NUTRITIONAL AND ORGANOLEPTIC QUALITIES OF VALUE ADDED PRODUCTS FROM BANANA *MUSA* (AAA GROUP) 'GRAND NAINE'

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Nutritional and organoleptic qualities of value added products from banana *Musa* (AAA Group) "Grand Naine"** is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed during the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that the thesis entitled **"Nutritional and organoleptic qualities of value added products from banana cv. *Musa* (AAA Group) "Grand Naine"** is a bonafide record of research work done independently by Ms. SRUTHY P. M. under my guidance and that it has not been previously formed during the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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INTRODUCTION

INTRODUCTION

Fruits and vegetables are important food to the human diet as they provide essential minerals, vitamins and fibre required for maintaining health. India ranks first in production of fruits and second in production of vegetables in the world. India produces 88.9 millons tonnes of fruits and 162.89 million tonnes of vegetables (NHB, 2014). However, this abundance in production is not fully utilized and about 30 per cent of wastage occurs at various stages of handling and distribution (Patil and Rawale, 2009).

Banana is a herbaceous plant belonging to the *Musaceae* family (Nakason and Paull, 1998). It is called *Kalpatharu* meaning herb with imaginable uses and it is an oldest fruit known as 'Apple of Paradise' (FAO, 2012). Banana stands first in production and second in area among the fruit crops grown in India. India leads the world in production of banana with an annual production of 264.7 lakh tonnes out of total world production of 950 lakh tonnes, among which only 3 - 4 per cent of banana is processed (NHB, 2010). Banana has nutritional, medicinal and industrial value and is one of the most important tropical fruits crops of the world. It is a highly perishable fruit and suffers from high post harvest losses to an extent of about 20 to 40 per cent.

Grand Naine banana is literally translated from French meaning "Large Dwarf". It is a cultivar of the well known Cavendish bananas. It is a popular high yielding cultivar and is one among the most popular banana varieties commonly grown in India. Its characteristic medium height and large fruit yield make it ideal for commercial agriculture. During peak season, large volumes of fruits are available and due to the perishable nature of the commodity, the producers are faced post harvest problems. Development of shelf stable value added products is essential to prevent the loss.

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The most popular processed product from banana in Kerala is Nendran chips. Compared to Nendran banana, Grand Naine banana has low market price and is highly perishable. The packaging studies and quality aspects of Grand Naine banana chips is an area which has not been yet explored for either cottage scale or commercial level production in Kerala.

Banana flour from unripe fruit is an excellent source of resistant starch and antioxidants. Flour is an important raw material in the baking and confectionery industry. The demand for flour in bakery products is increasing globally and banana flour is currently being utilized in baking and as complementary weaning foods. Banana flour has commercial importance by itself or as a base with other foods such as weaning foods and snacks. New economical strategy to increase utilization of banana includes the production of banana flour when the fruit is unripe, and its fortification in slowly digestive cookies and high fibre bread (Adeniji and Empere, 2001). Banana flour is a low cost ingredient for food industry and an alternative to minimize banana wastage. Hence, the production of banana flour from Grand Naine and to incorporate the flour into various products will have immense potential in the present scenario.

The post globalization world economy gives more weightage on processing and value addition. Processing industry can play a vital role in the economic uplifting of the country specially the agricultural sector. Considering the large fruit yields, highly perishable nature and immense potential for product development, the present study entitled 'Nutritional and organoleptic qualities of value added products from banana *Musa* (AAA Group) "Grand Naine" was proposed the with following objectives.

1. To standardize value added products from Grand Naine banana.
2. To evaluate the quality attributes and shelf life of the products.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The review of literature pertaining to the study entitled **Nutritional and organoleptic qualities of value added products from banana *Musa* (AAA Group) 'Grand Naine'** is presented under the following headings:

2.1. Nutritional importance of banana

2.2. Uses of banana in human diet

2.3. Importance of Cavendish banana

2.4. Product development from banana

2.4.1. Product development from Cavendish banana

2.5. Storage studies of banana products

2.1. Nutritional importance and chemical composition of banana

Banana is a herbaceous plant belonging to the *Musaceae* family (Nakason and Paull, 1998). It is called *Kalpatharu* meaning herb with imaginable uses and it is the oldest fruit known as 'Apple of Paradise' (FAO, 2012).

It is also known as common man's fruit (FAO, 2012). It occupies the fourth position among food crops in the developing world and is the most important food after rice, corn and milk (Arumugam and Manikandan, 2011). In banana production India tops the world with a production of 264.7 lakh tonnes of banana out of total world production of 950 lakh tonnes (NHB, 2010).

Banana and plantain (*Musa* spp.) are cultivated in more than 130 countries (tropical and sub-tropical regions) (FAOSTAT, 2013). The different banana varieties such as Grand Naine, Basrai, Robusta are mainly cultivated in India (NHB, 2010), while Nendran is the commercial variety of Kerala. It is an important staple food that

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is critical to the nutrition and economic status of millions of people throughout the developing world (Olorunda, 2000). Chadda (1989) reported that India is the second largest producer of banana and *Nendran* variety is mainly used for making chips and flour in Kerala.

Banana contain high amount of carbohydrates, vitamins and several minerals like calcium, potassium, phosphorus and magnesium. It is free from fat and is easy to digest (Singh and Uma, 1997). Banana contains minerals like calcium (8g/100g), phosphorus (26g /100g) and iron (0.7 mg/100 g) (Chaundawat and Sen, 2002). Thajudeen (2000) reported that the raw *Nendran* banana is high in starch and potassium. Minerals like calcium, phosphorus and iron content were high in *Karpooravally* whereas *Njalipoovan* had higher starch and vitamin C content. Lakshmy (2003a) reported that *Chengalikodan* and *Manjeri nendran* banana have the highest protein content (1.60 g/100g) compared to other *nendran* type bananas. Wall (2006) reported that ripe banana contain carotenoids such as lutein, α- carotene and β carotene. Besides this, it contributes to high amount of carbohydrates, fibre, vitamins and minerals and are low in fat. It is also rich in phytochemicals, unsaturated fatty acids and sterols. Edible portion of banana contain 75 per cent water, 85 kcal, 1.1 per cent protein, 0.2 per cent fat and 12.6 per cent carbohydrate.

Banana is found to be very rich in micro and macro nutrients. Phosphorus and manganese are found to be more concentrated in the ripe fruit, whereas the unripe fruit contains high amount of calcium and selenium. Aspartic acid, glutamic acid and leucine are the major amino acids in the ripe fruit (Barthakur and Arnold, 1990). Minerals present in the banana fruit are magnesium, iron, potassium, zinc, copper, phosphorus, aluminium, sodium, nitrogen and manganese (Offem and Njoku, 1993). Hundred grams of ripe banana provid approximately 116 kcal and it is also used as a supplementary staple food in daily diet (Kumar *et al.*, 2012). Pareek (2016) reported that banana is rich in potassium and low in sodium, and also contains other minerals such as iron, copper, zinc and calcium.

Banana peel contain high amount of carbohydrate (59 %), protein (6 - 9 %), fat (3.8 – 11 %), fibre (43.2 - 49.7 %) and starch (3 %) and it is also rich in polyunsaturated fatty acids like linoleic acid and alpha linolenic acid (Emaga *et al.*, 2007). Inflorescences are discarded parts in banana field. The inflorescences are mainly known as navels and it is considered as a nutritive supplement based on their high content of potassium and fibre (Fingolo *et al.*, 2012).

2.2. Uses of banana in human diet

Banana is well known for its high therapeutic value. They have soothing effect on the intestinal wall that helps to treat gastric ulcers, infant diarrhoea, celiac disease and colitis (Bhaskar, 2000). Plantain fruit act as laxative and it is used for children during constipation (Rai, 2000). Banana is rich in potassium, and low in sodium and hence beneficial for patients with high blood pressure and cardio vascular diseases (Pareek, 2016)

Banana is rich in non-digestable fibres including cellulose, hemicelluloses and α-glucans. It help to restore normal bowel activity, prevent constipation and diarrheoa, and normalize colon's function and aids in regular bowel movement (Kumar *et al.*, 2012). The author also indicated that all types of banana contain fructo oligosaccharide, which is a probiotic that nourishes friendly bacteria in the colon. Banana peel has high fibre content and it is suitable for the growth of the probiotic bacteria and helps for better immune function (Gonzalez *et al.*, 2010).

Boss and Mithra (1990) reported that 24 bananas each weighing 100 grams can provide energy for a sedentary worker. Banana peels contain soluble and insoluble fibre, which help in reducing the level of bad cholesterol there by prevents atherosclerosis (Subalgo *et al.*, 2001).

Ghoel *et al.* (1986) reported that pectin and other soluble fibers are present in banana and it act as antidiarrhoeal component. The author observed antiulcerogenic property on oral administration of banana pulp powder (0.5 mg/kg)).

According to Kumar *et al.* (2012) consuming bananas, oranges, and orange juice in the first two years of life may reduce the risk of developing childhood leukemia. As a good source of vitamin C, bananas can help to combat the formation of free radicals known to cause cancer. High fibre intake from fruits and vegetables like bananas are associated with a lowered risk of colorectal cancer.

