours. Maximum water loss was noticed in flakes prepared from slices soaked for six hours in T_8.

4.1.1.1.4. Sucrose gain

Percentage of sucrose gain in dehydrated sweet flakes is presented in Table 8. The sucrose gain in T_1 and T_2, which were treated with 30 per cent sugar solution varied from 15.20 to 19.10 per cent. In T_3 and T_4, which were treated with 40 per cent sugar solution, sucrose gain was found to be in the range of 14.82 to 21.35 per cent.

Table 8. Sucrose gain (%) in dehydrated sweet flakes

Treatments	Sugar (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	30	0.3	15.20	15.30	16.82	16.91	17.29	19.10
T_2	30	0.4	15.60	15.90	16.40	16.72	17.20	18.72
T_3	40	0.3	17.20	17.30	18.95	19.11	19.22	21.35
T_4	40	0.4	14.82	16.42	17.30	19.70	19.70	20.24
T_5	50	0.3	22.33	22.80	23.10	23.10	23.21	23.80
T_6	50	0.4	23.30	23.50	23.56	23.50	24.70	25.08
T_7	60	0.3	24.70	24.89	26.13	25.30	26.41	27.10
T_8	60	0.4	24.13	24.32	26.41	26.13	27.34	29.20

It is clear that, the percentage of sucrose gain increased with increase in concentration of sugar solution and advancement in duration of soaking. The flakes prepared by treating with 50 per cent (T_5 and T_6) and 60 per cent (T_7 and T_8) sugar solution had a sucrose gain varying from 22.33 per cent to 25.08 per cent and 24.13 per cent to 29.20 per cent respectively. Maximum sucrose gain of 29.20 per cent was noticed in flakes prepared by soaking in 60 per cent sugar and 0.4 per cent citric acid solution for six hours.

4.1.1.2. Kinetics of osmotic dehydration of salted flakes

4.1.1.2.1. Weight loss

Percentage of weight loss in salted flakes is presented in Table 9. Pumpkin slices dehydrated with three per cent salt solution (T_1 and T_2) had a weight loss varying from 0.60 to 2.80 per cent.

Table 9. Weight loss (%) in dehydrated salted flakes

Treatments	Salt (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	3	0.3	0.60	0.60	1.40	1.40	2.80	2.80
T_2	3	0.4	0.60	0.60	1.40	1.40	1.40	2.80
T_3	5	0.3	1.40	2.80	4.20	4.20	5.60	5.60
T_4	5	0.4	1.40	2.80	2.80	4.20	5.60	2.80
T_5	10	0.3	4.20	4.20	4.20	5.60	5.60	1.40
T_6	10	0.4	4.20	4.20	5.60	5.60	5.60	0.60
T_7	15	0.3	5.60	6.10	6.10	6.60	7.00	2.80
T_8	15	0.4	5.60	6.10	6.60	7.00	7.00	5.60

The flakes prepared with five per cent salt solution (T_3 and T_4) and 10 per cent salt solution (T_5 and T_6) had a weight loss varying from 1.40 to 5.60 per cent and

0.60 to 5.60 per cent respectively in different durations of soaking. The samples treated with 15 per cent salt solution (T_7 and T_8) had weight loss varying from 2.80 to 7.00 per cent. Maximum weight loss was noticed in the flakes dehydrated with 15 per cent salt solution soaked for five hours in T_7 and four and five hours in T_8.

In T_1 to T_3, the weight loss gradually increased with advancement in duration of soaking. In T_4 and T_5, the weight loss progressed gradually till five hours of soaking, and at sixth hour a sharp decline in weight loss was noticed.

The weight loss in T_6 was 4.20 per cent in the first two hours, which increased to 5.60 per cent at five hours. But, a sharp decline in weight loss was noticed in flakes soaked for six hours. In T_7, the weight loss was 5.60 per cent in one hour. Later, the percentage of weight loss increased to 6.10 during two and three hours of soaking. In fourth and fifth hours, the percentage of weight loss was 6.60 and 7.00 per cent respectively and decreased to 2.80 per cent in six hour soaked sample. The percentage of weight loss in T_8 was 5.60 per cent in one hour and increased to 6.10, 6.60 and 7.00 per cent during two, three, four and five hours respectively. In sixth hour, it decreased to 5.60 per cent.

4.1.1.2.2. Solid gain

The percentage of solid gain in salted pumpkin flakes is presented in Table 6. The solid gain in salted flakes prepared from T_1 and T_2, which were treated with three per cent salt solution increased with advancement in hours of soaking. The solid gain in T_1 and T_2 ranged from 2.80 to 5.60 per cent. The slices treated with five per cent salt solution (T_3 and T_4) had a solid gain varying from 2.80 to 7.00 per cent.

The flakes treated with 10 per cent salt solution (T_5 and T_6) had a solid gain of 4.20 to 8.30 per cent. The solid gain of T_7 and T_8, which were treated with 15 per cent salt solution varied from 2.80 to 8.30 per cent.

Table 10. Solid gain (%) in dehydrated salted flakes

Treatments	Salt (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	3	0.3	2.80	2.80	4.20	4.20	5.60	5.60
T_2	3	0.4	2.80	2.80	5.60	5.60	5.60	2.80
T_3	5	0.3	4.20	4.20	5.60	5.60	7.00	2.80
T_4	5	0.4	4.20	5.60	5.60	5.60	7.00	2.80
T_5	10	0.3	5.60	5.60	7.00	7.00	8.30	4.20
T_6	10	0.4	5.60	5.60	5.60	7.00	8.30	5.60
T_7	15	0.3	7.00	7.00	8.30	8.30	7.00	4.20
T_8	15	0.4	7.00	8.30	8.30	8.30	2.80	4.20

The treatments from T_1 to T_6 showed a gradual increase in salt concentration with advancement in time of soaking upto five hours. A decrease in solid gain was noticed in dehydrated salted flakes soaked for six hours in all treatments except T_1 in which the solid gain was found to be constant.

4.1.1.2.3. Water loss

The percentage of water loss in salted flakes is shown in Table 11. The water loss in salted flakes dehydrated with three per cent salt solution (T_1 and T_2) varied from 3.40 to 8.40 per cent in different durations of soaking. In samples (T_3 and T_4) treated with five per cent salt solution, the water loss varied from 5.60 to 12.60 per cent. The treatments T_5 and T_6 had a water loss ranging from 5.60 to 13.90 per cent. The water loss in T_7 and T_8 varied from 7.00 to 15.30 per cent.

In T_1, the percentage of water loss increased steadily with progress in the time of soaking. The water loss increased in T_2 and T_3 with advancement in the time of soaking upto five hours and decreased to 5.60 per cent in T_2 and 8.40 per cent in T_3 in six hour soaked samples.

In T_4, the percentage of water loss was 5.60 in one hour soaked flakes and it increased gradually upto five hours and in six hour soaked flakes, a decrease in the percentage of water loss was noticed (5.60%).

Table 11. Water loss (%) in dehydrated salted flakes

Treatments	Salt (%)	Citric acid (%)	Duration of soaking (hours)					
			1	2	3	4	5	6
T_1	3	0.3	3.40	3.40	5.60	5.60	8.40	8.40
T_2	3	0.4	3.40	3.40	7.00	7.00	7.00	5.60
T_3	5	0.3	5.60	7.00	9.80	9.80	12.60	8.40
T_4	5	0.4	5.60	8.40	8.40	9.80	12.60	5.60
T_5	10	0.3	9.80	9.80	11.20	12.60	13.90	5.60
T_6	10	0.4	9.80	9.80	11.20	12.60	13.90	6.20
T_7	15	0.3	12.60	13.10	14.40	14.90	14.00	7.00
T_8	15	0.4	12.60	14.40	14.90	15.30	9.80	9.80

In first two hours, the percentage of water loss in T_5 and T_6 was 9.80 per cent and it increased to 11.20 per cent in next one hour. The percentage of water loss in flakes soaked for four and five hours in T_5 and T_6 was 12.60 and 13.90 per cent respectively. In both treatments, the percentage of water loss decreased in the sixth hour. In T_7 and T_8, initially, the percentage of water loss was 12.60. Water loss increased in both treatments upto four hours of soaking and further a decrease was noticed.

4.1.1.2.4. Sodium chloride (salt) gain

Percentage of sodium chloride gain in salted flakes is presented in Table 12. The sodium chloride gain in T_1 and T_2, which were treated with three per cent salt solution, the gain ranged from 2.80 to 4.60 per cent. In T_3 and T_4, sodium chloride gain varied from 3.04 to 5.15 per cent.

Table 12. Sodium chloride gain (%) in dehydrated salted flakes

Treatments	Salt (%)	Citric acid (%)	Duration of soaking (hours)					
			1	**2**	**3**	**4**	**5**	**6**
T_1	3	0.3	2.80	3.10	3.60	3.90	4.20	4.50
T_2	3	0.4	2.80	3.30	3.60	3.80	4.30	4.60
T_3	5	0.3	3.50	3.90	4.40	4.60	4.80	5.03
T_4	5	0.4	3.04	3.80	4.40	4.60	4.80	5.15
T_5	10	0.3	4.40	4.80	6.10	6.50	7.02	8.10
T_6	10	0.4	4.50	4.60	6.10	6.40	6.90	8.31
T_7	15	0.3	7.70	9.10	9.80	10.53	12.52	14.63
T_8	15	0.4	7.55	9.40	10.12	10.40	12.87	14.51

The treatments T_5 and T_6 had a sodium chloride gain ranging from 4.40 to 8.31 per cent. The salt gain in flakes (T_7 and T_8) dehydrated with 15 per cent salt solution varied from 7.55 to 14.63 per cent in different durations of soaking. It is clear that the percentage of sodium chloride gain increased with increase in concentration of salt solution and increase in duration of soaking. Maximum sodium chloride gain of 14.63 and 14.51 per cent was noticed in T_7 and T_8 respectively, which were soaked for six hours.

4.1.2. Organoleptic qualities of dehydrated flakes

The dehydrated sweet and salted pumpkin flakes were evaluated for organoleptic qualities like appearance, colour, flavour, texture, taste and overall acceptability. The different quality attributes were ranked based on their mean scores using Kendall's (W) test.

4.1.2.1. Organoleptic qualities of sweet pumpkin flakes

Sweet pumpkin flakes prepared using eight different treatments (T_1 to T_8) and the control (T_0) were evaluated for their organoleptic qualities and the mean scores and the mean rank scores obtained for different quality attributes are presented in Tables 13 to 18.

4.1.2.1.1. Appearance

As revealed in Table 13, mean scores for appearance of sweet flakes varied from 7.20 to 8.70 with a mean rank score of 15.92 to 43.57. The lowest mean score for appearance was noticed in control (T_0). In T_1 to T_6, the mean scores for appearance varied from 7.20 to 7.70 with mean rank scores in the range of 16.17 to 28.43 among different time duration varying from one to six hours.

T_7 and T_8 had the maximum mean and rank scores for appearance and it ranged from 8.10 to 8.70 in one to six hours of soaking. Flakes prepared from pumpkin slices soaked in sugar syrup for five hours in T_7 and T_8 obtained the highest score (8.70) for appearance.

Table 13. Mean scores for appearance of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.40 (1.95)	-	-	-	-	-	-	-	-
1 hour	-	7.30 (18.12)	7.70 (26.82)	7.40 (20.95)	7.30 (18.63)	7.20 (16.85)	7.50 (23.55)	8.50 (40.37)	8.10 (35.03)
2 hours	-	7.30 (19.75)	7.20 (15.92)	7.50 (22.95)	7.30 (18.33)	7.30 (19.43)	7.30 (18.65)	8.30 (37.72)	8.20 (36.65)
3 hours	-	7.60 (24.50)	7.20 (16.35)	7.50 (22.37)	7.70 (28.43)	7.30 (18.90)	7.40 (20.58)	8.10 (34.10)	8.30 (37.52)
4 hours	-	7.40 (20.53)	7.50 (22.67)	7.60 (24.72)	7.60 (24.55)	7.50 (22.77)	7.50 (22.57)	8.20 (36.43)	8.20 (35.92)
5 hours	-	7.40 (20.32)	7.20 (16.30)	7.60 (24.72)	7.60 (24.50)	7.50 (22.78)	7.60 (25.65)	8.70 (43.23)	8.70 (43.57)
6 hours	-	7.40 (20.65)	7.30 (18.12)	7.20 (17.22)	7.20 (16.17)	7.60 (24.72)	7.60 (25.88)	8.40 (38.68)	8.30 (37.93)

Kendall's (W) value- 0.463**
(Figures in parenthesis are mean rank scores) **significant at 1% level

Based on Kendall's (W) value, significant agreement was observed among judges in the evaluation of appearance of sweet flakes.

4.1.2.1.2. Colour

The mean scores for colour of dehydrated pumpkin flakes were found to be maximum in T_7 and T_8 ranging from 8.00 to 8.60 in one to six hours of soaking (Table 14). Compared with the control (T_0), all treatments obtained higher mean scores and mean rank scores for colour.

The mean and rank scores for the control were found to be 5.30 and 1.65 respectively. In T_1 to T_6, the mean scores for colour ranged from 6.80 to 7.90 in different time durations. Among the different treatments, highest mean score of 8.60

with a rank score of 41.23 was obtained for flakes prepared from pumpkin slices soaked in syrup for one hour in T_7.

Table 14. Mean scores for colour of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.30 (1.65)	-	-	-	-	-	-	-	-
1 hour	-	7.80 (27.30)	7.60 (23.30)	7.60 (23.65)	7.30 (17.12)	6.80 (8.50)	7.40 (20.78)	8.60 (41.23)	8.00 (31.20)
2 hours	-	7.60 (25.78)	7.50 (21.05)	7.70 (25.72)	7.20 (16.55)	7.30 (18.25)	7.30 (16.97)	8.50 (39.68)	8.20 (34.60)
3 hours	-	7.90 (31.10)	7.30 (17.35)	7.40 (19.40)	7.70 (25.37)	7.30 (17.02)	7.50 (21.05)	8.40 (38.25)	8.30 (35.48)
4 hours	-	7.60 (24.60)	7.50 (21.55)	7.70 (25.25)	7.60 (22.97)	7.50 (21.47)	7.40 (19.45)	8.40 (37.43)	8.10 (32.63)
5 hours	-	7.70 (26.80)	7.30 (16.80)	7.80 (27.30)	7.90 (29.50)	7.50 (21.35)	7.50 (22.20)	8.40 (37.60)	8.30 (36.65)
6 hours	-	7.40 (20.20)	7.40 (18.95)	7.40 (19.20)	7.40 (19.10)	7.60 (23.50)	7.80 (27.55)	8.40 (37.45)	8.40 (37.15)

Kendall's (W) value- 0.427**
(Figures in parenthesis are mean rank scores) **significant at 1% level

The agreement among judges in evaluating the colour of dehydrated sweet pumpkin flakes was found to be statistically significant.

4.1.2.1.3. Flavour

It is clear from Table 15 that the lowest mean score for flavour of pumpkin flakes was recorded for the control, T_0 (6.90). In T_1 to T_6, the mean scores for flavour varied from 7.10 to 7.80 with mean rank scores in the range of 13.27 to 28.92 among different durations of soaking. Among different treatments, highest mean score of

8.80 was noticed in flakes prepared from pumpkin slices soaked for 2 hours in T_7. In T_7 and T_8, the mean scores for flavour ranged from 8.20 to 8.80 in different hours of soaking.

Table 15. Mean scores for flavour of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.90 (11.90)	-	-	-	-	-	-	-	-
1 hour	-	7.40 (21.52)	7.10 (13.92)	7.60 (22.92)	7.10 (13.27)	7.20 (15.32)	7.20 (15.20)	8.60 (40.55)	8.40 (37.30)
2 hours	-	7.40 (20.22)	7.50 (22.27)	7.60 (23.37)	7.30 (16.72)	7.10 (14.40)	7.40 (19.67)	8.80 (43.75)	8.50 (38.60)
3 hours	-	7.80 (28.92)	7.70 (25.12)	7.60 (23.52)	7.40 (19.47)	7.40 (20.22)	7.60 (23.42)	8.40 (37.92)	8.20 (34.10)
4 hours	-	7.40 (21.32)	7.50 (20.77)	7.30 (16.82)	7.60 (22.82)	7.20 (16.10)	7.60 (23.47)	8.50 (39.17)	8.30 (35.67)
5 hours	-	7.40 (20.87)	7.60 (20.72)	7.80 (26.82)	7.70 (24.82)	7.40 (19.07)	7.30 (19.30)	8.40 (37.57)	8.70 (41.60)
6 hours	-	7.30 (19.32)	7.60 (23.07)	7.80 (27.22)	7.60 (23.02)	7.60 (23.22)	7.70 (25.32)	8.20 (34.52)	8.50 (39.52)

Kendall's (W) value- 0.440**
(Figures in parenthesis are mean rank scores) **significant at 1% level

Significant agreement among judges was noticed in the evaluation of flavour of dehydrated sweet pumpkin flakes.