Banana is rich in potassium and hence helps to maintain fluid levels in the body and regulate the movement of nutrients and waste products in and out of cells. Banana peel is the richest source of antioxidants and hence helps in prevention of chronic disease like cancer, diabetes, atherosclerosis and also viral infections (Huang and Shen, 2012).

2.3. Importance of Cavendish banana

Cavendish banana is a special banana cultivar belonging to the Cavendish subgroup of the AAA cultivar group. The important cultivars are Dwarf Cavendish, Robusta and Grand Naine (Pedro *et al.,* 2003).

Grand Naine banana has become one of the most popular varieties for commercial plantations. They are of medium height and yields large fruits and hence ideal for commercial agriculture (Martin, 2008)

The Cavendish variety, Grand Naine is a high yielding variety introduced in India from Israel that produces bunches having 10-12 hands with 175-225 numbers of fruits, which is higher than other native varieties. Voldeck (2010) reported that Grand Naine banana is the most popular variety and is commonly grown in tropical regions of Central America, India and South Asia. *Musa cavendishii* (AAA Group) also

called as dessert banana is sweeter and less starchy than *Musa paradisiacal* and it is called as true banana.

Vanilarasu and Balakrishnamurthy (2014) reported that Grand Naine banana contain a TSS of (23.23 per cent), total sugar and non reducing sugars of 14.92 and 6.06 per cent content repectively with an ascorbic acid content of 12 -92 $mg/100g^{-1}$.

Ditchfield (2004) observed that during first stage of ripening, Grand Naine banana has a pH of 5.3, soluble solids (3.5 %) titrable acidity (0.37g/100g), total solids (33.3%) and firmness (25.8). Green dwarf banana flour produce protective effects on the intestinal inflammation and act as a probiotic.

Bezerra *et al.* (2013) reported that green banana with peel are good source of fibre and resistant starch with a content of 21.91 g/100g and 68.02 g/100g respectively.

The application of compost and biofertilizer, enriched with beneficial microorganisms in Cavendish banana provides sweeter fruits due to higher contents of reducing and total sugars and vitamin C (Ovando, *et al.,* 2012).

Kanazawa and Sakakibara (2002) reported that dopamine is an antioxidant that is identified in the Cavendish bananas. Bananas contain dopamine at high levels in both the peel and pulp. Dopamine levels ranged from 80 - 560 mg per 100 g in peel and 2.5 – 10 mg in pulp, even in ripened ready to eat bananas.

Tripathi *et al.* (1981) reported that ripe robusta banana had a TSS of 21.0° Brix, 0.45 per cent of titrable acidity and 20.3 per cent total sugars. Thippana and Tiwari (2015) compared the physico – chemical parameters of Robusta banana. Robusta banana had a moisture content of 73.05 per cent, total solids of 26.5 per cent, TSS of 21.0° brix, acidity of 0.45 per cent, reducing sugar of 14.1 per cent and total sugar content of 20.3 per cent.

2.4. Product development from banana

Banana is a highly perishable fruit due to its high moisture content. Post harvest losses in banana can be reduced by applying appropriate processing technique and converting them into semi-perishable product. Cost effective processing techniques help firmness in fetching a better price for the product (Patil and Rawale, 2009).

Banana products can be divided roughly into two types - those for direct consumption, such as figs, and those for use in food manufacturing industry, like example purees and powder (Viswanath and Venugopal, 2016).The main commercial value added products made from bananas are canned or frozen puree, dried figs, banana powder, flour, flakes, chips (crisps), canned slices and jams.

Banana flour has a great potential for commercialization. It has a high sugar and low starch content and can be used as a substitute for fresh banana in making traditional cakes or their premixes as well as in the processing of banana snacks, crackers or crisps. Selvamani *et al.* (2009) prepared banana flour from fresh mature green bananas, by peeling under water, treating with 0.05% sodium metabisulphite and then slicing to an average thickness of 1cm using sharp knife. The slices were then dried at 50°C for 48hr in air oven.

Viswanath and Venugopal (2016) reported that banana powder is mainly used for confectionary industry, ice cream preparation and baby food formulation and have a shelf life of more than 6 months.

Garcia *et al.* (2006) reported that unripe banana flour contains high amount of total starch (73.4 %), resistant starch (17.5 %) and dietary fibre (14.5 %). Unripe banana flour is rich in resistant starch, dietary fibre and good for colon health. Ripe banana flour contains high amount of iron, calcium, potassium and reducing sugars which helps in better blood circulation (Valencia *et al.*, 2007).

Starch liquefaction procedure has been applied to unripe banana powder to produce maltodextrin and glucose syrup (Perez *et al.*, 2002). This method to eliminate the high starch content and obtain fibre rich powder is used to formulate diverse functional foods.

Fibre rich powder (FRP) is mainly prepared from liquefaction of raw banana flour. It has high total dietary fibre, intermediate total and available starch content and is used as an ingredient for functional foods (Ambriz *et al.*, 2008). Banana flour can be utilized as functional ingredients and potential value added products such as cookies and bread can be prepared (Pragati *et al.*, 2014).

Acevedo *et al.* (2012) formulated cookies with banana flour. It had a high moisture content compared to ordinary cookies because the unripe banana flour contains high fibre content. Unripe banana flour contains less amount rapidly digested starch (RDS) and high amount slowly digestable starch (SDS) and hence it is a nutritional alternative for diabetic and obese patients.

Garcia, *et al.* (2006) substituted wheat flour with banana flour for preparing bread. The banana flour bread contained high resistant starch (6.7 %), dietary fibre (5.1%) and indigestible fraction (22.3%) content than commercial available bread. The banana flour had low glycaemic index (64) compared to other bakery bread (78) thus it is used as dietary aid by people with special low calorie requirements (Garcia *et al.*, 2006).

Banana is a starchy food that contains a high proportion of indigestible compounds such as resistant starch and non starch polysaccharides. Products with low glyceamic response such as pasta from banana flour are considered favorable to health (Tudorica *et al.*, 2002). Pasta product containing banana flour exhibit a low level of carbohydrate and has low glycaemic index and also increased levels of indigestible compounds (resistant starch and non – starch polysaccharide) that may be beneficial for intestinal health. Selvamani *et al.* (2009) revealed pasting behavior of

starch from Indian banana. This pasting behavior of banana is desirable for baby weaning foods, puddings, soups, gravies and non food products like thickener, water binder, emulsifier and stabilizer.

Papad is an oriental snack food made from dough consisting mainly of legumes such as black gram, green gram etc. *Papad* are also made from tapioca, sago, jackfruit, gelatinized rice flour and wheat flour (Arya, 1999). The substitution of unripe banana flour improves dough properties, resistant starch and oil content dspapas (Bhatawale *et al.,* 2012).

Banana chips are wide accepted in Kerala as a tasty snack item. Banana chips are prepared from mainly from "Nendran". The chips are commonly consumed by people in South India. Sonia (2014) reported that addition of banana peel was effective in improving quality and storage of banana chips. The unripe peeled Nendran bananas are thinly sliced, immersed in sodium or potassium metabisulphite solution and fried in coconut oil at 180 to 200° C, and dusted with salt, antioxidant and spices.

Elkhalifa *et al.* (2014) analysed the quality and acceptability of baked and fried banana chips. The banana chips were found to be a source of energy and minerals such as potassium, phosphorus. The fried chips were found to be of better quality and acceptability compared to baked banana chips.

Generally banana chips have storage life of 30 – 35 days under ambient condition and packing the chips in laminated pouches with nitrogen gas can extend its shelf life upto 4 months. Several other varieties of banana chips like flavoured, sweet, sweet and sour, flavoured with pepper etc is also catching up in the market (Bornare *et al.,* 2014).

Jam is made commercially, by boiling equal quantities of fruit and sugar with water and lemon juice, lime juice or citric acid, until setting point is reached. Banana

with sweet taste, fine flavour and texture can be processed into excellent jam. Banana puree have total soluble solid and pH value in the range of 24-26° Brix and 4.4- 4.6 respectively. The proportion of banana puree, sugar, pectin and citric acid used in the processing of banana jam produce a clear and fine textured jam with a good shelf life (Rethinam, 2008).

Banana fruit bar is a confectionary item prepared from ripe banana fruit of any variety. It is made by homogenizing banana pulp, sugar, citric acid and pectin in a suitable proportion and dehydrating the mass at 70^0C in an oven till it sets into a sheet. It is then cut into suitable size and packed in polyethylene pouches (Vagadia *et al.*, 2014).

Banana wine is produced by fermenting the enzyme treated clear banana juice with wine yeast *Saccharomyces cerevisiae var ellipsoideus.* The fermentation is carried out for about 14 days at 24 - 26^0C and the wine is filtered, clarified, bottled and pasteurized. The pasteurized wine is kept in bottles for aging. The alcohol content of banana wine varies from 9-12 per cent (Rethinam, 2008).