4.1.2.1.4. Texture

From Table 16, it is clear that pumpkin flakes prepared from pumpkin slices soaked in sugar syrup for two and three hours in T_7 had the highest mean score of 9.00 with a mean rank score of 46.35 for texture. The lowest mean score for texture was noticed in control, T_0 (6.20).

In T_1 to T_6, the mean scores for texture varied from 7.10 to 7.80 with rank scores varying from 13.82 to 27.33 among different time durations of soaking. The lowest score was noticed in flakes prepared by soaking in sugar solution for one hour in T_6 and highest score was obtained in T_2 and T_4 as well as T_6, which were soaked in sugar syrup for four hours and six hours respectively.

Table 16. Mean scores for texture of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.20 (3.20)	-	-	-	-	-	-	-	-
1 hour	-	7.40 (18.88)	7.60 (23.13)	7.50 (20.98)	7.60 (24.30)	7.40 (20.25)	7.10 (13.82)	8.50 (37.35)	8.00 (31.37)
2 hours	-	7.60 (22.68)	7.60 (22.98)	7.30 (16.93)	7.70 (24.98)	7.40 (19.08)	7.20 (15.82)	9.00 (46.35)	8.00 (31.37)
3 hours	-	7.40 (20.43)	7.50 (20.93)	7.60 (22.93)	7.50 (21.57)	7.40 (19.42)	7.30 (16.63)	9.00 (46.35)	8.00 (31.37)
4 hours	-	7.50 (20.58)	7.80 (27.18)	7.50 (21.08)	7.80 (27.05)	7.40 (19.08)	7.40 (19.57)	8.50 (40.37)	8.50 (40.37)
5 hours	-	7.30 (17.78)	7.60 (23.18)	7.50 (20.93)	7.60 (22.83)	7.60 (22.82)	7.40 (18.83)	8.50 (40.37)	8.50 (37.35)
6 hours	-	7.60 (22.13)	7.50 (20.98)	7.30 (16.83)	7.50 (21.40)	7.60 (23.08)	7.80 (27.33)	8.50 (40.37)	8.50 (40.37)

Kendall's (W) value- 0.512**

(Figures in paranthesis are mean rank scores) **significant at 1% level

In the evaluation of texture of flakes, the agreement among judges was found to be statistically significant.

4.1.2.1.5. Taste

The highest mean score (9.00) for taste was noticed in flakes prepared from two and three hour soaked samples in T_7 (Table 17). Compared to control (T_0), all treatments obtained higher mean scores for taste and the scores varied from 7.30 to 9.00. For control, the mean score for taste was found to be 6.00 with a mean rank score of 2.00.

Table 17. Mean scores for taste of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.00 (2.00)	-	-	-	-	-	-	-	-
1 hour	-	7.30 (15.30)	7.70 (23.55)	7.60 (21.40)	7.70 (23.40)	7.40 (18.15)	7.40 (17.90)	8.40 (36.10)	8.00 (29.65)
2 hours	-	7.40 (17.15)	7.60 (21.20)	7.80 (25.45)	7.70 (23.45)	7.40 (17.15)	7.40 (17.35)	9.00 (46.35)	8.00 (29.65)
3 hours	-	8.00 (30.85)	7.40 (17.25)	7.60 (21.25)	7.70 (23.30)	7.70 (23.40)	7.50 (19.40)	9.00 (46.35)	8.00 (29.65)
4 hours	-	7.60 (21.45)	7.50 (19.35)	7.60 (21.25)	7.90 (27.55)	7.60 (21.15)	7.40 (17.35)	8.60 (39.90)	8.60 (39.90)
5 hours	-	7.50 (19.25)	7.70 (23.40)	7.60 (21.30)	7.80 (25.55)	7.90 (27.65)	7.50 (20.00)	8.60 (39.90)	8.40 (36.10)
6 hours	-	7.50 (19.05)	7.70 (23.15)	7.60 (21.20)	7.50 (19.25)	7.60 (21.35)	7.70 (23.50)	8.60 (39.90)	8.60 (39.90)

Kendall's (W) value- 0.503**
(Figures in parenthesis are mean rank scores) **significant at 1% level

Based on Kendall's (W) value, the agreement among judges in the evaluation of taste was found to be statistically significant.

4.1.2.1.6. Overall acceptability

As revealed in Table 18, the mean scores for overall acceptability ranged from 5.70 to 8.70 with a mean rank score varying from 2.20 to 43.55 in dehydrated sweet pumpkin flakes. The lowest score was recorded in control (T_0). The highest score of

8.70 was noticed for dehydrated flakes prepared by soaking for five hours in T_7 and T_8.

Table 18. Mean scores for overall acceptability of sweet pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.70 (2.20)	-	-	-	-	-	-	-	-
1 hour	-	7.40 (18.55)	7.40 (19.10)	7.50 (21.05)	7.20 (14.65)	7.40 (18.70)	7.40 (19.55)	8.50 (39.80)	8.10 (33.80)
2 hours	-	7.50 (21.85)	7.40 (18.50)	7.40 (19.00)	7.40 (18.95)	7.30 (17.75)	7.60 (23.00)	8.30 (36.60)	8.20 (34.95)
3 hours	-	7.90 (30.45)	7.40 (18.65)	7.70 (25.50)	7.70 (25.25)	7.70 (25.05)	7.30 (16.55)	8.10 (32.25)	8.30 (36.15)
4 hours	-	7.40 (18.65)	7.50 (20.95)	7.40 (19.10)	7.90 (29.50)	7.80 (27.55)	7.30 (16.35)	8.20 (35.75)	8.20 (34.80)
5 hours	-	7.40 (19.00)	7.60 (23.00)	7.60 (23.00)	7.80 (27.20)	7.90 (29.60)	7.30 (17.40)	8.70 (43.65)	8.70 (43.55)
6 hours	-	7.40 (18.65)	7.60 (22.80)	7.40 (18.60)	7.50 (20.80)	7.80 (27.60)	7.70 (25.30)	8.40 (37.95)	8.30 (36.40)

Kendall's (W) value- 0.465**
(Figures in parenthesis are mean rank scores)   **significant at 1% level

In T_1 to T_6, the mean scores for overall acceptability varied from 7.20 to 7.90 with a mean rank score in the range of 14.65 to 29.60 among different hours of soaking. On evaluating the overall acceptability of sweet pumpkin flakes, significant agreement was noticed among judges.

4.1.2.2. Organoleptic qualities of salted pumpkin flakes

Dehydrated salted pumpkin flakes prepared using eight different treatments and the control (T_0) were evaluated for their organoleptic qualities and the mean and rank scores obtained are presented in Table 19 to 24.

4.1.2.2.1. Appearance

The mean scores for appearance of dehydrated salted flakes in different treatments varied from 4.70 to 6.90 in varying duration of soaking (Table 19). Salted flakes prepared from pumpkin slices soaked in salt solution for one hour in T_1 had the highest mean score of 6.90 and mean rank score of 38.10 for appearance. The lowest mean score for appearance was noticed in flakes prepared from pumpkin slices soaked in salt solution for two hours in T_8 (4.70). A mean score of 5.40 with mean rank score of 19.85 was noticed in control (T_0).

Table 19. Mean scores for appearance of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.40 (19.85)	-	-	-	-	-	-	-	-
1 hour	-	6.90 (38.10)	5.40 (19.53)	6.20 (30.28)	5.70 (21.25)	6.30 (31.72)	6.10 (28.07)	5.30 (18.50)	5.00 (19.73)
2 hours	-	5.80 (28.70)	5.90 (27.35)	6.20 (31.27)	5.53 (20.68)	6.30 (31.32)	6.00 (27.32)	5.10 (16.80)	4.70 (16.70)
3 hours	-	5.80 (28.82)	5.60 (22.00)	6.10 (30.03)	5.70 (21.60)	5.93 (29.38)	5.60 (23.88)	4.90 (15.75)	4.90 (17.95)
4 hours	-	6.10 (32.35)	5.90 (24.58)	6.30 (31.82)	5.70 (21.00)	5.96 (29.12)	5.60 (24.98)	5.30 (20.33)	4.80 (17.78)
5 hours	-	6.20 (30.70)	5.80 (24.33)	6.23 (31.73)	5.60 (20.35)	6.06 (30.13)	5.50 (23.83)	5.60 (24.73)	5.20 (22.15)
6 hours	-	5.70 (27.32)	6.10 (28.05)	6.00 (31.27)	5.70 (20.90)	6.10 (30.68)	5.30 (22.23)	5.20 (19.38)	5.00 (18.65)

Kendall's (W) value- 0.162**
(Figures in parenthesis are mean rank scores) **significant at 1% level

Compared to control, T_7 and T_8 had lower mean scores for appearance among different durations of soaking. Flakes prepared from pumpkin slices soaked for six hours in T_6 also obtained a lower score than control. A mean score similar to control was noticed in dehydrated flakes prepared from slices soaked for one hour in T_2. In the evaluation of appearance of flakes, the agreement among judges was found to be statistically significant.

4.1.2.2.2. Colour

As revealed in Table 20, mean scores for colour of salted pumpkin flakes varied from 3.60 to 6.63 with mean rank scores ranging from 9.18 to 37.32. The lowest mean score was noticed in flakes prepared from pumpkin slices soaked in brine for 6 hours in T_8. The highest mean score was noticed in flakes prepared from pumpkin slices soaked in brine for one hour in T_1. In control, the mean score and mean rank score for colour was found to be 5.30 and 24.55 respectively. T_7 and T_8 had the lower mean scores and mean rank scores for colour and it ranged from 3.60 to 4.73 with a mean rank score varying from 9.18 to 18.72.

Table 20. Mean scores for colour of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.30 (24.55)	-	-	-	-	-	-	-	-
1 hour	-	6.63 (37.32)	6.50 (35.98)	5.60 (29.07)	5.43 (25.87)	5.60 (27.47)	4.80 (19.58)	4.10 (10.28)	3.80 (9.28)
2 hours	-	6.53 (36.20)	6.33 (36.55)	5.73 (29.52)	5.60 (27.65)	5.53 (27.10)	4.80 (19.30)	4.60 (16.65)	3.70 (8.98)
3 hours	-	6.43 (36.17)	6.13 (33.48)	5.70 (29.73)	5.60 (28.48)	5.43 (25.73)	4.90 (21.70)	4.63 (17.32)	3.70 (8.98)
4 hours	-	6.00 (32.32)	6.23 (34.73)	5.80 (30.70)	5.33 (24.55)	5.53 (27.13)	5.10 (22.93)	4.53 (16.22)	3.70 (9.15)
5 hours	-	6.50 (36.23)	6.40 (36.85)	5.73 (30.08)	5.33 (24.97)	5.60 (27.60)	5.33 (26.32)	4.73 (18.72)	3.63 (8.92)
6 hours	-	6.50 (36.20)	6.50 (36.77)	5.70 (29.25)	5.60 (27.67)	5.50 (27.13)	4.33 (14.78)	4.33 (13.65)	3.60 (9.18)

Kendall's (W) value- 0.435**

(Figures in parenthesis are mean rank scores) **significant at 1% level

Treatments T_1 to T_5 in varying time durations of soaking and dehydrated flakes prepared from pumpkin slices soaked for five hours in T_6 had higher mean score for colour compared to control.

Based on Kendall's (W) value, significant agreement was observed among judges in the evaluation of colour of salted flakes.

4.1.2.2.3. Flavour

The highest mean score for flavour of dehydrated salted pumpkin flakes was noticed in T_1 (6.43) (soaked in brine solution for an hour), followed by control (6.20). As compared to the control (T_0), all treatments obtained lower mean and rank scores for flavour. In T_2 to $T_{8,}$ the mean scores for flavour ranged from 3.40 to 5.00 with mean rank scores in the range of 9.53 and 32.67.

Table 21. Mean scores for flavour of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.20 (44.77)	-	-	-	-	-	-	-	-
1 hour	-	6.43 (44.72)	4.40 (23.63)	3.90 (15.82)	4.90 (31.68)	4.60 (26.52)	5.00 (32.67)	4.30 (23.48)	3.70 (14.48)
2 hours	-	5.50 (36.52)	4.70 (28.30)	3.90 (15.82)	4.70 (27.88)	4.50 (25.07)	4.90 (30.47)	4.10 (21.03)	3.50 (10.63)
3 hours	-	5.50 (38.83)	4.80 (30.47)	3.80 (13.27)	4.80 (29.33)	4.60 (25.67)	4.50 (25.78)	4.00 (19.53)	3.50 (10.63)
4 hours	-	5.20 (32.47)	4.60 (26.67)	3.90 (14.77)	5.00 (33.18)	4.50 (24.22)	4.70 (28.82)	4.10 (19.28)	3.40 (9.53)
5 hours	-	5.20 (33.95)	4.80 (29.62)	4.00 (17.12)	4.90 (31.68)	4.60 (25.67)	4.60 (27.88)	4.10 (19.28)	3.50 (10.63)
6 hours	-	5.50 (37.37)	4.50 (24.50)	3.90 (15.62)	4.90 (31.68)	4.60 (26.57)	4.80 (28.68)	4.10 (19.28)	3.40 (9.53)

Kendall's (W) value- 0.441**

(Figures in parenthesis are mean rank scores) **significant at 1% level

The agreement among judges in evaluating the flavour of salted pumpkin flakes was found to be statistically significant.

4.1.2.2.4. Texture

The mean scores for texture ranged from 3.00 to 7.13 in dehydrated salted pumpkin flakes in different duration of soaking (Table 22). The lowest mean score for texture was noticed in flakes prepared from pumpkin slices soaked in brine for one hour in T_8. The highest mean score of 7.13 was observed in flakes prepared from one hour soaked slices in T_1. For control, the mean score for texture was found to be 6.90.

Table 22. Mean scores for texture of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.90 (44.95)	-	-	-	-	-	-	-	-
1 hour	-	7.13 (45.82)	5.60 (35.87)	4.50 (22.47)	4.60 (24.98)	5.40 (36.23)	4.33 (21.47)	3.80 (13.07)	3.00 (6.25)
2 hours	-	5.23 (30.67)	5.33 (31.53)	4.40 (21.15)	4.63 (24.33)	5.30 (35.13)	4.30 (20.25)	4.03 (17.03)	3.00 (6.25)
3 hours	-	5.00 (29.00)	5.60 (35.20)	4.60 (24.83)	4.83 (27.80)	5.40 (36.23)	4.50 (23.02)	4.13 (17.93)	3.20 (7.40)
4 hours	-	5.00 (27.83)	5.60 (35.38)	4.70 (26.62)	4.70 (26.98)	5.40 (36.23)	4.50 (22.97)	3.60 (12.50)	3.20 (7.43)
5 hours	-	5.20 (31.57)	5.60 (37.03)	4.70 (26.60)	4.63 (24.32)	5.30 (35.13)	4.60 (25.77)	3.60 (12.78)	3.23 (7.98)
6 hours	-	5.13 (30.08)	5.73 (37.35)	4.80 (27.02)	4.70 (26.75)	5.30 (34.53)	3.70 (13.12)	3.60 (11.30)	3.30 (8.85)

Kendall's (W) value- 0.585**
(Figures in parenthesis are mean rank scores) **significant at 1% level

While comparing with control, pumpkin flakes prepared from slices soaked for one hour in T_1 obtained the highest mean and rank scores. On evaluating the texture, significant agreement among judges was noticed.

4.1.2.2.5. Taste

From Table 23, it is clear that salted flakes prepared from pumpkin slices soaked in brine for one hour in T_1 had the highest mean score of 6.50 for taste and was found to be higher than control (6.00).