The weaning period is a crucial period in an infant's life. At the age of 5–6 months, most infants begin to take supplementary semisolid foods. At this stage homogenized infant foods play a major role in their nutrition (Martinez *et al.*, 2004). Twum (2014) revealed that banana composite flour is an ideal for weaning babies and infants because it contain high amount of minerals such as calcium, potassium and iron etc. Formulation of banana composite flour requires minimal infrastructure and the technology involved is quite simple for preparing in ordinary households. In kerala traditional weaning foods are prepared using flour from unripe fruits of 'Kunnan' and 'Nendran' varieties.

Health drink and baby food developed using banana flour/powder after supplementing with suitable natural sources of protein, minerals, vitamins and fat had a better shelf life of about 6 months and is suitable for children and adults (Rethinam,

2008). The instant porridges substituted with pregelatinized banana flour for brown rice flour improved the content of dietary fibre, resistant starch and enhanced its antioxidant activities. Pregelatinized banana flour has the potential to be used for producing functional instant porridge (Loypimai and Moongngarm, 2015).

Swami and Naik (2011) formulated *Soyamusa,* which is a plantain, based baby food consisting of 60 per cent plantain flour, 32 per cent soyabean grit and 8 per cent sugar.

Tannis (2011) stated that raw green bananas, is a form of probiotic because it contain resistant starch which help for probiotic bacteria to survive the acidic environment of the stomach so that they can reach the small and large intestine. Sharon *et al.* (2015) conducted a study to develop a banana based probiotic fermented food mixture involving *Lactobacillus acidophilus*. The result revealed that banana flour is a good substrate for developing a probiotic food with a total viable count of *L. acidophilus* ranging from 9.13 to 9.45 log cfu g^{-1}. The viable count of *L. acidophilus* in the developed probiotic food mixtures was within the recommended level of probiotic organism to assure health benefits.

Bornare *et al.* (2015) reported that banana fruit candy is mainly made from nendran banana and by adding jaggery and ginger. It is then subjected to osmotic dehydration and followed by sun during and is mainly prepared in Kerala state..

Tenbrink *et al.* (2009) reported that ripe bananas are crushed, with or without water, and the puree is preserved for use in bakery products, production of smoothie or dried powder. This also acts as a potassium supplement to the mixed fruit smoothie.

Accoring to Mishra *et al.* (2001) banana juice which is low in protein is fortified with protein source like whey protein powder or concentrate and used in the preparation of unfermented fortified beverage. Banana pectin on esterification has the ability to

improve the functional properties of whey protein by the improved pectin-protein bonding.

Banana fibre is extracted from the dried petioles and pseudostem of the banana plant. The banana fibre can be used in the preparation of special kind of papers, ropes, threads, baskets, toys and several utility fancy items (NRCB, 2006)

2.4.1. Product development from Cavendish banana

The Grand Naine Bananas (also spelled Grande Naine) literally translates from French meaning "Large Dwarf." It is a cultivar of the well known Cavendish bananas. (Ploetz, 2007).

According to Patel *et al.* (2015) Grand Naine is a commercial cultivar of banana and give higher quality production. Blended jam was standardized using banana (*Musa paradisiaca* L.) cv. Grand Naine and pineapple (*Annanas comosus*) cv. Queen.

Vagadia *et al.* (2016) observed that Grand Naine banana and papaya were suitable for making mixed fruit bar. Banana and papaya based fruit bar prepared with equal proportion had good quality attributes. Fruit bar had good shelf life and could be kept for more than 180 days without affecting the quality attributes.

Chingtham and Banik (2014) prepared banana puree with different banana varieties like *Martaman, Grand Naine* and *Kathali*. Blanching of banana is effective for preparing banana puree.

Mary (2005) reported that good quality spray dried ripe robusta banana powder could be obtained with an inlet air temperature of 150°C, keeping the outlet temperature at 100°C with two per cent maltodextrin and three per cent soluble starch on wet basis as additives.

Ranjitha *et al.* (2015) reported that unpasteurized robusta banana juice diluted in 2:1 ratio can be used for improving the sensory quality of banana wine as

compared to wines from pulp, pasteurized and natural juice. Wine prepared from Robusta had an alcohol content of 11.67 per cent, total acidity of 0.75 per cent and of volatile acidity of 0.04%.

Santo *et al.* (2012) formulated yoghurt with apple, banana (Cavendish variety) and passion fruit by using different probiotic strains. The fruit fibres can improve the fatty acid profile of probiotic yoghurt and hence suitable for new innovative fermented dairy products.

Banana figs are dried banana fruits, with a sticky consistency and sweet taste. Fully ripe banana fruits of variety Dwarf Cavendish are mainly used for this product. The ripe bananas are peeled, treated with 0.1% potassium metabisulphite solution and dried either in sun or oven at 50°C. These figs are packed in polyethylene bags. They have a shelf life of about 3-4 months under ambient condition (Rethinam, 2008).

Cavendish banana smoothies are blended beverages mainly from fresh fruit, milk, yoghurt, ice, honey or syrup and have a milk shake like consistency (Brown, 2005).

Banana flour has been incorporated into various products such as flakes (Ruales *et al.,* 1990), slowly digestible cookies (Saguilan *et al.,* 2007), mayonnaise (Izidoro *et al.*, 2007)

Ruales *et al.* (1990) formulated flakes with the combination of dehulled soyabean and banana pulp by using drum drier. The protein content of banana – soy flake (22 %), was suitable for children between 7 and 10 years of age.

Saguilan *et al.* (2007) formulated cookies with incorporation of cavendish banana flour and wheat flour by the addition of resistant starch powder from banana starch. The use of nutraceutical ingredients may be useful in the development of new products for population sectors with reduced caloric and glyceamic requirements.

Thippana and Tiwari (2015) conducted a study on the osmotic pre treatment of banana. The slice with 60°Brix sugar syrup for 24 hour was best for robusta banana.

2.5. Storage studies of banana products

Stover and Simmonds (1987) reported that shelf life of plantain chips is reduced when exposed to light, moisture and air, hence chips must be packed in moisture proof bags to prevent absorption and loss of crispness. Roopa *et al.* (2006) studied the shelf life of nendran banana chips packed in different packing materials. Packing using polyethylene and polypropylene were acceptable for 3 months whereas nylon – polypropylene, metalized polyester were acceptable upto 4 months under ambient condition.

Sonia *et al.* (2015) reported that incorporation of 0.02% fresh banana peel to frying oil at smoke point of 165^0C and storing in laminated pouches ensures shelf life of three months to Nendran banana chips. Banana peel treated chips packed in laminated pouches showed low moisture 6.83%, FFA value 5.79 mg KOH/g, peroxide value 8.13 meq. O2/ kg highest iodine value 9.22 yellowness index 108.54 and a crispiness of 4.10 parameters throughout storage period.

Sandhu and Bawa (1993) found that the banana chips packed in aluminum foil of 0.02 mm thickness had very good acceptability even after 90 days of storage under ambient conditions, while the chips stored in polyethylene (100 μm) remained acceptable upto 60 days under similar conditions of storage. Manikantan *et al.* (2012) says that polypropylene based nanocomposite food packaging films has applicability in other high value food products.

According to Lakshmy (2003) the moisture content of banana flour varied from 5.40 per cent at the initial stage and 7.7 per cent during the third month of storage. Adeniji (2005) reported that Nendran banana chips can be stored for six months with adequate packaging in dark cupboard in the absence of light.

Mary (2005) reported that Banana fruit powder stored in vaccum packing reduced the moisture content and non – enzymatic browing. Banana RTS beverage were successfully stored upto six months under ambient condition.

Adams *et al.* (2017) applied different packaging technology to robusta banana fruit. The perforated punnet was better for packaging banana to reduce the rate of ripening and increased the shelf life.

Ripe banana slices are dehydrated by using sulphur fumigation @ 2g/kg for 2 h followed by soaking in 60°Brix sugar syrup (1:2 w/v) + 0.1% KMS + 0.1%citrate + 0.2% ascorbic acid which gave better colour, appearance, flavour, texture, taste and overall acceptability and it was stored for 6 months under ambient condition without any adverse effect on quality (Chavan *et al.*, 2010).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled Nutritional and organoleptic qualities of value added products from banana cv. *Musa* (AAA Group) 'Grand Naine' comprises of

3.1. Collection of raw ingredients

3.2. Selection of judges for acceptability

3.3. Preparation of primary product - Grand Naine chips

3.3.1. Physical analysis

3.3.2. Organoleptic evaluation

3.3.3. Keeping quality

3.4. Standardisation of Grand Naine banana flour

3.4.1. Organoleptic evaluation of banana flour

3.4.2. Physico-functional properties of flour

3.4.3. Biochemical and nutritional properties of flour

3.4.4. Keeping quality

3.5. Standardisation of secondary product – *payasam ada*

3.5.1. Organoleptic qualities of the products

3.5.2. Keeping quality

3.6. Cost of production

3.7 Statistical analysis

3.1. Collection of raw ingredients

Fully matured unripe Grand Naine bananas were collected from the Banana Research Station, Kannara and demonstration farm of Centre for Plant biotechnology and Molecular biology (CPBMB), Kerala Agricultural University. All other ingredients required for the study were purchased from the local market.

3.2. Selection of judges for acceptability studies

A series of acceptability trials were carried out using a simple triangle test as suggested by Jellinek (1985) to select a panel of 15 judges.

3.3. Preparation of primary product Grand Naine chips

Fully mature unripe banana was washed in clean water, peeled manually and dipped in turmeric water. The fruits were sliced into uniform size of 2 mm thickness. After slicing they were divided into two lots and were fried in refined oil. One lot was salted and other was salted and spiced (3g pepper powder/100g) Plate 1.

3.3.1. Physical analysis

The prepared Grand Naine chips were physically analysed for the following constituents by standard procedures (Ranganna, 1995)

3.3.1.1. Frying time

The Grand Naine banana slices were dried to a moisture content of 75 per cent and then the frying time was determined as the time required to obtain 4 per cent moisture content in fried chips.

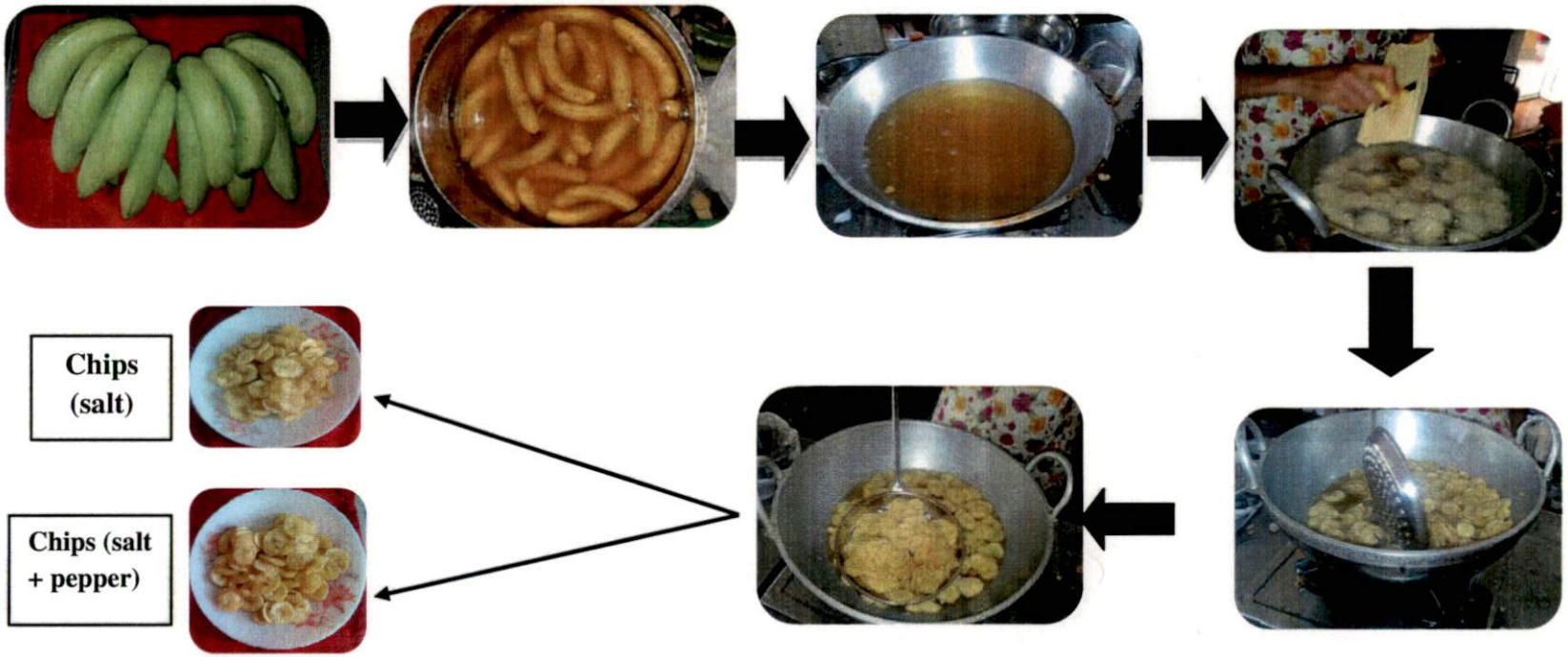

Plate 1. Preparation of Grand Naine banana chips

3.3.1.2. Oil content

Oil content in the fried chips was calculated as follows and is expressed in per centage

$$\text{Per cent oil content} = \frac{\text{Weight of oil}}{\text{Weight of sample}} \times 100$$

3.3.1.3. Product recovery

Weight of fried chips prepared from 50g fresh banana slices, were recorded in an electronic balance and product recovery was calculated

$$\text{Product recovery (\%)} = \frac{\text{Weight of chips after frying (g)}}{\text{Weight of raw banana slices before frying}} \times 100$$

3.3.2. Organoleptic evaluation

The chips were evaluated for organoleptic qualities such as appearance, colour, flavour, texture, taste, crispiness and overall acceptability with the panel of selected judges using nine point hedonic scale.

3.3.3. Keeping quality

The prepared chips were packed (200g/packet) in polyethylene bags (250 gauge) and laminated pouches and were stored for one month. The organoleptic qualities, peroxide value and moisture content were evaluated initially and at an interval of 10 days for one month (Plate 2).

T_1 (Chips [salt] packed in polyethylene bags)

T_2 (Chips[salt + pepper] packed in polyethylene bags)

T_3(Chips [salt]packed in laminated pouches)

T_4 (Chips [salt + pepper] packed in laminated pouches)

Plate 2. Keeping quality of Grand Naine banana chips

3.3.3.1. Moisture

Moisture content of chips was estimated by the method of A.O.A.C (1980). To determine the moisture content of the products, five gram of sample was taken in a petridish and dried at 60^0c to 70^0c in a hot air oven, cooled in a desiccator and weighed. The process of heating and cooling was repeated till constant weight was achieved. The moisture content of the sample was calculated from the loss in weight during drying. Moisture content of the chips stored in polyethylene bags and laminated pouches were analysed at 10 days interval for one month.

$$\text{Moisture content (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

3.3.3.2. Peroxide value

Peroxide values of chips were estimated to find the rate of rancidity during storage. It was estimated by the procedure given by Sadasivam and Manickam (1992). One gram of extracted oil sample was taken in a boiling tube and to that one gram of potassium iodide and 20 ml solvent mixture (glacial acetic acid and chloroform) were added. The tube was placed in boiling water for 30 seconds and the contents were transfered to a conical flask containing 20 ml of 5 per cent potassium iodide solution. The tubes were washed twice with 25 ml water and collected in a conical flask. This was titrated against N/500 sodium thiosulphate solution until yellow colour disappears. Later 0.5ml of starch solution was added and titrated till the appearance of blue colour. A blank solution was also prepared and peroxide value was calculated and expressed in milliequivalent per kg of the sample.

3.4. Standardisation of Grand Naine banana flour

The fresh mature green bananas were peeled under water and dipped in a solution of ascorbic acid and citric acid for two time periods as detailed below (Table 1 and plate 3)