Table 23. Mean scores for taste of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	6.00 (47.97)	-	-	-	-	-	-	-	-
1 hour	-	6.50 (48.05)	3.30 (30.45)	2.73 (22.65)	3.63 (35.63)	3.20 (27.07)	2.30 (23.35)	1.60 (8.62)	1.60 (7.68)
2 hours	-	4.10 (34.72)	3.43 (32.42)	2.73 (22.63)	3.73 (34.15)	3.20 (28.95)	2.60 (17.17)	1.60 (8.15)	1.63 (8.67)
3 hours	-	4.10 (36.45)	3.43 (31.52)	2.80 (23.68)	3.63 (35.62)	3.13 (28.57)	2.23 (22.13)	1.60 (7.68)	1.63 (8.67)
4 hours	-	3.90 (35.23)	3.63 (33.65)	2.90 (24.23)	3.70 (34.75)	3.30 (28.45)	2.93 (26.18)	1.60 (7.68)	1.93 (11.73)
5 hours	-	3.90 (35.08)	3.50 (32.93)	2.90 (23.73)	3.73 (35.77)	3.00 (23.45)	2.93 (26.08)	1.60 (7.68)	1.93 (11.73)
6 hours	-	3.90 (34.52)	3.40 (31.95)	2.80 (23.63)	3.10 (25.45)	2.63 (26.02)	2.93 (26.08)	1.60 (7.68)	1.93 (11.73)

Kendall's (W) value- 0.679**
(Figures in parenthesis are mean rank scores) **significant at 1% level

In T_2 to T_6, the mean scores for taste varied from 2.23 to 3.63 among different durations of soaking. Flakes prepared from pumpkin slices soaked for one to six hours in T_7 as well as one hour soaked slices in T_8 obtained the lowest mean score of

1.60 for taste. In the evaluation of taste of flakes, the agreement among judges was found to be statistically significant.

4.1.2.2.6. Overall acceptability

The mean scores for overall acceptability ranged from 1.80 to 5.70 in different treatments and varying time durations of soaking (Table 24). The lowest mean score was noticed in flakes prepared from slices soaked for five and six hours in T_8. Maximum mean score of 5.70 for overall acceptability was observed in flakes prepared from one hour soaked pumpkin slices in T_1. Compared to control (T_0), all treatments except flakes prepared from one hour soaking in T_1 obtained lower mean scores for overall acceptability. For control, the mean score and mean rank score for overall acceptability was found to be 5.60 and 47.67 respectively.

Table 24. Mean scores for overall acceptability of salted pumpkin flakes

Duration of soaking	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
0 hour	5.60 (47.67)	-	-	-	-	-	-	-	-
1 hour	-	5.70 (46.37)	3.50 (31.43)	2.60 (16.72)	3.80 (34.53)	3.10 (25.45)	2.80 (21.47)	2.90 (21.27)	1.90 (8.25)
2 hours	-	4.80 (42.85)	3.50 (30.55)	2.50 (15.45)	3.70 (32.97)	3.00 (23.45)	2.80 (19.30)	2.50 (15.75)	2.10 (9.73)
3 hours	-	4.50 (41.55)	3.60 (31.72)	2.60 (16.72)	3.80 (34.53)	3.10 (25.45)	2.60 (18.27)	2.50 (15.75)	2.10 (9.73)
4 hours	-	4.40 (40.68)	3.60 (31.72)	2.70 (18.28)	3.70 (32.53)	3.00 (23.45)	3.43 (29.37)	2.30 (12.97)	2.00 (8.32)
5 hours	-	4.30 (39.77)	3.60 (31.72)	2.70 (18.28)	3.70 (32.53)	3.00 (23.45)	3.63 (32.37)	2.20 (11.55)	1.80 (8.98)
6 hours	-	4.50 (41.20)	3.60 (31.72)	2.60 (16.72)	3.70 (32.53)	3.00 (23.45)	3.30 (27.45)	1.90 (10.07)	1.80 (8.98)

Kendall's (W) value- 0.673**

(Figures in parenthesis are mean rank scores) **significant at 1% level

Based on Kendall's (W) value, the agreement among judges in the evaluation of overall acceptability was found to be statistically significant.

4.2. Standardisation of ready to use pumpkin custard powder

Standardisation of ready to use custard powder from pumpkin was carried out in seven different treatments and was evaluated for various organoleptic qualities. The results are furnished in section **4.2.1**.

4.2.1. Organoleptic qualities of custard powder

Organoleptic qualities of custard powder were evaluated by preparing custard using the appropriate quantity of water for each treatment, which was standardised as per **3.2.4.5.** The time taken to prepare custard was also standardised as explained in **3.2.4.5.** Fifteen gram of extra sugar was added while preparing custard to enhance the taste. Different quality attributes like appearance, colour, flavour, texture, taste and overall acceptability were evaluated and the results are presented in Table 25.

The mean scores for appearance of pumpkin custard varied from 2.50 to 7.86 with mean ranks varying from 1.47 to 5.55. The highest mean score was noticed in custard prepared from T_4 followed by T_2 and T_3 (7.83), and T_1 (7.80). The lowest mean score of 2.50 was recorded in T_7.

The mean score for colour of custard prepared from ready to use custard powder varied from 2.40 to 8.10 with the highest in T_2 and lowest in T_7. In T_1, T_3 and T_4, the mean scores for colour of custard were found to be 7.66, 7.80 and 7.70 respectively with rank scores of 5.30, 5.57 and 5.20 respectively.

For flavour, the highest mean score of 8.10 with a mean rank score of 5.90 was noticed in custard prepared from T_3. The lowest mean score of 3.30 was obtained for custard prepared from T_6. The custard prepared from T_1, T_2, T_4, T_5 and T_7 obtained a mean score of 7.70, 8.03, 7.60, 4.60 and 3.70 respectively for flavour.

Table 25. Mean scores for the organoleptic qualities of pumpkin custard

Treatments	**Appearance**	**Colour**	**Flavour**	**Texture**	**Taste**	**Overall acceptability**
T_1	7.80 (5.43)	7.66(5.30)	7.70 (5.28)	8.13 (5.55)	8.03 (5.37)	7.80 (5.27)
T_2	7.83 (5.48)	8.10(5.93)	8.03 (5.78)	8.23 (5.80)	8.50 (6.08)	8.46 (6.35)
T_3	7.83 (5.53)	7.80(5.57)	8.10 (5.90)	8.10 (5.60)	8.20 (5.52)	8.10 (5.75)
T_4	7.86 (5.55)	7.70(5.20)	7.60 (5.03)	7.80 (5.05)	7.90 (5.03)	7.46 (4.63)
T_5	5.03 (2.97)	4.13(2.83)	4.60 (2.57)	5.06 (2.52)	3.96 (2.38)	4.46 (2.72)
T_6	2.93 (1.63)	3.00(1.85)	3.30 (1.62)	3.63 (1.73)	2.96 (2.15)	3.30 (2.13)
T_7	2.50 (1.47)	2.40(1.32)	3.70 (1.82)	3.53 (1.75)	2.20 (1.47)	2.33 (1.15)
Kendall's (W) value	0.902**	0.858**	0.857**	0.829**	0.858**	0.919**

(Figures in parenthesis are mean rank scores) ** significant at 1% level

Among different treatments, the highest mean score of 8.23 for texture was obtained for custard prepared from T_2. The lowest mean score of 3.53 was noticed in T_7. T_1 and T_3 also obtained a mean score above 8.00 for texture.

The mean scores for taste of custard varied from 2.20 to 8.50 with mean rank scores varying from 1.47 to 6.08. Custard prepared using T_2 had the highest mean score for taste. The lowest mean score for taste was noticed in custard prepared from T_7.

The mean scores for overall acceptability of custard varied from 2.33 (T_7) to 8.46 (T_2). High scores above 8.00 for overall acceptability were noticed in T_2 and T_3. The lowest mean score of 2.33 and mean rank score of 1.15 for overall acceptability was noticed in T_7.

Based on the Kendall's (W) value, significant agreement among judges was noticed in the evaluation of different quality attributes of pumpkin custard.

4.3. Selection of the most acceptable treatment for the preparation of pumpkin products

From the various treatments tried for the standardisation of pumpkin products namely sweet and salted flakes, and pumpkin custard powder, one each from dehydrated sweet flakes, dehydrated salted flakes and ready to use custard powder were selected for further studies. The mean scores obtained for various organoleptic qualities were taken into account to select the most acceptable treatments.

For the selection of most acceptable treatment in dehydrated pumpkin flakes, more importance was given for the mean scores obtained for flavour, texture and taste. In sweet flakes, highest mean scores for flavour, texture and taste were noticed in T_7 (flakes prepared using 60 per cent sugar solution). In T_7, the mean scores for flavour, texture and taste varied from 8.20 to 8.80, 8.50 to 9.00 and 8.40 to 9.00 respectively among different durations of soaking. The highest mean score among them for flavour, texture and taste was noticed in flakes soaked for two hours. Hence, flakes prepared from slices soaked in 60 per cent sugar solution for two hours was selected as the most acceptable treatment for preparation of sweet flakes.

Similarly for the selection of most acceptable salted flakes, the mean score for flavour, texture and taste was taken into consideration. In salted flakes, the highest mean scores for flavour, texture and taste were noticed in T_1. Among the different hours of soaking in T_1, the mean scores for flavor, texture and taste varied from 5.20 to 6.43, 5.00 to 7.13 and 3.90 to 6.50 respectively. The highest score among them for flavour, texture and taste was noticed in flakes prepared from one hour soaked samples in three per cent salt solution. Hence, the flakes prepared from slices soaked in three per cent salt solution for one hour was selected as the most acceptable treatment for the preparation of salted pumpkin flakes.

The most acceptable treatment for the preparation of ready to use custard powder was selected on the basis of mean scores obtained for colour, texture and taste of the custard. The maximum score obtained for colour of the custard was 8.10 in T_2. Better texture was noticed in T_2 with the highest mean score of 8.23. The taste was also found to be good in T_2 with a mean score of 8.50. Since, the most desirable characteristics of custard like colour, texture and flavour were found to be good in T_2. Therefore, it was selected as the most acceptable treatment for the preparation of ready to use custard powder.

4.4. Quality evaluation of selected pumpkin products on storage

Three selected products namely dehydrated sweet and salted flakes and ready to use custard powder were packed in metalised polyester laminate pouches and stored under ambient conditions for a period of three months. The products were evaluated for various physical, chemical, organoleptic and shelf life qualities. Dehydrated flakes were evaluated for various quality attributes initially and at monthly intervals for a period of three months of storage. The quality parameters of custard powder were evaluated initially and at the end of three months of storage. The results are presented in this section.

4.4.1. Physical qualities of stored custard powder

Pumpkin custard powder was evaluated for physical qualities like free flowness and bulk density initially and at the end of three months of storage.

4.4.1.1. Free flowness

The custard powder was freely flowing without any lump formation initially and at the end of three months of storage.

4.4.1.2. Bulk density

The bulk density of custard powder was constant throughout the storage period. The bulk density of 0.72 g per ml was obtained for custard powder initially and after three months of storage.

4.4.2. Chemical composition of stored dehydrated flakes and custard powder

Chemical constituents such as moisture, pH, titrable acidity, β carotene, reducing sugar, total sugar and TSS of the selected dehydrated sweet and salted flakes were evaluated at monthly intervals for a period of three months. The variation in chemical composition of dehydrated pumpkin flakes during storage was statistically analysed using paired 't' test. In custard powder, all the above mentioned chemical constituents were analysed initially and at the end of three months of storage. The changes in chemical composition of custard powder during storage were interpreted statistically using Wilcoxon signed rank test (Z).

4.4.2.1. Chemical composition of dehydrated sweet flakes during storage

The changes in chemical constituents of dehydrated sweet pumpkin flakes on storage are given in Table 26.

4.4.2.1.1. Moisture

Initially, the moisture content in dehydrated sweet flakes was 6.70 per cent. During first and second month of storage, the moisture content increased to 7.70 per cent and 8.30 per cent respectively. But the increase was found to be statistically insignificant.

During the third month of storage, the moisture content in sweet flakes was found to be 11.00 per cent. The increase observed at three month of storage was found to be statistically significant.

4.4.2.1.2. pH

The pH of dehydrated sweet flakes was observed to be 5.92 initially which decreased to 5.85 and 5.78 at the end of first and second months of storage respectively. The decrease in pH noticed till the end of second month of storage was statistically insignificant. At the end of third month of storage, pH of the flakes further decreased to 5.56 and the decrease was found to be statistically significant.

4.4.2.1.3. Titrable acidity

The titrable acidity of sweet pumpkin flakes gradually increased from 0.60 per cent (initially) to 1.32 per cent towards the end of third month of storage. Titrable acidity of 0.81 per cent and 0.90 per cent was noted in sweet flakes at the end of first and second months of storage respectively. The increase in titrable acidity in sweet flakes was found to be statistically insignificant over different periods of storage.

4.4.2.1.4. β carotene

β carotene content of sweet flakes decreased from 219.50 µg initially to 215.90 µg per 100g towards the end of first month of storage. By the end of second and third months of storage, β carotene content in flakes further decreased to 210.40 µg and 209.01 µg per 100g respectively. The reduction observed in the β carotene content of the sweet flakes during storage was found to be statistically insignificant.

Table 26. Effect of storage on the chemical constituents of sweet pumpkin flakes

Chemical constituents	Storage period (months)				T statistics		
	0	1st	2nd	3rd	0 Vs 1st	1st Vs 2nd	2nd Vs 3rd
Moisture (%)	6.70	7.70	8.30	11.00	0.423^{NS}	0.529^{NS}	0.015**
pH	5.92	5.85	5.78	5.56	0.394^{NS}	0.266^{NS}	0.007**
Titrable acidity (%)	0.60	0.81	0.90	1.32	0.199^{NS}	0.910^{NS}	0.128^{NS}
βcarotene (µg/100g)	219.50	215.90	210.40	209.01	0.790^{NS}	0.669^{NS}	0.767^{NS}
Total sugar (%)	40.39	40.34	39.00	38.43	0.983^{NS}	0.364^{NS}	0.631^{NS}
Reducing sugar (%)	13.60	13.41	13.20	13.14	0.634^{NS}	0.778^{NS}	0.981^{NS}
TSS (ºbrix)	15.00	12.60	12.00	10.50	0.020**	0.184^{NS}	-

**significant at 1% level NS- Not significant

4.4.2.1.5. Total sugar

Initially, the total sugar content in sweet flakes was found to be 40.39 per cent which decreased to 40.34 per cent and 39.00 per cent at the end of first and second months of storage respectively. Total sugar content of 38.43 per cent was observed at the end of third month of storage. The decrease in total sugar content of flakes over periods of storage was statistically insignificant.

4.4.2.1.6. Reducing sugar

Initially, the reducing sugar content in sweet flakes was found to be 13.60 per cent which decreased slightly during storage with no statistical significance. Reducing sugar content decreased to 13.41 per cent, 13.20 per cent and 13.14 per cent at the end of first, second and third months of storage respectively.

4.4.2.1.7. TSS

The TSS of sweet flakes gradually decreased from an initial content of 15 ^{o}brix to 10.50 ^{o}brix at the end of third month of storage. At the end of first and second months of storage, the TSS in sweet flakes was found to be 12.60 ^{o}brix and 12 ^{o}brix respectively. The decrease noticed in TSS up to the end of first month of storage was statistically significant. The further decrease observed in TSS towards the end of second month of storage was not significant.

4.4.2.2. Chemical composition of dehydrated salted flakes during storage

The changes in chemical composition of dehydrated salted pumpkin flakes during storage are given in Table 27.

4.4.2.2.1. Moisture

There was an increase in moisture content of salted flakes from 4.30 to 6.70 per cent by the end of first month and it further increased to 8.30 per cent and 12.30 per cent towards the end of second and third months of storage respectively. The increase in the percentage of moisture observed from the initial level to the end of first month and from the end of second month to the end of third month of storage was statistically significant.

4.4.2.2.2. pH

The pH of salted flakes decreased from 6.50 to 6.40 at the end of first month of storage. Towards the end of second month of storage the pH further decreased to 6.20 and by the end of three months of storage it decreased to 5.92. However the decrease in pH observed during storage was statistically insignificant.

4.4.2.2.3. Titrable acidity

The titrable acidity of salted pumpkin flakes gradually increased from 1.15 per cent (initially) to 1.40 per cent towards the end of first month of storage. Titrable acidity of 1.60 per cent and 1.70 per cent was noted in salted flakes at the end of second and third months of storage respectively. The increase noticed in the titrable acidity of salted flakes was found to be statistically insignificant during storage.

4.4.2.2.4. β carotene

β carotene content of salted flakes decreased from 221.20 μg to 215.64 μg per 100g towards the end of first month of storage. By the end of second month, β carotene content of the flakes decreased to 215.40 μg per 100g and it further decreased to 214.60 µg per 100g by the end of third month of storage. The reduction observed in the β carotene content of the salted flakes during storage was found to be statistically insignificant.

Table 27. Effect of storage on the chemical constituents of salted pumpkin flakes

Chemical constituents	**Storage period (Months)**				**T statistics**		
	0	**1st**	**2nd**	**3rd**	**0 Vs 1st**	**1st Vs 2nd**	**2nd Vs 3rd**
Moisture (%)	4.30	6.70	8.30	12.30	0.073**	0.130^{NS}	0.020**
pH	6.50	6.40	6.20	5.92	0.748^{NS}	0.422^{NS}	0.591^{NS}
Titrable acidity (%)	1.15	1.40	1.60	1.70	0.337^{NS}	0.336^{NS}	0.227^{NS}
βcarotene (µg/100g)	221.20	215.64	215.40	214.60	0.521^{NS}	0.987^{NS}	0.937^{NS}
Total sugar (%)	9.94	9.93	9.85	9.74	0.992^{NS}	0.944^{NS}	0.845^{NS}
Reducing sugar (%)	3.6	3.10	2.69	2.73	0.022^{NS}	0.118^{NS}	0.769^{NS}
TSS (°brix)	11.00	10.30	9.00	8.30	0.184^{NS}	0.057**	0.184^{NS}

**significant at 1% level NS- Not significant

4.4.2.2.5. Total sugar

Initially, the total sugar content in salted flakes was 9.94 per cent which decreased to 9.93 per cent and 9.85 per cent at the end of first and second month of storage respectively. Total sugar content of 9.74 per cent was observed at the end of third month of storage. The decrease in total sugar content of salted flakes over periods of storage was found to be statistically insignificant.

4.4.2.2.6. Reducing sugar

Initially, the reducing sugar content of salted flakes was found to be 3.60 per cent which decreased slightly on storage with no statistical significance. Reducing sugar content decreased to 3.10 per cent, 2.69 per cent and 2.73 per cent at the end of first, second and third months of storage respectively.

4.4.2.2.7. TSS

The TSS of salted flakes gradually decreased from an initial value of 11 ^{o}brix to 8.30 ^{o}brix at the end of third month of storage. At the end of first and second month of storage, the TSS in salted flakes was 10.30 ^{o}brix and 9 ^{o}brix respectively. The decrease noticed in TSS up to the end of second month of storage was statistically significant. The further decrease observed in TSS towards the end of three months of storage was not significant.

4.4.2.3. Ready to use custard powder

The changes in chemical composition of selected custard powder during storage are shown in Table 28.

4.4.2.3.1. Moisture

The initial moisture content in custard powder was 4.33 per cent which increased to 5.33 per cent after three months of storage. Significant variation was not observed in the moisture content of custard powder during storage.

4.4.2.3.2. pH

The pH of custard powder decreased from 6.43 to 5.10 towards the end of three months of storage and the decrease was found to be statistically significant.

Table 28. Effect of storage on the chemical constituents of pumpkin custard powder

Chemical constituents	Storage period		Wilcoxon signed rank test (Z)
	Initial	Final	
Moisture (%)	4.33	5.33	0.816^{NS}
pH	6.43	5.10	1.604*
Titrable acidity (%)	0.128	0.313	1.604*
βcarotene (μg/100g)	23.60	22.20	1.604*
Total sugar (%)	20.47	20.42	0.01 ^{NS}
Reducing sugar (%)	4.74	4.40	1.069^{NS}
TSS (^{o}brix)	20.00	15.00	1.732*

*significant at 5% level NS- Not significant

4.4.2.3.3. Titrable acidity

Initially, the titrable acidity in custard powder was 0.128 per cent which increased to 0.313 per cent at the end of three months of storage. The increase in titrable acidity was found to be statistically significant.

4.4.2.3.4. β carotene

The β carotene content of pumpkin custard powder was 23.60 μg per 100g initially and it decreased to 22.20 μg per 100g at the end of three months of storage. Significant variation was observed in the β carotene content of pumpkin custard powder during storage.

4.4.2.3.5. Total sugar

The custard powder had a total sugar content of 20.47 per cent initially and it decreased to 20.42 per cent at the end of three months of storage without any statistical significance.

4.4.2.3.6. Reducing sugar

Initially, the reducing sugar of custard powder was 4.74 per cent. At the end of three months of storage, the reducing sugar content in custard powder decreased to 4.40 per cent and the decrease was found to be statistically insignificant.

4.4.2.3.7. TSS

The TSS content in the custard powder was found to be 20 ^{o}brix, which decreased to 15 ^{o}brix at the end of three months of storage. Significant reduction was observed in TSS of the custard powder during storage.

4.4.3. Organoleptic qualities of stored dehydrated flakes and custard powder

The three pumpkin products stored for three months were evaluated for various quality attributes like appearance, colour, flavour, texture, taste and overall acceptability. The sweet and salted flakes were evaluated initially and at monthly intervals and custard powder was evaluated initially and at the end of storage. The mean scores of the organoleptic qualities were statistically interpreted with Kruskal Wallis test and Wilcoxon signed rank test. The results are furnished in Table 29, 30 and 31.

4.4.3.1. Organoleptic qualities of sweet flakes during storage

Mean scores obtained for various quality attributes of sweet flakes during storage are presented in Table 29. As revealed in the table, the mean scores for appearance of the sweet flakes was found to be 8.30 initially, which decreased to 8.10 at the end of first month of storage. At the end of second and third months, the mean scores for appearance further decreased to 7.90 and 7.60 respectively.

A mean score of 8.50 was noticed for the colour of sweet flakes initially. At the end of first and second months, the mean scores decreased to 8.30 and it further decreased to 8.20 at the end of third month of storage.

When the flavour of the sweet flakes was evaluated, maximum score of 8.70 was found initially which reduced to 8.50 at the end of first month. In second and third months of storage, further decrease in mean scores was noticed and it decreased to 8.30 and 8.10 respectively.

The mean score for texture of the sweet flakes was found to be 8.80 initially, which gradually decreased to 8.50, 8.10 and 7.50 at the end of first, second and third months of storage respectively.

For the quality attribute taste, a gradual decrease in mean score was noticed with advancement of storage period. The mean score decreased from an initial score of 8.50 to 8.20, 7.90 and 7.60 at the end of first, second and third months of storage respectively. Overall acceptability of sweet flakes decreased from a mean score of 8.30 (initially) to 8.20 by the first month and further reduction of scores to 7.80 and 7.60 during second and third months of storage was also observed.

Table 29. Mean scores for sensory qualities of sweet pumpkin flakes during storage

Parameters	**Storage period (Months)**				**Kruskal-Wallis value**
	0	**1st**	**2nd**	**3rd**	
Appearance	8.30(74.30)	8.10(64.55)	7.90(59.00)	7.60(44.15)	17.22***
Colour	8.50 (71.00)	8.30 (59.00)	8.30(59.00)	8.20(53.00)	6.44*
Flavour	8.70 (77.45)	8.50 (65.75)	8.30(54.05)	8.10(44.75)	19.80***
Texture	8.80 (87.80)	8.50 (72.50)	8.10(53.45)	7.50(28.25)	58.64**
Taste	8.50 (83.75)	8.20 (68.00)	7.90(52.55)	7.60(37.70)	45.023***
Over all acceptability	8.30 (77.30)	8.20 (72.20)	7.80(51.50)	7.60(41.00)	35.57***

(Figures in parenthesis are mean rank scores) ***significant at 1% level **significant at 5% level *significant at 10% level

The decrease noticed in the mean scores of all quality attributes during storage of sweet flakes was found to be statistically significant.

4.4.3.2. Organoleptic qualities of salted flakes during storage

The mean scores for different quality attributes of salted flakes during storage are presented in Table 30.

Table 30. Mean scores for sensory qualities of salted pumpkin flakes during storage

Parameters	Storage period (Months)				Kruskal-Wallis value
	0	1st	2nd	3rd	
Appearance	6.90(69.92)	6.46(53.22)	6.43(52.40)	6.43(66.47)	6.48*
Colour	6.63(59.52)	6.53(67.42)	6.43(65.18)	6.33(49.88)	4.96^{NS}
Flavour	6.43(77.30)	6.20(69.30)	5.70(48.55)	5.60(46.85)	19.35***
Texture	7.13(83.35)	6.43(71.12)	5.70(51.38)	5.40(37.15)	33.60***
Taste	6.56(81.30)	6.20(68.35)	5.70(56.90)	5.40(35.45)	32.20***
Over all acceptability	5.60(74.25)	5.20(65.05)	5.13(57.48)	4.76(45.22)	12.59***

(Figures in parenthesis are mean rank scores) ***significant at 1% level **significant at 5% level *significant at 10% level

The initial score for the appearance for salted flakes was found to be 6.90 which decreased to 6.46 by the end of first month of storage. A mean score of 6.43 was recorded for the appearance of salted flakes at the end of second and third months of storage. Initially, the mean score for colour of salted flakes was 6.63 which decreased to 6.53 by the end of first month. At the end of second and third months of storage, the mean scores for colour decreased to 6.43 and 6.33 respectively.

Initially, the salted flakes obtained a mean score of 6.43 for flavour which decreased to 6.20, 5.70 and 5.60 by the end of first, second and third months of storage respectively. For texture highest mean score of 7.13 was obtained initially which decreased to 6.43, 5.70 and 5.40 by the end of first, second and third months of storage respectively.

Taste of the salted flakes gradually decreased from an initial mean score of 6.56 to 6.20 by the end of first month of storage. At the end of second and third months, it further decreased to 5.70 and 5.40 respectively. Overall acceptability decreased from the initial mean score of 5.60 to 5.20, 5.13 and 4.76 towards the end of first, second and third months of storage respectively.

The mean scores obtained for different quality attributes during storage of salted flakes was interpreted statistically and the decrease noticed in mean scores of different quality attributes was found to be significant except colour.

4.4.3.3. Organoleptic qualities of custard powder during storage

The organoleptic qualities of custard powder during storage was evaluated by preparing custard and mean scores for different quality attributes are shown in Table 31.

The mean score for the appearance of custard increased from 7.83 to 8.10 by the end of third month of storage. Initially, the mean score obtained for colour of the custard was 8.10 which decreased to 8.03 at the end of three months of storage. Regarding the flavour of custard, the initial mean score of 8.03 decreased to 7.93 after three months of storage.

The mean score for texture of the custard was 8.23 initially and it decreased to 8.20 after three months of storage. A mean score of 8.50 was noticed for taste and overall acceptability of custard in both periods under study.

Table 31. Mean scores for sensory qualities of pumpkin custard during storage

Parameters	Period of storage		Wilcoxon signed rank test (Z)
	Initial	Final	
Appearance	7.83	8.10	1.597 NS
Colour	8.10	8.03	0.258 NS
Flavour	8.03	7.93	0.669 NS
Texture	8.23	8.20	0.025 NS
Taste	8.50	8.50	0.172 NS
Overall acceptability	8.50	8.50	0.020 NS

NS- Not significant

Statistically significant variation was not observed in mean scores of any of the quality attributes during storage.

4.4.4. Microbial enumeration of stored dehydrated flakes and custard powder

Microbial enumeration of the selected pumpkin products namely dehydrated sweet and salted flakes and custard powder was carried out for bacteria, fungi and yeast. In flakes, the microbial population was evaluated initially and at monthly intervals for a period of three months. In custard powder, the enumeration of total microflora was conducted, initially and at the end of three months of storage.

4.4.4.1. Microbial count in dehydrated sweet flakes during storage

As revealed in Table 32, bacterial count was not detected in dehydrated sweet flakes initially. Bacterial count of 0.33×10^5 cfu g^{-1} observed at the end of first month of storage remained unchanged till the end of second month. Towards the end of third month of storage, the bacterial count further increased to 0.66×10^5 cfu g^{-1}.

Initially, fungal count was not noticed in the sweet pumpkin flakes. At the end of first month of storage, fungal count of 3.33×10^3 cfu g^{-1} was observed in sweet flakes, which decreased to 1.70×10^3 cfu g^{-1} at the end of second month of storage. The fungal count was found to be 2.00×10^3 cfu g^{-1} by the end of third month of storage.

Table 32. Microbial count in sweet pumpkin flakes during storage

Microorganism	**Microbial population (cfu g^{-1})**			
	0 month	**1^{st} month**	**2^{nd} month**	**3^{rd} month**
Bacteria ($\times 10^5$)	ND	0.33	0.33	0.66
Fungi ($\times 10^3$)	ND	3.33	1.70	2.00
Yeast ($\times 10^3$)	ND	1.00	0.33	1.00

ND- Not detected

Initially, yeast growth was not detected in dehydrated sweet pumpkin flakes. In first month, the count was 1.00×10^3 cfu g^{-1} which decreased to 0.33×10^3 cfu g^{-1} by the end of second month of storage. At the end of third month of storage, the yeast count increased to $1.00x10^3$ cfu g^{-1}.

4.4.4.2. Microbial count in dehydrated salted flakes during storage

Bacterial count was not noticed in salted flakes initially (Table 33). Bacterial count of $0.33x10^5$ cfu g^{-1} was observed at the end of first month and it remained unchanged throughout the period of storage.

Initially, fungal growth was not detected in salted flakes. Highest count of $3.0x10^3$ cfu g^{-1} was observed at the end of first month of storage, which decreased to $2.70x10^3$ cfu g^{-1} and $2.00x10^5$ cfu g^{-1} towards the end of second and third months of storage respectively.

Table 33. Microbial count in salted pumpkin flakes during storage

Microorganism	Microbial population (cfu g^{-1})			
	0 month	1st month	2nd month	3rd month
Bacteria ($\times10^5$)	ND	0.33	0.33	0.33
Fungi ($\times10^3$)	ND	3.00	2.70	2.00
Yeast ($\times10^3$)	ND	4.70	3.00	2.33

NS- Not significant

Initially, yeast count was not noticed in salted flakes. At the end of first month of storage, the yeast count was $4.70x10^3$ cfu g^{-1}, which decreased to $3.00x10^3$ cfu g^{-1} and $2.33x10^3$ cfu g^{-1} at the end of second and third months of storage respectively.

4.4.4.3. Microbial count in custard powder during storage

The microbial count in selected custard powder was evaluated initially and at the end of three months of storage and the result is presented in Table 34.

Table 34. Microbial count in pumpkin custard powder during storage

Storage period	Microbial population (cfu g^{-1})		
	Bacteria ($\times 10^5$)	Fungi ($\times 10^3$)	Yeast ($\times 10^3$)
Initial	ND	ND	ND
Final	ND	ND	0.33

ND- Not detected

Bacterial and fungal growth was not detected in custard powder initially and at the end of three months of storage. Initially, yeast growth was not detected at the end of storage yeast count of $0.33 x 10^3$ cfu g^{-1} was observed in custard powder.

4.4.5. Insect infestation in custard powder

Insect infestation in custard powder was evaluated initially and at the end of three months of storage and presence of insects was not detected throughout the period of study.

4.5. Cost of production of pumpkin products

The cost was worked out for the different products like dehydrated sweet and salted flakes and ready to use custard powder based on the various ingredients required for the preparation of products. The cost of production of 500 g of dehydrated sweet flakes and salted flakes was Rs. 67.00 and Rs. 70.00 respectively. The cost of production of 100 g of ready to use custard powder was Rs. 35.00.

Discussion

5. DISCUSSION

Results of the study entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** are discussed under the following headings.