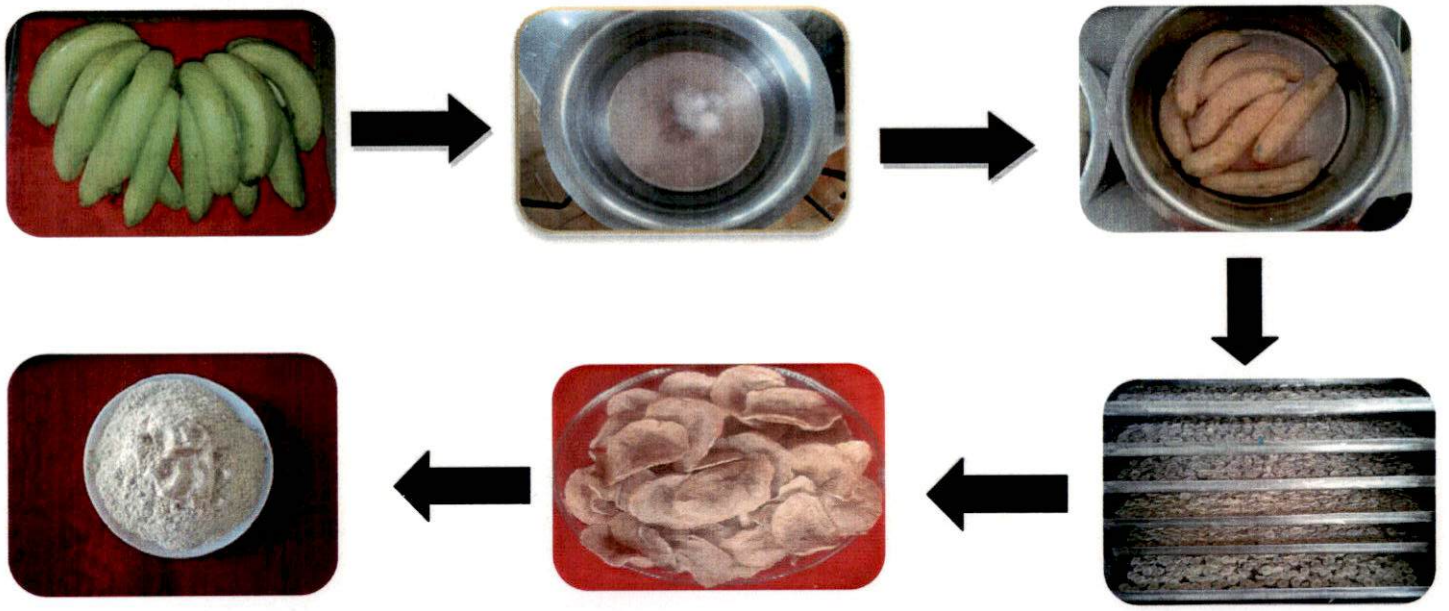

Plate 3. Preparation of Grand Naine banana flour

Table 1. Composition and immersion time of various pre treatment media

Sl. No	Treatments	Particulars	Time (min)
	T_0	Without pre treatment	-
1	T_1	0.5 % AA + 0.1 % CA	5
2	T_2	0.5 % AA + 0.1 % CA	10
3	T_3	0.5 % AA+ 0.2 % CA	5
4	T_4	0.5 % AA + 0.2 % CA	10
5	T_5	1.0 % AA + 0.1 % CA	5
6	T_6	1.0 % AA + 0.1 % CA	10
7	T_7	1.0 % AA + 0.2 % CA	5
8	T_8	1.0 % AA + 0.2 % CA	10
9	T_9	1.5 % AA + 0.1 % CA	5
10	T_{10}	1.5 % AA + 0.1 % CA	10
11	T_{11}	1.5 % AA + 0.2 % CA	5
12	T_{12}	1.5 % AA + 0.2 % CA	10

(AA – Ascorbic acid, CA – Citric acid)

After pre treatment it was sliced to an average thickness of 1 cm. The slices were dried at 50°c for 48 hrs in hot air oven. The dried chips were ground and sieved to get an uniform flour.

3.4.1 Organoleptic evaluation of banana flour

Porridge was prepared using banana flour, adopting the standard procedure by Thajudeen (2000) and was organoleptically evaluated.

Organoleptic qualities such as appearance, colour, flavour, texture and taste were evaluated by the selected panel of judges using the nine point hedonic scale. Based on the organoleptic scores, the best treatment was selected for further studies.

The overall acceptability of flour was evaluated and the best treatment was selected for further studies.

The prepared flour was stored in polyethylene bags (250 gauge) for three months under ambient condition (Plate 4)

3.4.2 Physico – functional properties of flour

The flour was evaluated initially and at monthly interval for three months. Properties such as pH, moisture, water holding capacity, oil absorption capacity and bulk density were analysed using standard procedures

3.4.2.1 pH

pH was determined using pH paper (Ranganna, 1995). Sample (5g) was weighed in a beaker containing 25 ml distilled water. It was allowed to stand for 30 minutes with constant stirring. pH was determined using pH paper.

3.4.2.2 Moisture

The procedure is already mentioned in 3.3.3.1

3.4.2.3 Water holding capacity

Water holding capacity of the banana flour was calculated using the standard procedure (Ranganna, 1995). About 2.5g of the flour sample was suspended in 30 ml of distilled water in a centrifuge tube. It was then intermittently stirred for 30 minutes and was centrifuged at 3000 rpm for 10 minutes. The sediments were weighed after complete removal of supernatant.

Water holding capacity = Weight of the sediment – Weight of the raw sample

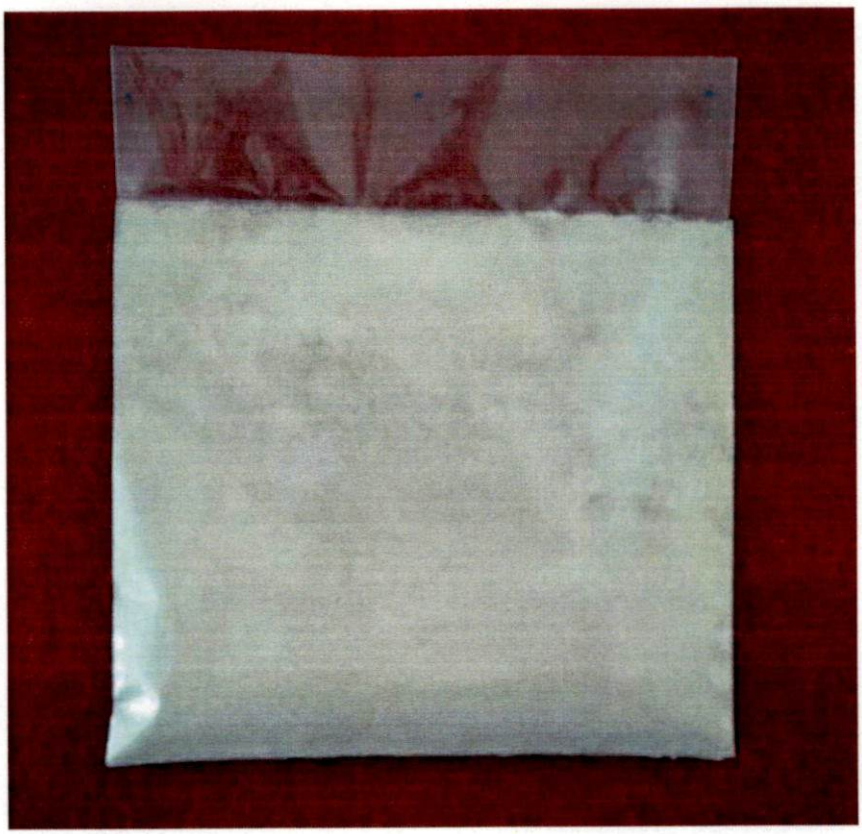

Plate 4. Grand Naine banana flour packed in polyethylene bags (250 gauge)

3.4.2.4 Oil absorption capacity

Oil absorption capacity is the quantity of oil added to the sample by a known volume of supernatant. The standard procedure given by Ranganna (1995) was used to determine oil absorption capacity. One gram sample was mixed with 10 ml of oil for 30 seconds. The sample was allowed to stand at room temperature for 30 minutes. It was then centrifuged at 3000 rpm for 30 minutes. The volume of supernatant was noted in a 10 ml graduated cylinder.

Oil absorption capacity = Initial volume of oil added to the sample – Volume of the supernatant

3.4.2.5 Bulk density

Bulk density is the ratio of the weight of the sample to the weight of an equal volume of water. Bulk density is used as an index for comparing the volume of different foods. The sample was taken at a height of 20 cm in a 50 ml beaker. It was levelled without compressing. The weight of the sample was removed from the beaker and water was filled to the same level of 20 cm. Weight of the water with beaker was recorded and calculated using the formula.

$$\text{Bulk density} = \frac{\text{Weight of the sample}}{\text{Weight of the equal volume of water}}$$

3.4.3 Biochemical and nutritional properties of flour

The banana flour was analysed for TSS, total sugar, starch, protein, fibre, calcium, phosphorus, iron, potassium, *in vitro* digestability of starch, *in vitro* availability of calcium, iron, zinc and phosphorus was calculated initially and at the end of the storage.

3.4.3.1 Total soluble solids

Total soluble solids in banana flour were recorded using hand refractometer (range 0 - 35°brix) at room temperature and the values were expressed in degree brix.

3.4.3.3 Reducing sugar

Reducing sugar was determined by using standard procedure (Ranganna, 1986). To 25 g of the sample, 100ml distilled water was added. It was clarified with neutral lead acetate. The excess lead was removed by adding potassium oxalate and was made up to 250 ml. Aliquot of the solution was titrated against a mixture of Fehlings solution A and B using methylene blue as indicator. The reducing sugar was expressed as percentage.

3.4.3.2 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 neutralised with sodium hydroxide and the volume was made upto 250 ml. An aliquot of this solution was titrated against fehlings solution A and B. The total sugar content was expressed as percentage.

3.4.3.4 Starch

The starch content was estimated colorimetrically using anthtrone reagent as suggested by Sadasivam and Manickam (1992). Sample (0.5g) was extracted with hot 80 per cent ethanol to remove sugar completely. Centrifuged and retained the residue washes with residue repeatedly with hot 80 per cent ethanol. Dried the residue well over a water bath. To the residue, added 5 ml of water and 6.5 ml of 52 per cent perchloric acid extract at 0°c for 20 minutes centrifuged and saved the supernatant.

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Repeated the extraction using perchloric acid centrifuge and cooled the supernatant and maked up to 100 ml. Pipetted out 0.1 ml or 0.2 ml of the supernatant and make up to the volume to 1 ml with water. Prepare the standards by taking 0.2, 0.4, 0.6, 0.8 and 1 ml of the working standard and maked up the volume to 1 ml in each tube with water. Added 4 ml of anthrone reagent to each tube. Heated for eight minutes in a boiling water bath. Cooled rapidly and read the intensity of green to dark colour at 630nm.