5.1. Kinetics of osmotic dehydration of sweet and salted pumpkin flakes
5.2. Organoleptic qualities of dehydrated pumpkin flakes and custard powder
5.3. Selection of the most acceptable treatment for the preparation of pumpkin products
5.4. Quality evaluation of selected pumpkin products during storage
  5.4.1. Physical qualities of stored custard powder
  5.4.2. Chemical composition of stored dehydrated flakes and custard powder
  5.4.3. Organoleptic qualities of stored dehydrated flakes and custard powder
  5.4.4. Microbial enumeration of stored dehydrated flakes and custard powder
  5.4.5. Insect infestation in stored custard powder
5.5. Cost of production of pumpkin products

5.1. Kinetics of osmotic dehydration of sweet and salted pumpkin flakes

The weight loss in sweet and salted flakes varied from 1.40 to 11.10 per cent (Fig. 1) and 0.60 to 7.00 per cent (Fig. 2) respectively in different treatments. In sweet flakes, maximum weight loss was noticed in flakes prepared with 60 per cent sugar solution (T_7 and T_8). In salted flakes, the maximum percentage of weight loss was noticed in flakes prepared with 15 per cent salt solution (T_7 and T_8). In both flakes, the percentage of weight loss increased with increase in solute concentration and advancement in duration of soaking. Rahaman and Lamb (1990) and Tiwari and

Fig. 1. Percentage of weight loss in sweet flakes

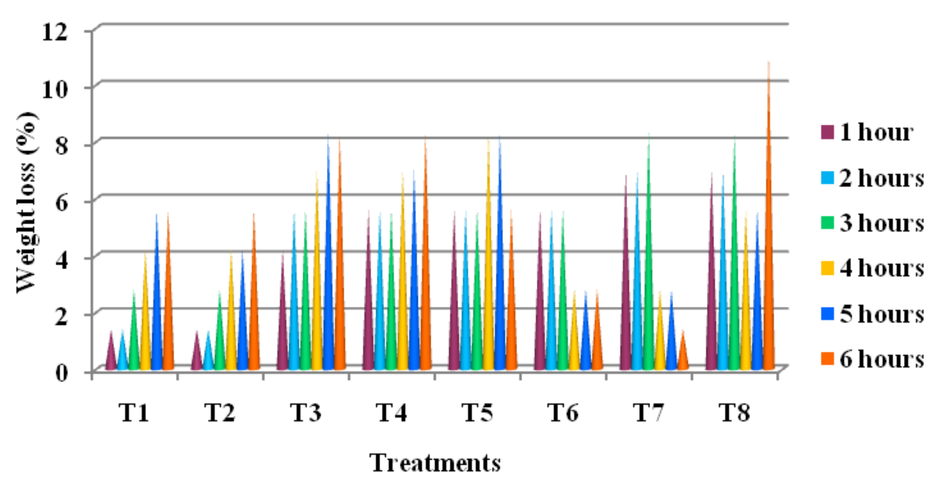
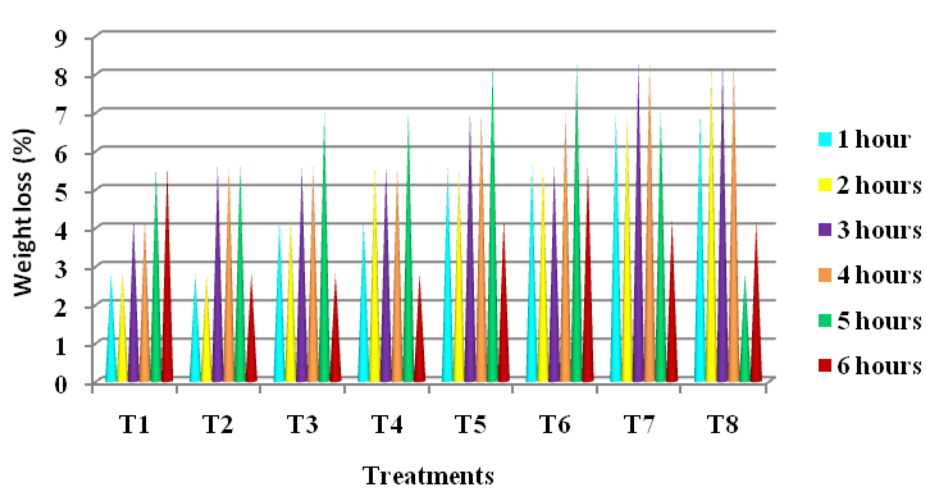


Fig. 2. Percentage of weight loss in salted flakes



Jalali (2004) studied weight loss in pineapple and reported that the percentage of weight loss increased with increase in sugar concentration. A study conducted in onion slices by Sutar and Gupta (2007) also revealed that the kinetics of water removal is strongly affected by the kind of osmotic agent and its concentration.

The solid gain in sweet (Fig. 3) and salted (Fig. 4) flakes increased with increase in concentration of the solute as well as advancement in duration of soaking. In sweet flakes, the highest percentage of solid gain was noticed in the flakes prepared with 60 per cent sugar solution (T_7 and T_8). A similar observation was reported by Ertekin and Cakaloz (1996) in peas using 60 per cent sucrose solution. The salted flakes prepared with 15 per cent salt solution (T_7 and T_8) obtained the highest percentage of solid gain. Similar observation was reported by Singh *et al*. (2007) during osmotic dehydration of carrot cubes and reported that the enhanced solid gain may be due to the effect of salt to develop high osmotic potential.

The percentage of water loss in sweet and salted flakes among different treatments varied from 2.80 to 16.70 per cent (Fig. 5) and 3.40 to 15.30 per cent (Fig. 6) respectively. Maximum percentage of water loss was noticed in flakes prepared with 60 per cent sugar solution in sweet flakes (T_7 and T_8) and in salted flakes the water loss percentage was maximum in flakes prepared with 15 per cent salt solution (T_7 and T_8). Similar observation was made by Singh *et al*. (2007) in carrot. The percentage of water loss increased with advancement in duration of soaking in almost all treatments. Mayor *et al*. (2005) reported similar observation in pumpkin.

Upto fourth hour of soaking, sweet and salted flakes showed a steady increase in percentage of weight loss, solid gain and water loss. In fifth and sixth hours of soaking, fluctuation in the percentage of weight loss, solid gain and water loss was observed in sweet and salted flakes. Mayor *et al.* (2005) reported that at sixth hour of

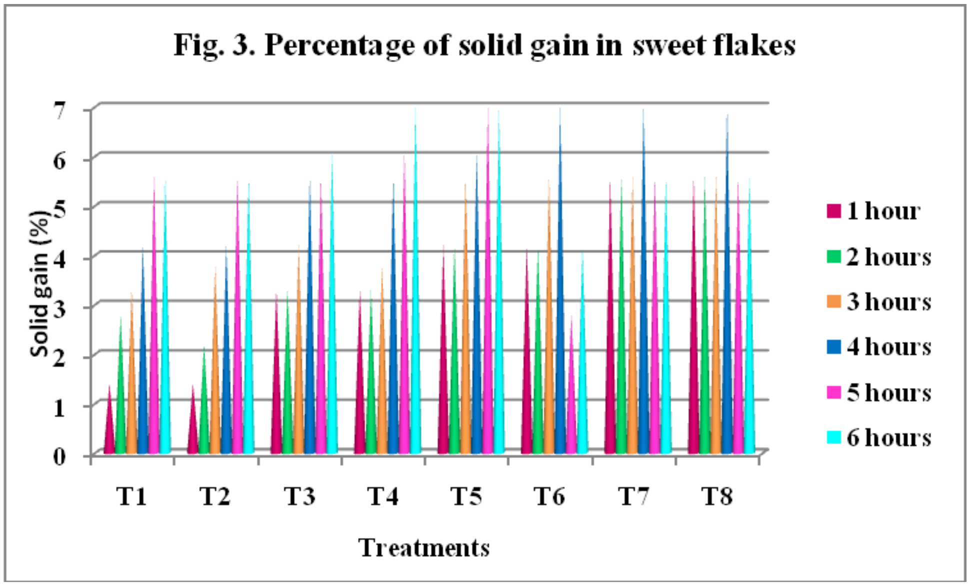


Fig. 3. Percentage of solid gain in sweet flakes
Solid gain (%)
0
1
2
3
4
5
6
7
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
1 hour
2 hours
3 hours
4 hours
5 hours
6 hours

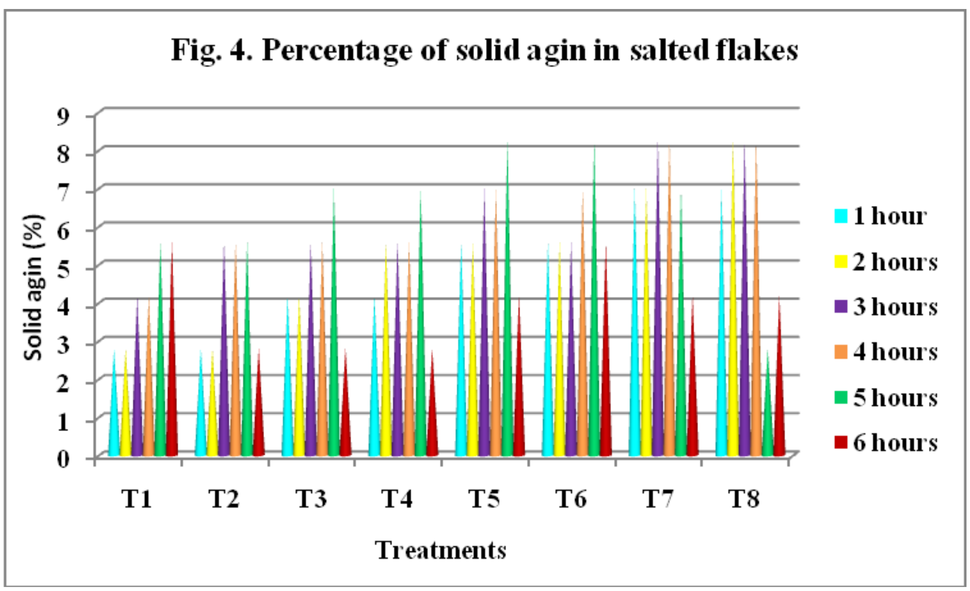


Fig. 4. Percentage of solid agin in salted flakes
Solid agin (%)
0
1
2
3
4
5
6
7
8
9
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
1 hour
2 hours
3 hours
4 hours
5 hours
6 hours

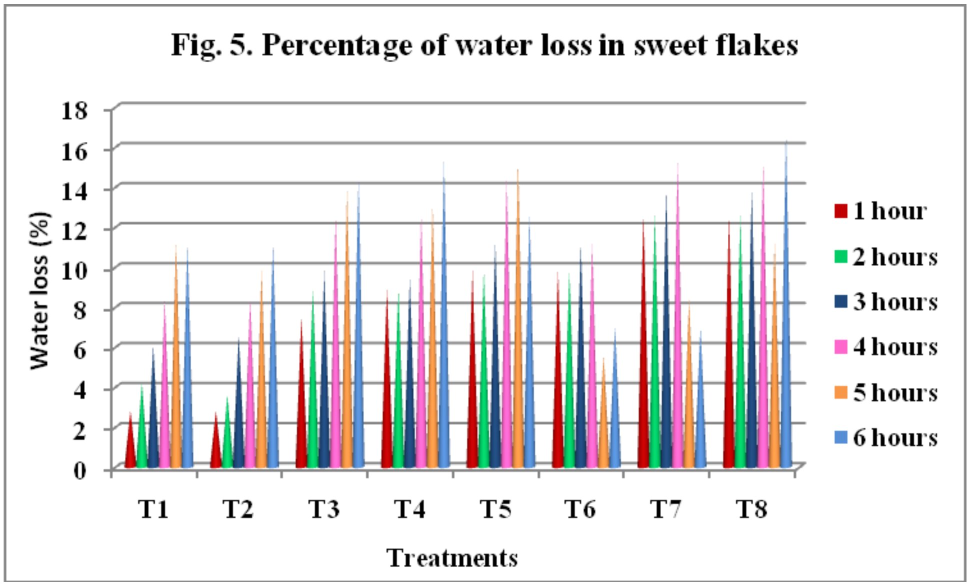


Fig. 5. Percentage of water loss in sweet flakes
Water loss (%)
0
2
4
6
8
10
12
14
16
18
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
1 hour
2 hours
3 hours
4 hours
5 hours
6 hours

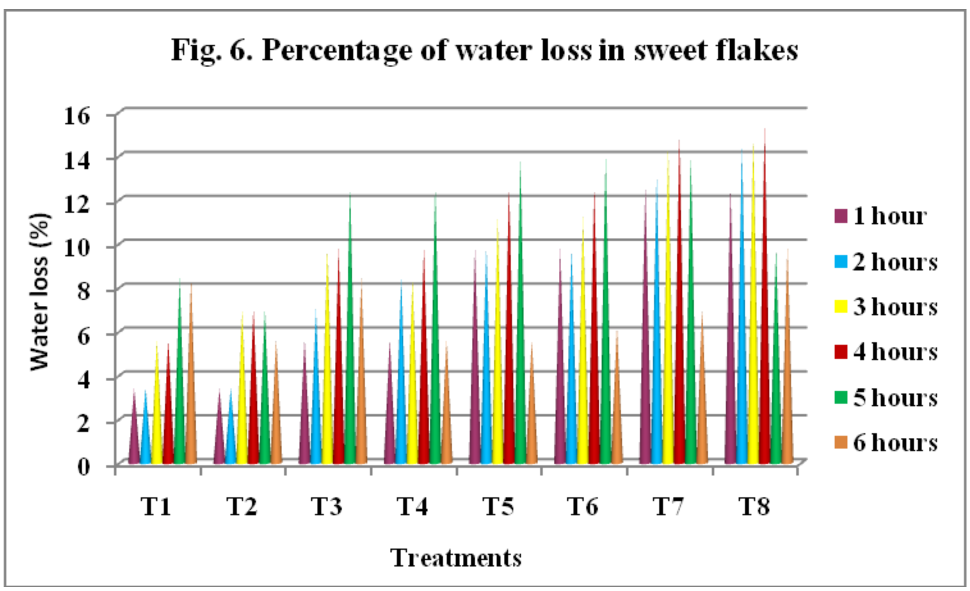


Fig. 6. Percentage of water loss in sweet flakes
Water loss (%)
0
2
4
6
8
10
12
14
16
T1
T2
T3
T4
T5
T6
T7
T8
Treatments
1 hour
2 hours
3 hours
4 hours
5 hours
6 hours

soaking, pseudo-equilibrium was reached during osmotic processing of pumpkin. The fluctuations in percentage of mass transfer observed in the present study might be due to the pseudo-equilibrium state achieved in the fourth hour of soaking.

The percentage of sucrose gain in sweet flakes increased with increase in concentration of sugar solution (Fig. 7). The sucrose gain in sweet flakes varied from 15.20 to 29.20 per cent among different treatments. A steady increase with advancement in duration of soaking was also noticed in sucrose gain of sweet flakes. Beristian *et al*. (1990) and Denise *et al*. (2005) noticed similar findings in pineapple and acerola fruits respectively.

A gradual increase in percentage of salt or sodium chloride gain was noticed in salted flakes (Fig. 8) with increase in concentration of salt solution and with advancement in duration of soaking. The maximum sodium chloride gain of 14.63 per cent was noticed in flakes prepared with 15 per cent salt solution soaked for six hours. A similar result was reported by Mayor *et al*. (2005) in pumpkin. The authors suggested an enhancement in diffusion of salt into pumpkin tissues with an increase in solute concentration. This might have contributed to higher per cent of salt gain noticed in flakes prepared with 15 per cent salt solution.

5.2. Organoleptic qualities of dehydrated pumpkin flakes and custard powder

The different quality attributes of sweet flakes obtained higher mean scores for all the treatments compared to control (T_0). The mean scores for appearance and colour of sweet flakes increased with increase in sugar concentration and maximum scores were noticed in flakes prepared using 60 per cent sugar solution. Higher concentration of sugar might have imparted more glaziness and enhanced the bright orange colour of pumpkin. Shrinkage was not observed in any of the osmotically

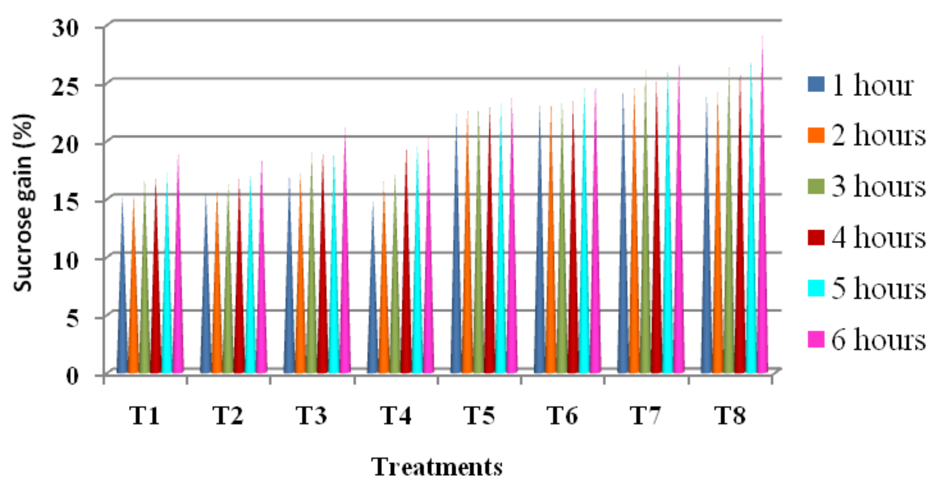


Fig. 7. Percentage of sucrose gain in sweet flakes

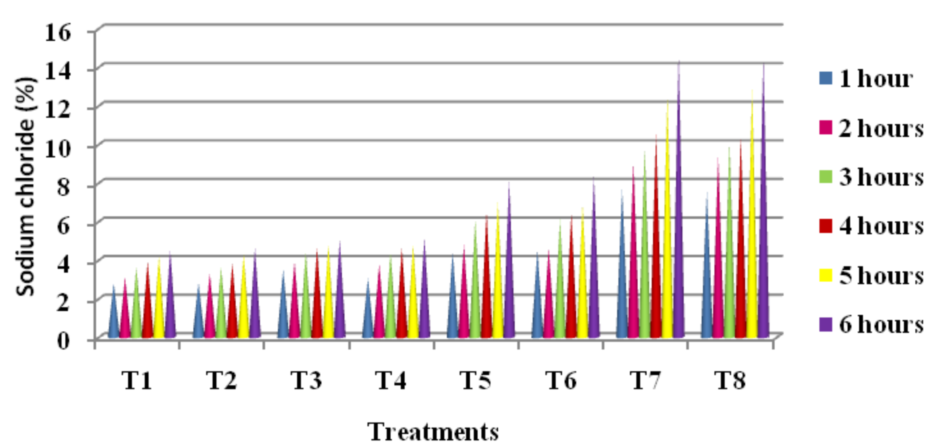


Fig. 8. Percentage of sodium chloride gain in salted flakes

dehydrated sweet flakes. Better colour in osmotically dehydrated banana (Prasad and Das, 1997) and osmotically pre-treated air dried pepper were also reported by Falade and Oyedele (2010) respectively.

The mean scores for flavour, texture and taste were higher in sweet flakes prepared with 60 per cent sugar solution. The mean scores for flavour of sweet flakes of different treatments were almost similar to that of control (T_0). From this, it is clear that osmotic process did not influence the flavour components of sweet pumpkin flakes. Moreover, it might have helped in retention of the flavour components. Better texture and flavour in dehydrated products were reported by Heng *et al*. (1990); Omowaye *et al*. (2002); Pragati and Dhawan (2003) and Azoubel and Murr (2004) and concluded that osmosis followed by drying retained the volatile compounds in fruits resulting in enhanced flavour and texture. Higher mean scores for taste was noticed in flakes prepared with 60 per cent sugar solution which might be due to the increased sucrose gain during osmosis.

All the treatments had higher mean scores for overall acceptability compared to control (T_0), and flakes prepared with 60 per cent sugar solution obtained maximum score for overall acceptability. A similar study conducted by Gudapaty *et al.* (2010) indicated that the osmotically dehydrated aonla was liked very much because of its appealing colour, preferable texture, flavour and overall acceptability.

For appearance and colour of the salted flakes, wide variation was noticed in mean scores among various treatments. The highest mean score for appearance was noticed in flakes prepared by soaking the slices in three per cent salt solution for one hour in T_1, in which shrinkage was comparatively less. The lower mean scores noticed for appearance in other treatments might be due to the excess shrinkage during osmotic dehydration with increased concentration of salt. Similar findings were reported by Viberg *et al.* (1998) in strawberries and Giraldo *et al*. (2005) in mango. When compared to the flakes prepared without any solute (T_0), flakes prepared with higher concentration of solute had lower mean scores for colour. Dhingra *et al*. (2008) noticed colour changes in salt treated vegetables due to the browning reactions.

The highest mean scores for flavour, texture and taste was noticed in flakes prepared from slices soaked in three per cent salt solution for one hour in T_1. In all other treatments, the mean score for flavor, texture and taste decreased with increase in concentration of solute and advancement in duration of soaking, and were found to be lower than the control. Lenart (1996) reported that the retention of volatile compounds by sodium chloride is lower than sugar. Percentage of water loss was comparatively lower in salted flakes than sweet flakes, which caused a soggy texture in the flakes. Saltiness of flakes increased with increase in concentration of solute, which in turn lowered the mean scores for taste of salted flakes. For overall acceptability, highest mean score was noticed in flakes prepared from slices soaked in three per cent salt solution for one hour in T_1. In all other treatments, the mean scores for overall acceptability were lower than the control.

The mean score for different quality attributes of custard prepared using ready to use pumpkin custard powder was found to be high in T_1 to T_4. The custard prepared from T_1 to T_4 had appealing colour and the percentage of pumpkin powder was in the range of 5 to 20. Custard prepared from T_5 to T_7 was dark in colour and had lower mean scores for appearance and colour. Custard powder from T_1 to T_4 had higher mean scores for flavour, texture and taste. Custard prepared from T_5 to T_7 had raw flavour and taste of pumpkin, which negatively influenced the mean scores for flavour and taste. The better texture in custard prepared from T_1 to T_4 might be due to the high percentage of corn flour in them. A study conducted by Marwaha and

Sandhu (1999) on potato custard powder indicated that the addition of starch or starch flour combination acted as thickeners and were effective in bringing the desired consistency for the custard.The highest mean scores for overall acceptability was also noticed in T_1 to T_4. Ready to use instant potato custard powder prepared by mixing low percentage of potato flour with other blending materials (Raj *et al*., 2008) was acceptable. Thus, the finding of the present study was found to be in line with the above observations.

5.3. Selection of the most acceptable treatment for the preparation of pumpkin products

The selection of the most acceptable treatment was based on the mean scores obtained for different quality attributes in the organoleptic evaluation. The desirable quality attributes required for acceptable flakes are mainly flavour, texture and taste. Priority was given for the mean scores obtained for these attributes to select the best sweet and salted flakes from different treatments. To select the most acceptable treatment for preparation of custard powder, priority was given for maximum scores obtained for colour, texture and taste of the custard prepared using the ready to use pumpkin custard powder.

Highest mean scores for texture and taste was noticed in flakes prepared from pumpkin slices soaked in sugar syrup for two and three hours in 60 per cent sugar solution containing 0.3 per cent citric acid. Since the mean scores for texture and taste were highest in two different time durations, flavour of the flakes was also taken into consideration. The maximum score for flavour was observed in flakes soaked in 60 per cent sugar solution containing 0.3 per cent citric acid for two hours. For appearance, colour and overall acceptability also sweet flakes of T_7 got a score of 8.30 and above. Hence, flakes soaked in 60 per cent sugar solution containing 0.3 per cent citric acid for two hours was selected as the most acceptable treatment for the preparation of sweet flakes.

In salted flakes, the highest mean scores for flavour, texture and taste was noticed in flakes prepared from slices soaked in three per cent salt solution containing 0.3 per cent citric acid (T_1) for one hour and the mean scores were 6.43, 7.13 and 6.50 respectively. The highest mean scores for appearance (6.90), colour (6.63) and overall acceptability (5.70) were also noticed in the same treatment. Hence, flakes soaked in three per cent salt solution containing 0.3 per cent citric acid (T_1) for one hour was selected as the most acceptable treatment for the preparation of salted flakes.

The highest mean scores for colour, texture and taste were noticed in custard prepared using T_2. Mean scores for flavour and overall acceptability was also found to be high inT_2. For appearance T_2 had a mean score of 7.83 and was found to be very close to the highest mean score noticed in T_4 (7.86). Hence, for the preparation of ready to use custard powder T_2 was selected as the most acceptable one.

5.4. Quality evaluation of selected pumpkin products during storage

The selected sweet flakes, salted flakes and custard powder were packed in metalised polyester laminate pouches and stored under ambient conditions for three months and evaluated for various quality attributes.

5.4.1. Physical qualities of stored custard powder

The custard powder was free flowing without lump formation initially and after three months of storage which might be due to the high degree of uniformity among particles without stickiness and relatively low moisture content in the custard powder. Similar observations were noticed in mango powder by Chauca *et al*. (2005) and Jaya and Das (2005).

The bulk density of custard powder was 0.72 g per ml in both periods under study. The slight increase in moisture content of custard powder during storage did not make any change in the bulk density of custard powder.

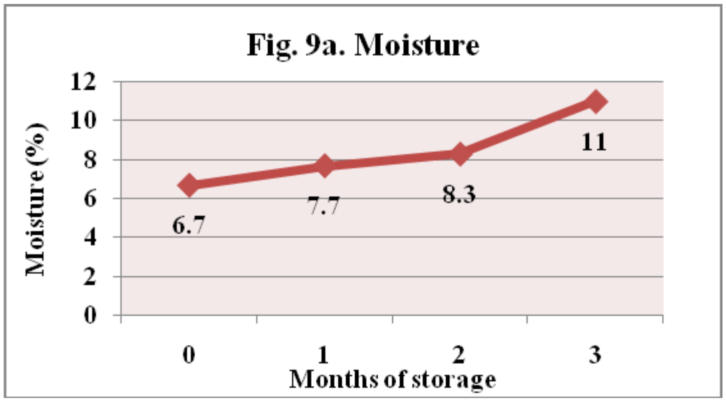
5.4.2. Chemical composition of stored dehydrated flakes and custard powder

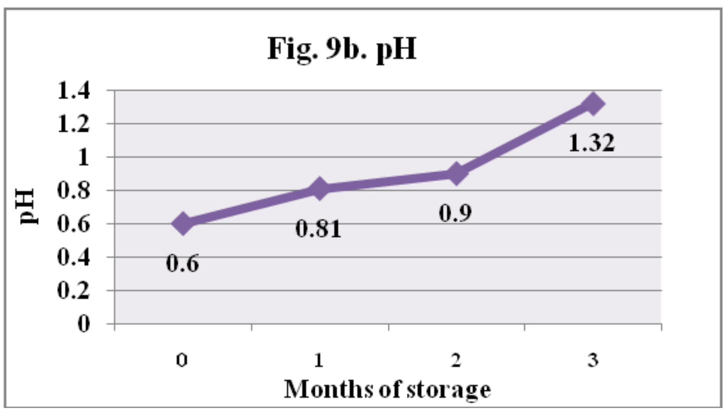
Moisture content in sweet and salted flakes and custard powder increased during three months of storage (Fig. 9a, 10a and 11a). Initially, the moisture content in sweet flakes, salted flakes and custard powder was 6.70 per cent, 4.30 per cent and 4.33 per cent respectively which increased to 11.00 per cent, 12.30 per cent and 5.33 per cent in three months of storage. The increase in moisture content of pumpkin flakes and custard powder during storage might be due to the absorption of moisture from atmosphere due to the permeability of polythene bags to water vapours as suggested by Raj *et al.* (2008) in potato custard powder. Another reason for the moisture absorption might be the higher relative humidity around the storage vicinity of the products.

The pH in sweet and salted flakes and custard powder (Fig. 9b, 10b and 11b) decreased to 5.56, 5.92 and 5.10 at the end of three months of storage from the initial pH of 5.92, 6.50 and 6.43. The decrease in pH during storage of the flakes and custard powder is due to the increase in the acidity of the products during storage.

There was an increase in the titrable acidity of sweet and salted flakes and custard powder (Fig. 9c, 10c and 11c) throughout the storage period. In sweet and salted flakes, the acidity increased from an initial value of 0.60 per cent and 1.15 per

Fig. 9. Effect of storage on the chemical constituents of sweet pumpkin flakes





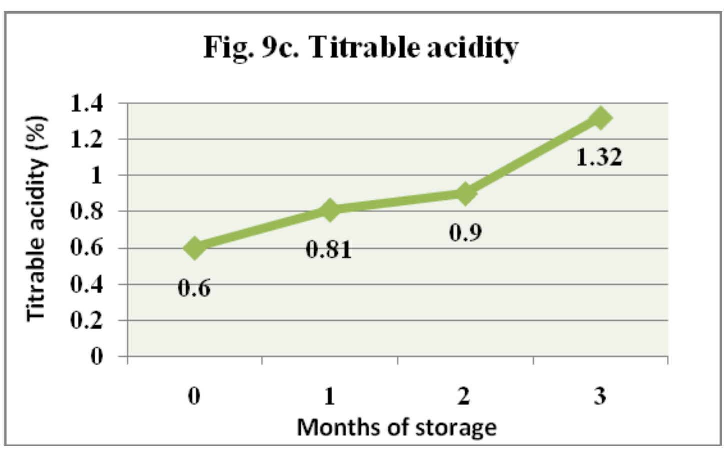
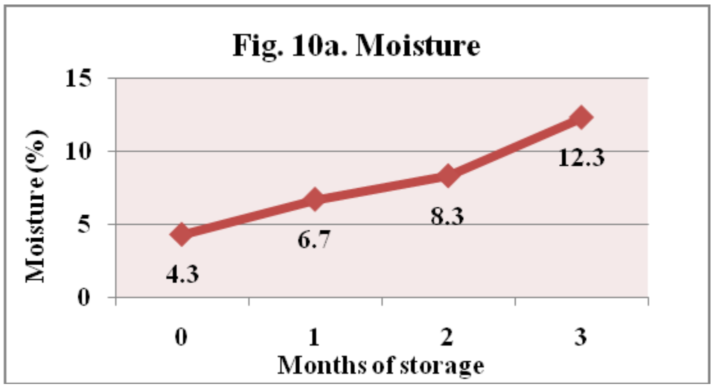
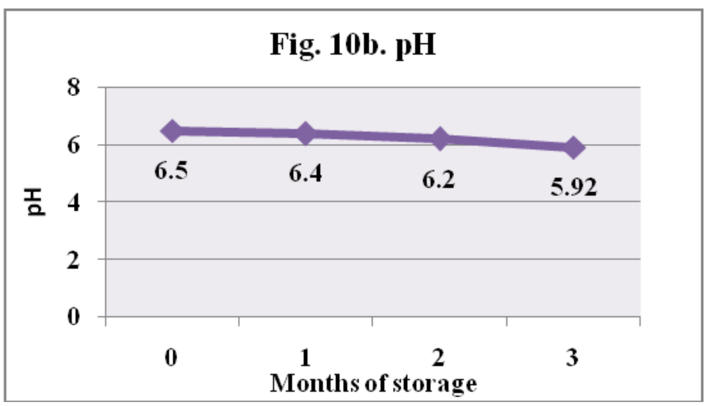


Fig. 10. Effect of storage on the chemical constituents of salted pumpkin flakes





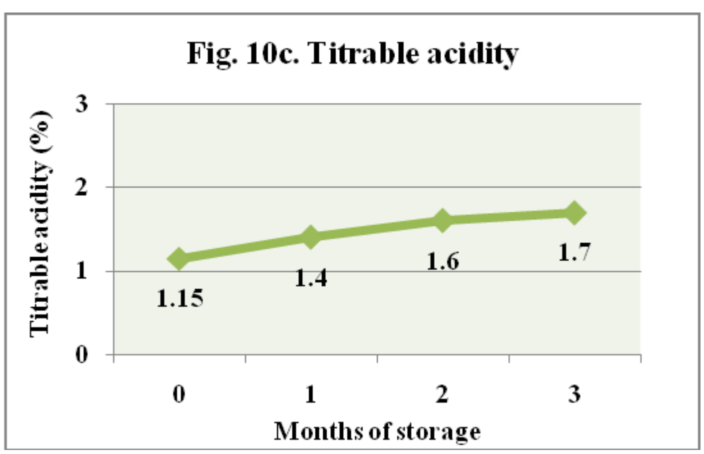
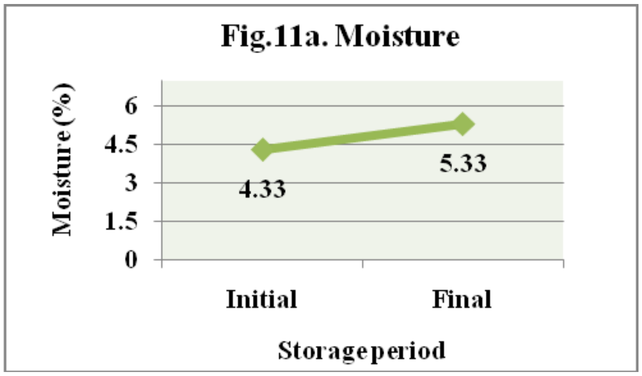
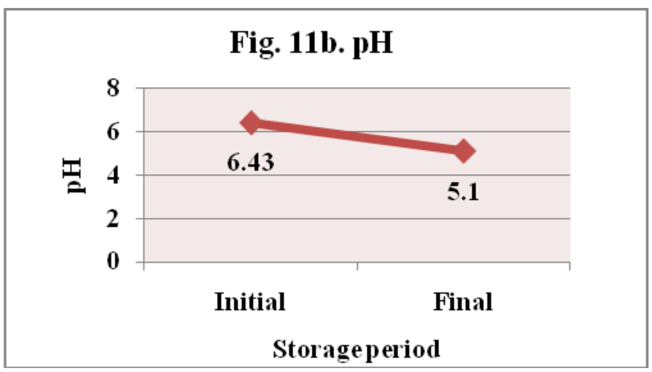
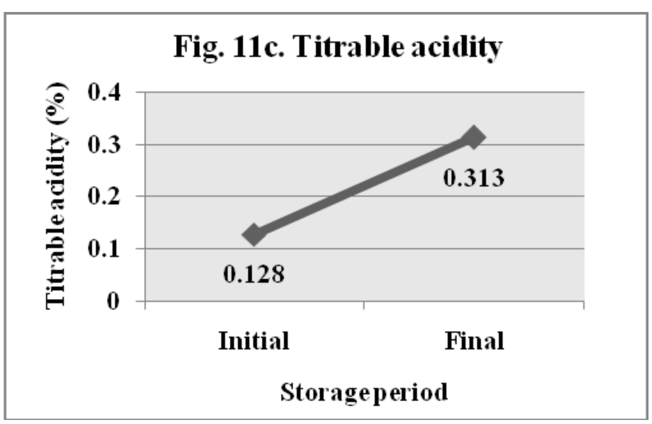


Fig. 11. Effect of storage on the chemical constituents of pumpkin custard powder







cent to 1.32 per cent and 1.70 per cent respectively at the end of three months of storage. In custard powder, the acidity increased significantly from 0.128 to 0.313 per cent during three months of storage. Dhiman *et al*. (2007) reported that the titrable acidity of ripe pumpkin is 0.07 per cent. Compared to the acidity of ripe pumpkin, the products developed from pumpkin had high percentage of titrable acidity, which occured due to the addition of citric acid during the processing of pumpkin. The increase in titrable acidity in dried carrot during storage was reported by Rahman *et al*. (2010). The compositional changes occurred in the products during storage might also have contributed to the increase in acidity.