A standard graph was prepared using serial dilution of standard glucose solution. From the graph, glucose content of the sample was obtained.

3.4.3.5 Protein

The protein content was estimated by using method of AOAC (1980). The sample was digested with 6ml con.H_2SO_4 after adding 0.4g of $CuSO_4$ and 3.5g K_2SO_4 in a digestion flask, until the color of the sample changed. After digestion added 25 ml of 40 percent NaOH was pumper. The distillate was collected in 2 per cent boric acid containing mixed indicators and titrated with 0.2N HCl to determine the nitrogen content. The nitrogen content obtained was multiplied with factor of 6.25 to get the protein content and was expressed in grams.

3.4.3.6 Fibre

The crude fibre of products was estimated using method given by Sadasivam and Manickam (1992). Two grams of dried and powdered sample was boiled with 200ml of 1.25 per cent sulphuric acid for 30 minutes. It was filtered using muslin cloth and washed with boiling water. The residue was again boiled with 200ml of 1.25 per cent of sodium hydroxide for 30 minutes. Repeated the filtration through muslin cloth and residue was washed with 25ml of boiling 1.25% of sulphuric acid, three 50 ml portion of water and 25ml of alcohol. Then obtained residue was taken in ashing dish (W_1) dried at 130^0c for 2 hours, cooled the dish in a desiccator and

weighed (W_2). The residue was again ignited in muffle furnace at 600^0c for 30 minutes, cooled in a desiccator and reweighed (W_3).

Crude fibre in ground sample (%):

$$\frac{\text{Loss in weight on ignition (W2 – W1) – (W3 – W1)}}{\text{Weight of the sample}} \times 100$$

3.4.3.7 Calcium

Calcium content was estimated using titration method with EDTA suggested by Perkin-Elmer (1982). One gram of dried powdered sample was predigested with 10 ml of 9:4 mixtures of nitric acid and perchloric acid and volume was made up to 100 ml. diacid extract Five ml, 10 ml water, 10 drops of hydroxylamine hydrochloride, 10 ml triethanolamine, 2.5 ml sodium hydroxide and 10 drops of calcone were added. Then it was titrated with 0.02 N EDTA until the apperaence of permanent blue colour. Calcium content was expressed in mg $100g^{-1}$ of the sample.

3.4.3.8 Phosphorus

The method suggested by Jackson (1973) was followed Phosphorus content was estimated colorimetrically which gives yellow colour with nitric acid and vandate molybdate reagent.

One gram sample was pre-digested with 12 ml of 9:4 diacid and volume made up to 100 ml. To the five ml of predigested aliquot, five ml of nitric acid, vandate molybdate reagent was added in to the volumetric flask and made upto 50 ml with distilled water. After 10 minutes the optical density was red at 470nm. A standard graph was prepared using serial dilution of standard phosphorus solution. The phosphorus content was expressed in mg $100g^{-1}$.

3.4.3.9 Iron

The iron content of products was estimated using Atomic Absorption Spectrophotometric method using diacid extract prepared from the sample (Perkin – Elmer 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100ml and used directly in Atomic Absorption Spectrophotometer for the estimation of iron and expressed in mg per 100 g of the sample.

3.4.3.10 Potassium

The potassium content of products was assessed in an Atomic absorption Spectrophotometer using diacid extract prepared from the sample (Perkin – Elmer 1982). One gram of the sample was predigested with 10ml of 9:4 mixtures of nitric acid and perchloric acid and made up to 100ml and used directly in Atomic Absorption Spectrophotometer for the estimation of potassium and expressed in mg per 100 g of the sample.

3.4.3.11 *In vitro* digestibility of starch

One gram of sample in 100 ml water was gelatinized and boiled for one hour and filtered. One ml of the gelatinized solution was taken and one ml of the enzyme solution (saliva diluted with equal quantity water). The mixture was incubated at 37°c for 1-2 hours; the reaction was stopped by adding one ml of sodium hydroxide. Later the glucose was estimated.

3.4.3.12 *In vitro* availability of minerals

HCl extractability

The sample was extracted with 0.03N hydrochloric acid by shaking the contents at 37°C for 3 hours. The clear extract obtained after filtration with whatman No.42 filter paper was oven dried at 100°c and wet acid digested. The amount of the

HCl extractable calcium, phosphorus, iron, potassium and zinc in the digested sample were determined by the methods as described for the estimation of minerals.

$$\text{Mineral extractability} = \frac{\text{Mineral extractability in 0.03N HCl}}{\text{Total mineral}} \times 100$$

3.4.4 Keeping qualities

The banana flour was evaluated for the organoleptic qualities and presence of bacteria, yeast and fungi initially and at monthly interval for three months. The method suggested by Agarwal and Hasija (1986) were microbe's serial dilution and plate count method. Ten gram of sample was added to 90 ml of sterile water and shaken for 20 minutes. From that 1 ml of solution was transferred to a test tube containing 9 ml of sterile water to get 10^{-2} dilution and similarly 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions were also prepared. Enumeration of total micro flora was carried out using nutrient agar media for bacteria, Potato dextrose agar media for fungi and Sabouraud's dextrose agar media for yeast. The dilution for bacteria was 10^{-6} and for yeast 10^{-3} and for fungi 10^{-3}.

3.5 Standardisation of secondary product – *Payasam Ada*

Ada preparation was standardised by incorporating the banana flour at different levels with rice flour. The treatments adopted for standardisation are given below (Table 2)

Table 2. Proportions of rice flour and banana flour for preparing *ada*

S.l No	Treatments	Combinations
1	T_0	100% Rice flour (Control)
2	T_1	100% Banana flour
3	T_2	80% Banana flour+ 20% Rice flour
4	T_3	70% Banana flour+ 30% Rice flour
5	T_4	60% Banana flour+ 40% Rice flour
6	T_5	50% Banana flour+ 50% Rice flour

The batter prepared with the flour was used to make *payasam ada* by traditional method. The drying temperature and time for the above treatments were standardised by varying the temperature to 60°C, 65°C and 70°C until it attains a moisture content of 10 per cent.

3.5.1 Organoleptic qualities of the products

Organoleptic evaluations of the prepared ada were conducted by preparing milk based *payasam* and jaggery based *payasam* by the panel of 15 selected judges. The best treatment for milk based *payasam* and jaggery based *payasam* were selected and stored in polyethylene bags (250 gauge) for three months (Plate 5).

3.5.2 Keeping quality

Ada were evaluated for organoleptic qualities, insect infestation and the presence of bacteria, fungi and yeast initially and at monthly intervals for three months

Organoleptic qualities of milk based *payasam* and jaggery *payasam* were evaluated at monthly intervals for three months.

Plate 5. *Payasam ada* packed in polyethylene bags (250 gauge)

3.6 Cost of production

Cost of most acceptable banana chips, banana flour, and selected *payasam ada* were estimated based on the expenses incured for the raw ingredients. The cost of production was computed based on the market price of procured ingredients used for preparation of products. The cost was calculated for 1 kg of the product.

3.7 Statistical analysis of the data

The observations recorded were tabulated and data was analysed by using t test, two factor analysis and Kendall's Coefficient of Concordance (W).

RESULTS

4. RESULTS

The results pertaining to the study entitled, Nutritional and organoleptic qualities of value added products from banana *Musa* (AAA Group) 'Grand Naine' are presented under the following headings.

4.1. Preparation of Grand Naine banana chips

4.1.1. Physical analysis

4.1.2. Organoleptic evaluation

4.1.3. Keeping quality

4.2. Standardisation of Grand Naine banana flour

4.2.1. Organoleptic evaluation of banana flour

4.2.2. Physico – functional properties of selected flour

4.2.3. Biochemical and nutritional properties of flour

4.2.4. Keeping quality of banana flour

4.3. Standarisation of secondary product – *Payasam ada*

4.3.1. Organoleptic qualities of the products

4.3.2. Keeping quality

4.4. Cost of production of selected products

4.1. Preparation of Grand Naine banana chips

Fully mature unripe banana was washed in clean water. It was peeled manually and the fruits were cut into uniform size of 2mm thickness. After slicing they were divided into two lots and were fried in refined oil. The treatment T_1 was prepared by adding salt and T_2 with salt and pepper (3g pepper powder /100g).

4.1.1 Physical analysis of Grand Naine banana chips

The physical analysis like frying time, oil content, moisture content and product recovery of fresh Grand Naine banana chips were analysed.

Physical analysis of freshly prepared Grand Naine chips was carried out using standard procedures and the results are furnished in Table 3.