The β carotene content of sweet and salted flakes and custard powder (Fig. 9d, 10d and 11d) decreased from an initial content of 219.50 µg, 221.20 µg and 23.6 µg to 209.01 µg, 214.60 µg and 22.20 µg per 100 g respectively during three months of storage. Compared to the β carotene content of 80.64 µg per 100 g in drum dried banana flakes as reported by Fernandes *et al*. (2006), the flakes prepared in the present study had higher β carotene content. This might be due to the higher β carotene content of pumpkin used for the preparation of flakes and by the retention of carotenoids in the osmotic dehydration. The reduction in β carotene content of flakes and custard powder during storage was found to be statistically insignificant.

The total sugars in sweet and salted flakes and custard powder (Fig. 9e, 10e and 11e) reduced during three months of storage from the initial content of 40.39 per cent, 9.94 per cent and 20.47 per cent to 38.43 per cent, 9.74 and 20.42 per cent respectively. Initially, the reducing sugars in sweet and salted flakes and custard powder (Fig. 9f, 10f and 11f) were 13.6 per cent, 3.6 per cent and 4.74 per cent, which decreased slightly to 13.14 per cent, 2.73 per cent and 4.40 per cent respectively during three months of storage. The reduction noticed in reducing sugars of pumpkin flakes and custard powder was statistically insignificant. Muralikrishna *et*

Fig. 9. Effect of storage on the chemical constituents of sweet flakes

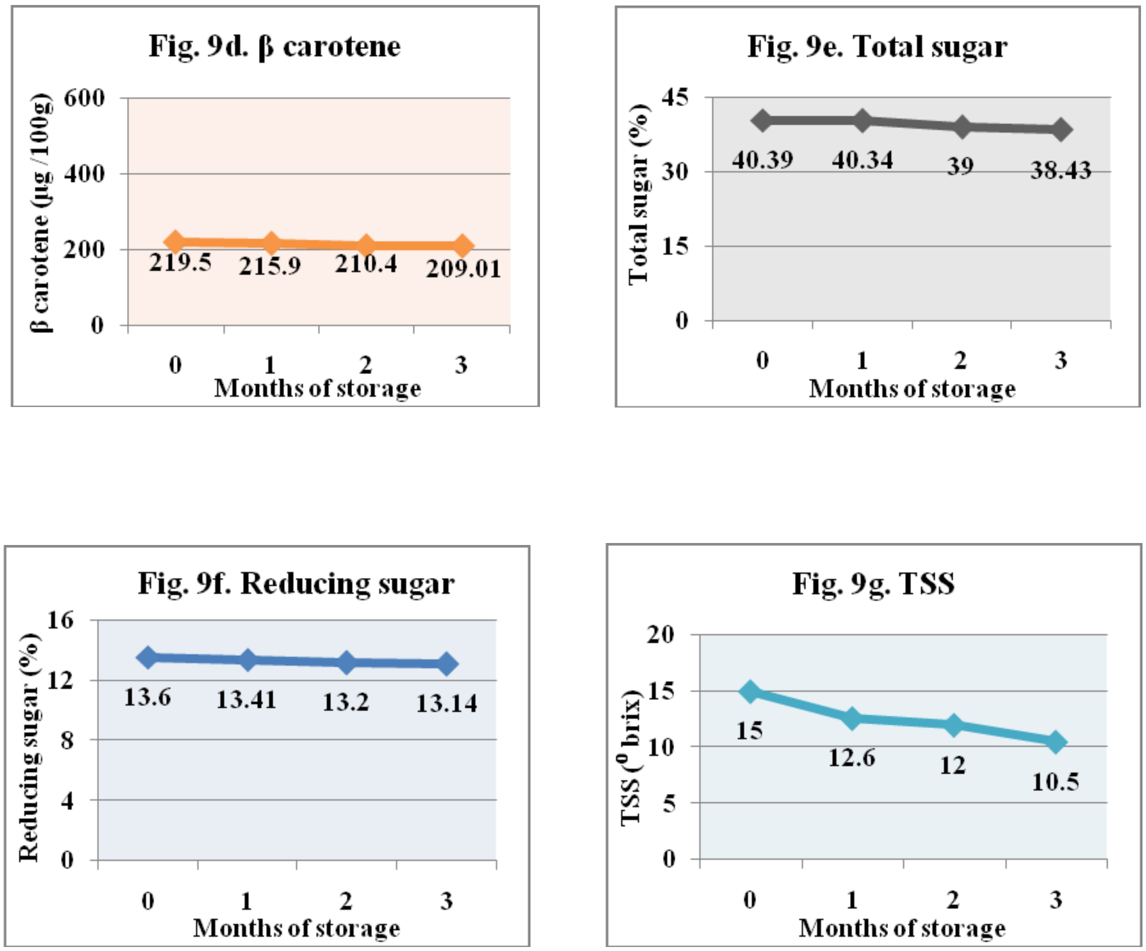


Fig. 10. Effect of storage on the chemical constituents of salted flakes

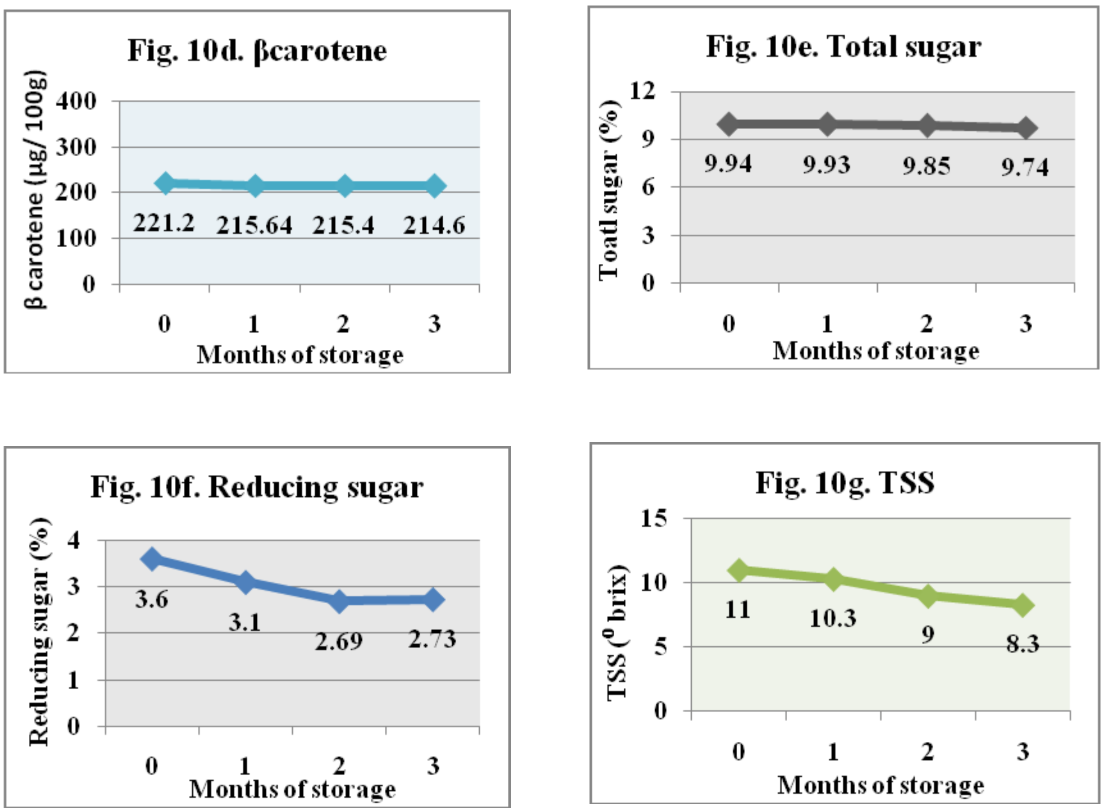
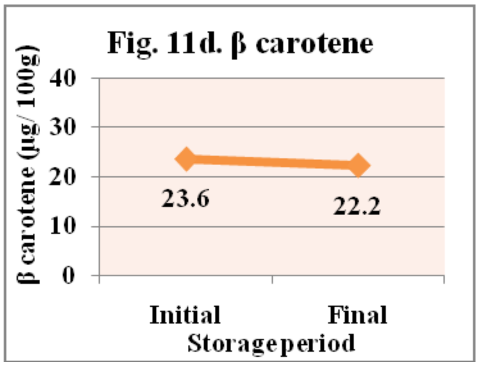
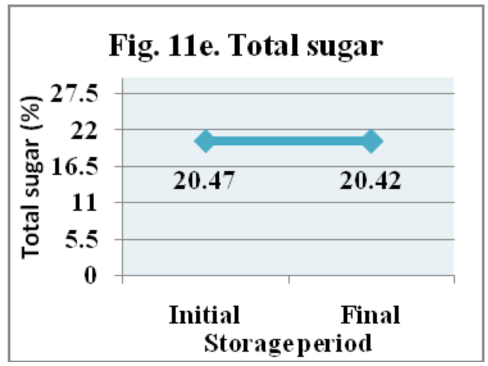
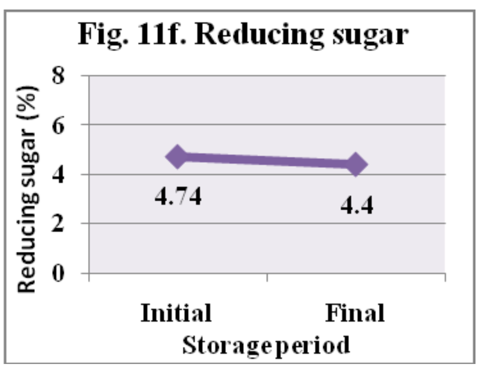
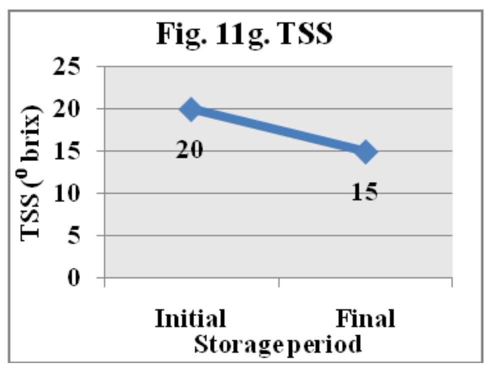


Fig. 11. Effect of storage on the chemical constituents of pumpkin custard powder









al. (1969) reported that total, reducing and non-reducing sugars probably decreased during storage due to the inversion of sugars to monosaccharides by acid hydrolysis. The decrease in total sugars during storage might be due to the condensation of reducing sugar with amino acids as suggested by Thakur *et al*. (2000). The TSS of the sweet flakes, salted flakes and custard powder (Fig.9g, 10g and 11g) was 15 ^{o}brix, 11 ^{o}brix and 20 ^{o}brix respectively before storage, which decreased to 10.50 ^{o}brix, 8.30 ^{o}brix and 15 ^{o}brix in three month of storage.

5.4.3. Organoleptic qualities of stored dehydrated flakes and custard powder

The mean scores for appearance of sweet and salted flakes (Fig. 12 and 13) decreased gradually during three months of storage. The gradual decrease in mean scores might be due to the soggy appearance caused by the increase in moisture content. The mean scores for colour of sweet and salted flakes decreased to 8.20 and 6.33 respectively from an initial score of 8.50 and 6.63 respectively. A gradual decrease in the mean scores for flavour, texture, taste and overall acceptability was noticed in both sweet and salted flakes during storage. The increase in moisture content in both flakes during storage negatively affected the textural qualities of flakes. The flakes started loosing its crispness by the end of second month of storage itself. Towards the end of third month of storage, both flakes were degraded in their quality making them least acceptable in sensory attributes.

The mean score for appearance of the custard (Fig. 14) prepared using ready to use custard powder increased after storage of three months. Regarding the colour, flavour and texture of the custard, slight reduction was noticed in the mean scores during three months of storage. The taste and overall acceptability of the custard remained unchanged during storage. The variation in mean scores of all the quality attributes was found to be statistically insignificant

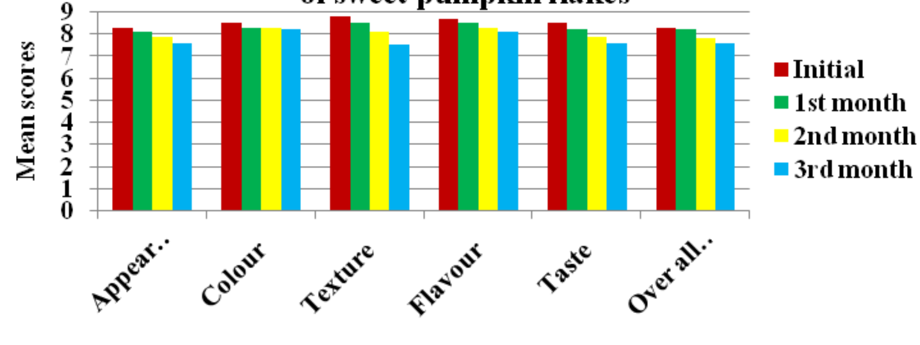


Fig. 12. Effect of storage on the organoleptic qualities of sweet pumpkin flakes

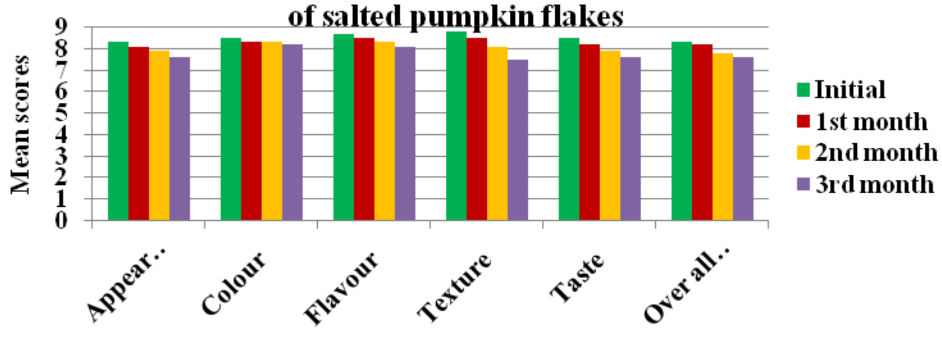


Fig. 13. Effect of storage on the organoleptic qualities of salted pumpkin flakes

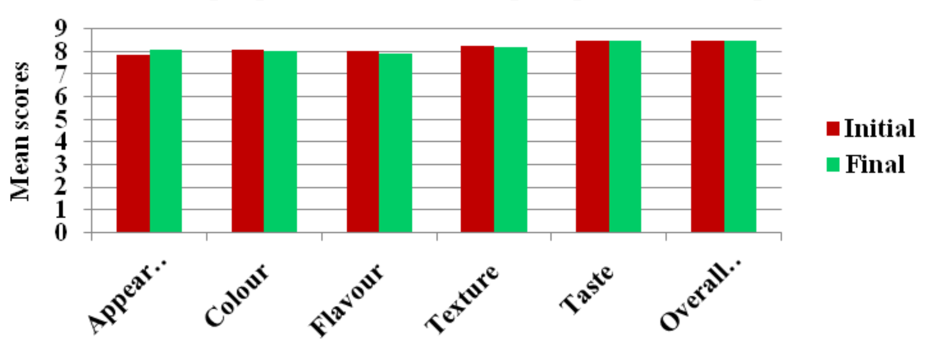


Fig. 14. Mean scores for the organoleptic qualities of custard prepared from stored pumpkin custard powder

5.4.4. Microbial enumeration of stored dehydrated flakes and custard powder

The microbial growth or microbial damage of a product is dependent upon certain factors both chemical and physical, which are favourable for their growth (Frazier and Westhoff, 1974).