Table 3. Physical analysis of Grand Naine banana chips

Treatments	Frying time (minutes)	Oil content (%)	Moisture content (g $100g^{-1}$)	Product recovery (%)
T_1	3.2	38.67	2.43	39.86
T_2	3.2	39.74	2.28	39.66
t value	-	0.815^{NS}	4.294^{NS}	0.287^{NS}

T_1 – Salt, T_2 – salt + pepper NS – Non significant

The required frying time of Grand Naine banana chips was 3.2 minutes. The oil content of freshly prepared Grand Naine banana chips was 38.67 and 39.74 per cent for T_1 and T_2 respectively. The oil content of T_1 was lower compared to T_2, but there was no significant difference in oil content among the treatments.

A moisture content of 2.43 g 100 g^{-1} was noticed in T_1, whereas T_2 had a moisture content of 2.28 g 100 g^{-1}. No significant change in moisture content was observed among the treatments.

A slightly higher product recovery of 39.86 per cent was observed in T_1 compared to T_2 (39.66 %). There was no significant change in product recovery between these two treatments.

4.1.2. Organoleptic evaluation of Grand Naine banana chips

The prepared chips were evaluated organoleptically using score card for different quality attributes like appearance, colour, flavour, texture, taste, crispness and overall acceptability. The mean scores obtained for various organoleptic attributes of freshly prepared Grand Naine chips are presented in table 4 and figure 1 and plate 6.

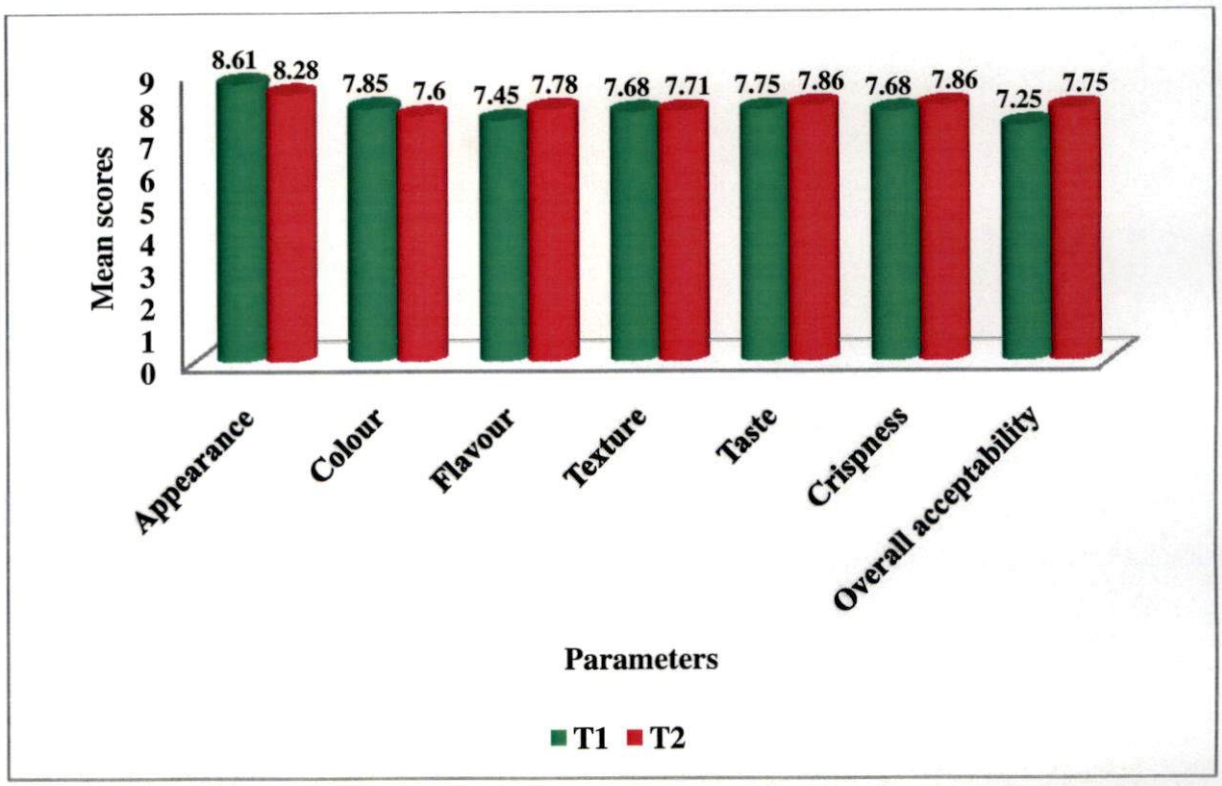


Figure 1. Mean scores obtained for organoleptic qualities of Grand Naine banana chips

Chips (salt)

Chips (salt + pepper)

Plate 6. Grand Naine banana chips

Table 4. Mean scores obtained for organoleptic evaluation of Grand Naine chips

Parameters	T_1	T_2	W
Appearance	8.61 (1.83)	8.28 (1.17)	0.667**
Colour	7.85 (1.67)	7.6 (1.33)	0.152**
Flavour	7.45 (1.10)	7.78 (1.90)	0.800**
Texture	7.68 (1.47)	7.71 (1.53)	0.006*
Taste	7.75 (1.37)	7.86 (1.63)	0.089*
Crispness	7.68 (1.23)	7.86 (1.77)	0.356**
Overall acceptability	7.25 (1.43)	7.75 (1.57)	0.033*
Total score	54.27	54.84	

Values in parentheses are mean rank scores based on Kendall's W which was significant (** significant at 1% level, * significant at 5% level)

Organoleptic evaluation of Grand Naine banana chips was carried out by a panel of fifteen judges using nine point hedonic scale. The results are furnished in Table 4. The different quality attributes were ranked based on their mean scores using Kendall's coefficient (W) test.

A score of 8.61 for appearance was recorded highest for T_2 and a score of 8.28 was obtained for T_1. The mean rank scores for appearance ranged from 1.17 to 1.83.

Among the prepared chips the highest score for colour was recorded for T_1 (7.85) and a score of 7.6 was noticed in T_2 with the mean rank scores from 1.33 to 1.67.

The characteristic flavour of fresh chips had a maximum score of 7.78 for T_2 with a mean score of 7.45 for T_1, and mean rank scores varying from 1.10 to 1.90.

Among two treatments tried for the preparation of Grand Naine chips, the highest mean score for texture was recorded for T_2 (7.71). The mean rank scores for texture ranged from 1.47 to 1.53 for T_1 and T_2 respectively.

The mean scores for taste of Grand Naine chips ranged from 7.75 – 7.86 with highest score for T_2. The low mean score of 7.75 for taste was noticed in T_1. The mean rank scores for taste varied from 1.37 to 1.63.

Among the prepared chips the highest score for crispness was recorded for T_2 (7.86) and T_1 attained a score of 7.68. The mean rank scores for crispness ranged from 1.23 to 1.77.

The treatment T_2 obtained a slightly higher overall acceptability mean score and rank score of 7.75 and 1.57 respectively. The treatment T_1 had a mean score of 7.25 with a mean rank score of 1.43.

The treatment T_2 obtained a slightly higher total score of 54.84 and T_1 had score of 54.27.

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

4.1.3. Keeping quality

4.1.3.1. Peroxide value

The peroxide value of Grand Naine chips and the effect of storage period in polyethylene bags (250 gauge) and laminated pouches are given in table 5 and figure 2.

Table 5. Peroxide value (meq/O_2/kg) of chips

Treatments		Polyethylene bags			Laminated pouches			
	Initial	10^{th} day	20^{th} day	30^{th} day	Treatments	10^{th} day	20^{th} day	30^{th} day
T_1	6.02	8.00	10.03	11.57	T_3	8.13	9.35	11.1
T_2	6.11	7.99	8.22	10.90	T_4	8.173	9.17	9.29

T_1 - Chips [salt] packed in polyethylene bags, T_2 Chips [salt + pepper] packed in polyethylene bags, T_3- Chips [salt] packed in laminated pouches, T_4 - Chips [salt + pepper] packed in laminated pouches

As observed in table 5, the peroxide value increased with storage. An increase in peroxide value was observed among all treatments with a period of storage for 30 days. The initial peroxide value observed was 6.02 meq/O_2/kg and 6.11 meq/O_2/kg for T_1 (salt) and T_2 (salt along with pepper) respectively. Peroxide value was comparatively low in chips flavoured with pepper and packed in laminated pouches (T_4) after the storage period.