Microbial enumeration of sweet and salted flakes was done initially and at monthly intervals of storage. Microbial count was not observed in sweet and salted flakes initially. Bacterial count of 0.33 x 10^5 cfu g^{-1} observed during first month, remained unchanged till the end of second month of storage in sweet flakes, which further increased to 0.66 x 10^5 cfu g^{-1} in the third month. The increase in bacterial count might be due to the increase in moisture content during storage. Bacterial count (0.33 x 10^5 cfu g^{-1}) noticed in salted flakes during the first month of storage remained unchanged throughout storage.

There was no fungal and yeast growth initially in both sweet and salted flakes. In sweet flakes, fungal count was observed during first month, which reduced to 1.70 x 10^3 cfu g^{-1} in second month and further increased during third month of storage. A gradual reduction in fungal count from 3.00 x 10^3 cfu g^{-1} to 2.00 x 10^3 cfu g^{-1} was noticed in salted flakes during three month of storage. In sweet flakes, yeast count increased during first month, which decreased in second month and further increased to 1.00 x 10^3 cfu g^{-1} during third month of storage. A gradual reduction in yeast count was noticed in salted flakes, which may be due to the presence of salt added while processing.

Bacterial and fungal growth was not detected in custard powder initially and at the end of three months of storage. Initially, yeast growth was not detected and yeast count of 0.33×10^3 cfu g^{-1} was observed in custard powder at the end of three months of storage.

5.4.5. Insect infestation in stored custard powder

The custard powder was free from insect infestation initially and after three months of storage. Nasir *et al*. (2003) reported moisture as an important factor which affects the insect infestation in wheat flour. According to the authors, wheat flour having moisture less than 9 per cent after storage showed no insect infestation. Hence, the absence of insect infestation in custard powder could be attributed to low moisture content noticed in custard powder even after storage.

5.4.6. Cost of production of pumpkin products

The cost of production of sweet and salted flakes was found to be Rs. 67.00 and Rs. 70.00 respectively per 500 g. The cost of flakes was compared with the price of jackfruit flakes produced and marketed by Krishi Vigyan Kendra, Pathanamthitta. For 500 g of jackfruit flakes, the cost was Rs. 60.00 whereas in dehydrated sweet and salted pumpkin flakes, it was found to be high. The quantity required for processing and the cost of raw material was found to be high for pumpkin when compared to jackfruit, therefore a price hike was noticed in the present study.

The cost of production of 100 g of ready to use pumpkin custard powder was Rs. 35.00. The cost of vanilla flavoured custard powder available in the market is Rs. 22.00. When compared to this, the cost of production of pumpkin custard powder was found to be high. The main ingredient of the custard powder available in the market is corn flour, while the standardised custard powder in the present study was enriched with milk solids, cashewnuts and dessicated coconut powder. The cost of raw pumpkin, labour charge and electricity charges also contributed to the price hike of the developed product. However in terms of nutritive value, pumpkin custard powder is considered superior due to its high β carotene content.

Summary

6. SUMMARY

The present study entitled **"Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products"** was undertaken to standardise the process variables for value added products of pumpkin. The study also aimed to evaluate the nutritional and organoleptic qualities and shelf life of the products. In the present study, three products namely dehydrated sweet flakes, dehydrated salted flakes and ready to use pumpkin custard powder were prepared.

The percentage of weight loss, solid gain and water loss increased gradually in dehydrated sweet and salted flakes with increase in concentration of the solute upto four hours of soaking. Fluctuations in the above mentioned parameters were noticed in the fifth and sixth hours of soaking. In sweet flakes, maximum sucrose gain was noticed in flakes prepared from pumpkin slices soaked in 60 per cent sugar solution. The salted flakes prepared using 15 per cent salt solution had the highest percentage of salt gain.

The organoleptic qualities of dehydrated sweet and salted flakes and custard prepared from pumpkin custard powder were evaluated. Among the different treatments tried for the preparation of sweet flakes, the flakes prepared with 60 per cent sugar solution and 0.3 to 0.4 per cent citric acid in different hours of soaking obtained maximum scores (above 8.00) for all the sensory qualities like appearance, colour, flavour, texture, taste and overall acceptability.

In salted flakes, the highest mean scores for different quality attributes such as appearance (6.90), colour (6.63), flavour (6.43), texture (7.13), taste (6.50) and overall acceptability were noticed in flakes prepared from pumpkin slices soaked in three per cent salt solution containing 0.3 per cent citric acid for one hour.

The custard prepared from 5 to 20 per cent pumpkin powder and 15 to 30 per cent corn flour obtained highest mean scores (above 7.00) for all the quality attributes like appearance (7.80 to 7.86), colour (7.66 to 8.10), flavour (7.60 to 8.10), texture (7.80 to 8.23), taste (7.90 to 8.50) and overall acceptability (7.46 to 8.46).

The selection of the most acceptable treatment was based on the mean scores obtained for different quality attributes in the organoleptic evaluation. Sweet flakes prepared from pumpkin slices soaked in 60 per cent sugar solution containing 0.3 per cent citric acid for two hours and salted flakes prepared from pumpkin slices soaked in three per cent salt solution containing 0.3 per cent citric acid for one hour were selected as the most acceptable treatments for the preparation of sweet and salted flakes respectively. The selected sweet and salted flakes obtained maximum scores of above 8.0 for flavour, texture and taste. The custard prepared from custard powder (T_2), having 10 per cent pumpkin powder and 25 per cent corn flour obtained the highest mean scores for colour, texture and taste. Hence, T_2 was selected as the best treatment for the preparation of custard powder.

The selected custard powder was evaluated for various physical qualities. The free flowness of custard powder was evaluated initially and at the end of storage and it was found that the powder was freely flowing without any lumps. Bulk density of 0.72 g per ml was observed in custard powder throughout the storage period.

The moisture content and titrable acidity of sweet and salted flakes and custard powder increased during storage. The increase in moisture content was from 6.70, 4.30 and 4.33 per cent to 11.00, 12.30 and 5.33 per cent in sweet flakes, salted flakes and custard powder respectively. Titrable acidity of the sweet and salted flakes and custard powder showed an increasing trend during three months of storage.

Gradual decrease was observed in the pH, β carotene, total and reducing sugars and TSS of the flakes and custard powder during storage. The decrease noticed in pH of the sweet and salted flakes and custard powder was from the initial pH of 5.92, 6.50 and 6.43 to 5.56, 5.92 and 5.10 respectively by the third month of storage.

The β carotene content in sweet and salted flakes and custard powder decreased during the three months of storage. The total sugars in sweet and salted flakes and custard powder reduced from an initial content of 40.39 per cent, 9.94 per cent and 20.47 per cent to 38.43 per cent, 9.74 and 20.42 per cent respectively.

The TSS of the sweet flakes, salted flakes and custard powder was 15 ^{o}brix, 11 ^{o}brix and 20 ^{o}brix respectively before storage, which decreased to 10.50 ^{o}brix, 8.30 ^{o}brix and 15 ^{o}brix in three months of storage.

The enhanced moisture absorption during storage decreased the crispness of flakes there by affecting the acceptability of the products. The mean scores for different organoleptic qualities of sweet and salted flakes decreased during three months of storage. The mean scores for appearance of the sweet and salted flakes were 8.30 and 6.90 initially, which decreased to 7.60 and 6.43 respectively after three months of storage. The mean scores for colour of sweet and salted flakes decreased to 8.20 and 6.33 respectively from an initial score of 8.50 and 6.63. A gradual decrease in the mean scores for flavour (8.70 to 8.10), texture (8.80 to 7.50), taste (8.50 to 7.60) and overall acceptability (8.30 to 7.60) was noticed in sweet flakes during storage. The mean scores for flavour, texture, taste and overall acceptability of salted flakes also decreased during three months of storage. The custard prepared from ready to use custard powder was acceptable throughout the period under study.

Microbial count was not observed in sweet and salted flakes initially. But on storage, microbial contamination occured from first month onwards. Bacterial count of $0.33x10^{5}$ cfu g^{-1} observed during first month, remained unchanged till the end of second month of storage in sweet flakes, which further increased to $0.66x10^{5}$ cfu g^{-1}

in the third month. Bacterial count ($0.33x10^5$ cfu g^{-1}) noticed in salted flakes during the first month of storage remained unchanged throughout storage.

In sweet flakes, fungal count was observed during first month, which reduced to $1.70x10^3$ cfu g^{-1} in second month and further increased during third month of storage. A gradual reduction in fungal count from $3.00x10^3$ cfu g^{-1} to $2.00x10^3$ cfu g^{-1} was noticed in salted flakes during three months of storage. In sweet flakes, yeast count increased during first month, which decreased in second month and further increased to $1.00x10^3$ cfu g^{-1} during third month of storage.

In custard powder, bacterial and fungal growth was not observed throughout the storage period but yeast count of $0.33x10^3$ cfu g^{-1} was observed at the end of three months of storage. Insect infestation was not observed in the custard powder throughout the storage period.

The cost of production of 500 g of dehydrated sweet flakes and salted flakes was Rs. 67.30 and Rs. 69.00 respectively. The cost of production of 100 g of ready to use custard powder was Rs. 35.00. The cost computed for the production of dehydrated pumpkin products was found to be slightly higher than the similar products available in the market.

Nowadays pumpkin has acceptance only as a vegetable. But it has high potential for product diversification. In the present scenario of changing food habits and busy life schedule, individuals have a positive inclination towards processed products. Day by day, the demand for fruit and vegetable products is increasing. Pumpkin is a vastly cultivated crop in Kerala and has utmost importance in the daily diet. Therefore, pumpkin has a good scope for commercial exploitation and if commercially exploited, it can fetch a good market.

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*** Originals not seen**

Appendix

APPENDIX I

Score card for organoleptic evaluation of pumpkin products

Name of the judge:
Date :

Characteristics	Score		
	1	2	3
Appearance			
Colour			
Texture			
Flavour			
Taste			
Over all acceptability			

9 point Hedonic scale

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

Signature :

APPENDIX II

Cost of production of pumpkin products

1. **Cost of production of 500 g of dehydrated sweet pumpkin flakes**

Sl. No.	Items	Quantity	Cost (Rupees)
1	**Raw materials**		
	Pumpkin	2 Kg	24.00
	Sugar (reusable)	600 g	19.20
	Citric acid	6 g	1.50
	KMS	2 g	0.84
2	**Other items**		
	Electricity charge	2 units	7.60
	Labour cost	30 minutes	15.00
		Total	**67.30** **~ 67.00**

2. **Cost of production of 500 g of dehydrated salted pumpkin flakes**

Sl. No.	Items	Quantity	Cost (Rupees)
1	**Raw materials**		
	Pumpkin	3.5 Kg	42.00
	Salt	105 g	1.05
	Citric acid	10.5 g	2.70
	KMS	3.5 g	1.50
2	**Other items**		
	Electricity charge	2 units	7.60
	Labour cost	30 minutes	15.00
		Total	**69.85** **~ 70.00**

3. Cost of production of 100 g of ready to use pumpkin custard powder

Sl. No.	Items	Quantity	Cost (Rupees)
1	**Raw materials**		
	Pumpkin	100 g	1.20
	Corn flour	25 g	2.90
	Milk powder	15 g	3.50
	Sugar	40 g	1.28
	Cashewnuts	5 g	2.20
	Salt	1 g	0.01
	Dessicated coconut powder	4 g	0.60
	KMS	0.1 g	0.042
2	**Other items**		
	LPG	5 minutes	0.50
	Electricity charge	2 units	7.60
	Labour cost	30 minutes	15.00
		Total	**34.832 ~ 35.00**

OPTIMISATION OF PROCESS VARIABLES FOR VALUE ADDED PUMPKIN (*Cucurbita moschata* Poir.) PRODUCTS

By

SHABINA B.

ABSTRACT OF THE THESIS

***Submitted in partial fulfilment of the requirement*for the degree of**

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Kerala Agricultural University, Thrissur

DEPARTMENT OF HOME SCIENCE

COLLEGE OF HORTICULTURE

VELLANIKKARA, THRISSUR - 680 656

KERALA, INDIA

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ABSTRACT

The present study entitled "Optimisation of process variables for value added pumpkin (*Cucurbita moschata* Poir.) products" was undertaken to standardise the process variables for value added dehydrated products of pumpkin such as sweet and salted flakes and ready to use custard powder. The study also aimed to evaluate the nutritional and organoleptic qualities and shelf life of the products.

The percentage of weight loss, solid gain and water loss increased gradually in dehydrated sweet and salted flakes with increase in concentration of the solute upto four hours of soaking. Fluctuations in the above mentioned parameters were noticed in the fifth and sixth hours of soaking. In sweet flakes, maximum sucrose gain was noticed in flakes prepared from pumpkin slices soaked in 60 per cent sugar solution. The salted flakes prepared using 15 per cent salt solution had the highest percentage of salt gain.

The organoleptic qualities of dehydrated sweet and salted flakes and custard were evaluated. Sweet flakes prepared from pumpkin slices soaked in 60 per cent sugar solution containing 0.3 to 0.4 per cent citric acid had maximum mean scores of above 8.00 for different quality attributes. The mean scores for different oragnoleptic qualities of salted flakes was found to be high in flakes prepared by soaking in three per cent salt solution containing 0.3 per cent citric acid for one hour. Among seven treatments tried, custard prepared from custard powder having 5 to 20 per cent pumpkin and 15 to 30 per cent corn flour had maximum mean scores for different quality attributes.

Sweet flakes prepared from pumpkin slices soaked in 60 per cent sugar and 0.3 per cent citric acid solution for two hours and salted flakes prepared from pumpkin slices soaked in three per cent salt solution containing 0.3 per cent citric acid for one hour were selected as the most acceptable treatments. For the

preparation of ready to use custard powder, the treatment having 10 per cent pumpkin powder and 25 per cent corn flour was selected as the most acceptable one.

The selected custard powder was evaluated for various physical qualities. The custard powder was freely flowing without any lumps even after three months of storage. Bulk density of the product was found to be constant (0.72g per ml) throughout the storage period.

The moisture content and titrable acidity of sweet and salted flakes and custard powder increased during storage, whereas a reduction in pH was noticed during storage. Due to inter conversion of biological components, the reducing sugar, total sugar and TSS showed a decreasing trend in all the three products. A decrease in β carotene content was also noticed during three months of storage.

The enhanced moisture absorption during storage slightly decreased the crispness of flakes thereby affecting their acceptability. The mean scores for different organoleptic qualities of sweet and salted flakes decreased during three months of storage. The custard prepared from custard powder was acceptable throughout the period under study.

Microbial count was not observed in sweet and salted flakes initially. But on storage, microbial contamination was noticed from first month onwards. In custard powder, bacterial and fungal growth was not observed throughout the storage period but yeast count of 0.33×10^3 cfu g^{-1} was observed at the end of three months of storage. Insect infestation was not observed in custard powder throughout the storage period.

Cost of production of dehydrated sweet and salted flakes and custard powder was computed and was found to be slightly higher than the flakes and custard powder available in the market.