On statistical interpretation as given in Appendix II, there was a significant difference in peroxide value with days of storage and type of packaging materials. A low significant difference was observed in chips stored in polyethylene bags

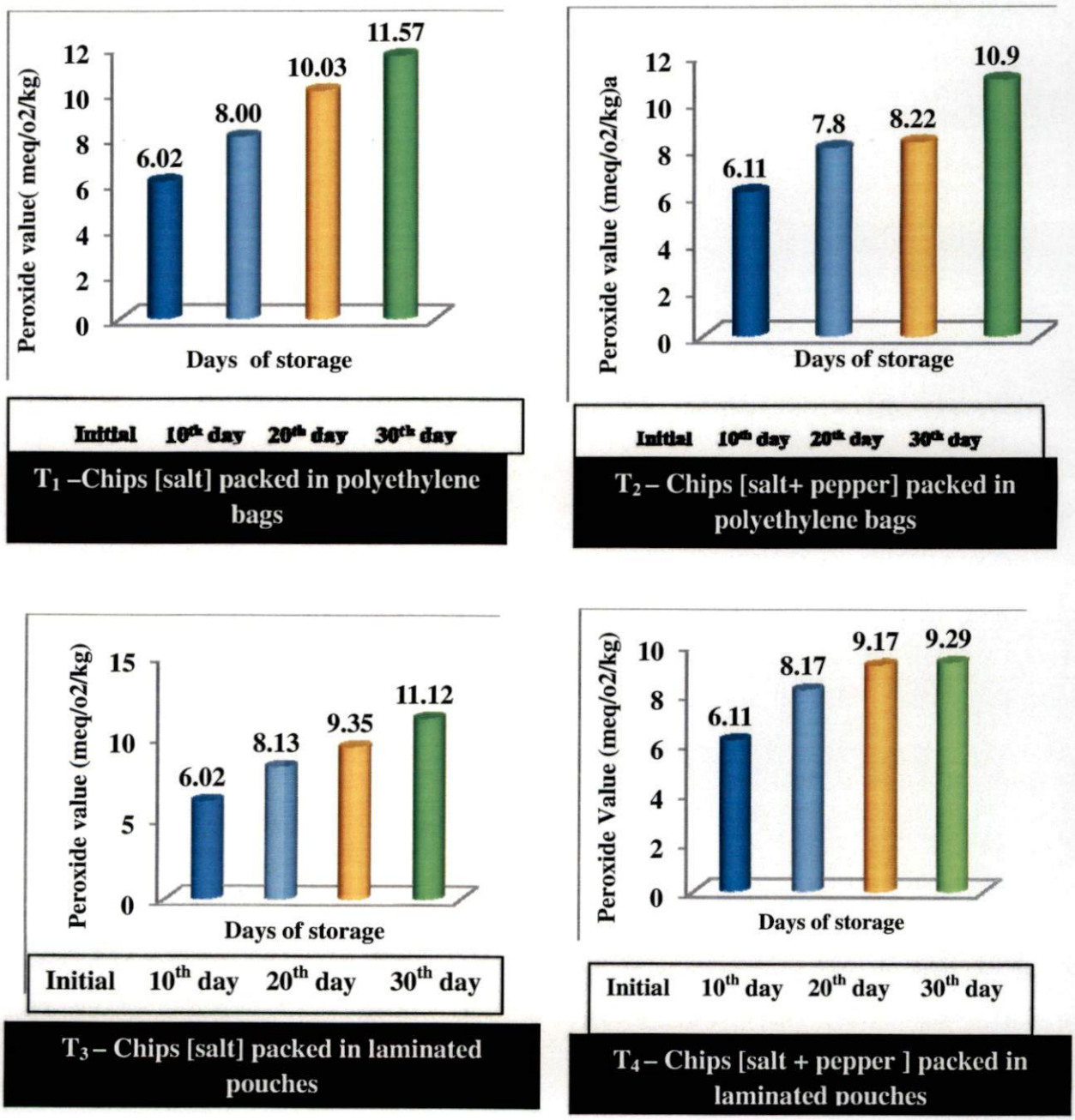


Figure 2. Peroxide value of Grand Naine chips banana chips

compared to laminated pouches. On comparing the treatments by statistical interpretation it was observed that chips flavoured with salt and pepper (T_2 and T_4) had less significant difference with days of storage for peroxide value compared to salted chips (T_1 and T_3).

4.1.3.2. Moisture content

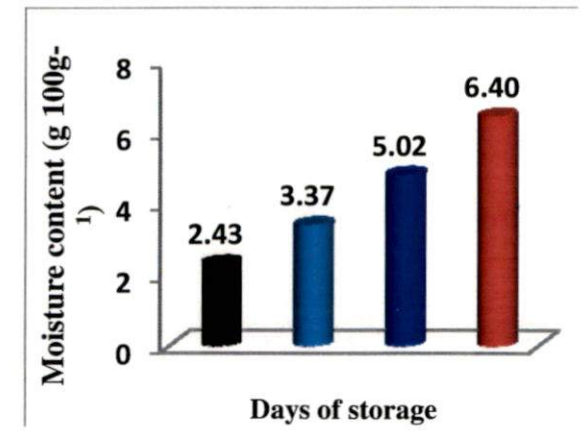
The moisture content of different treatments is given in Table 6 and figure 3.

Table 6. Moisture content of Grand Naine banana chips (g $100g^{-1}$)

		Polyethylene bags				Laminated pouches		
	Initial	**10^{th} day**	**20^{th} day**	**30^{th} day**		**10^{th} day**	**20^{th} day**	**30^{th} day**
T_1	2.43	3.37	5.02	6.40	**T_3**	3.51	4.76	6.38
T_2	2.28	3.06	5.34	5.99	**T_4**	3.44	5.02	5.46

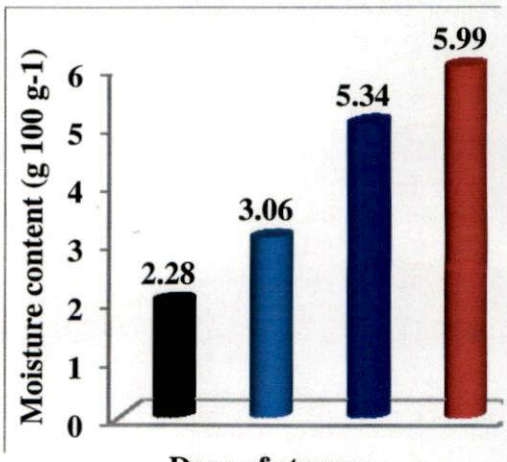
T_1 - Chips [salt] packed in polyethylene bags, T_2 Chips [salt + pepper] packed in polyethylene bags, T_3- Chips [salt] packed in laminated pouches, T_4 - Chips [salt + pepper] packed in laminated pouches

As observed in table 6 and figure 3 the moisture content of chips gradually increased with storage period in both polyethylene bags and laminated pouches. The initial moisture content of salted chips was 2.43 g $100g^{-1}$. After a storage period of 30 days the moisture content increased upto 6.40 g $100g^{-1}$ and 6.38 g $100g^{-1}$ when stored in polyethylene bags and laminated pouches respectively. Chips prepared by adding salt along with pepper had a lower moisture content of 2.28 g $100g^{-1}$ and increased to 5.99 and 5.46 g $100g^{-1}$ when stored in polyethylene bags and laminated pouches respectively. Moisture content was comparatively less in chips prepared by adding salt along with pepper and packed in laminated pouches.



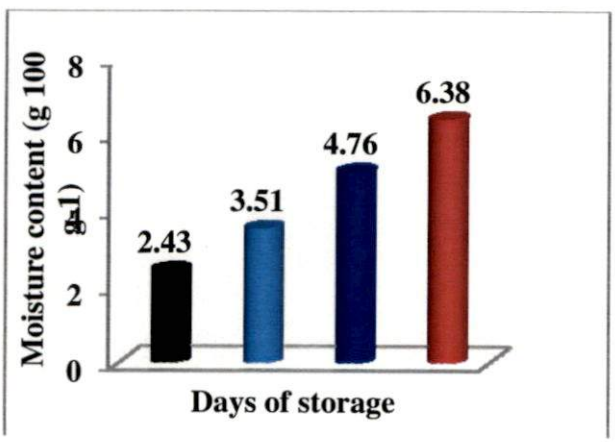
Initial 10th day 20th day 30th day

T_1 –Chips[salt] packed in polyethylene bags



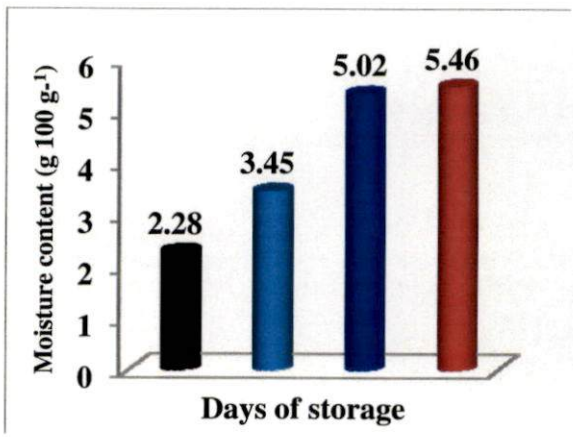
Initial 10th day 20th day 30th day

T_2 – Chips [salt + pepper]packed in polyethylene bags



Initial 10th day 20th day 30th day

T_3 –Chips [salt] packed in laminated pouches



Initial 10th day 20th day 30th day

T_4– Chips [salt + pepper] packed in laminated pouches

Figure 3. Moisture content of Grand Naine banana chips

The data was analysed statistically and is furnished in Appendix II. There was no significant difference during storage of T_2 and T_4 in polyethylene bags and laminated pouches. A significant difference in moisture content was observed with days of storage. A comparatively higher significant difference in moisture content was observed in T_2 and T_4 with days of storage compared to T_1 and T_3.

4.1.3.3. Organoleptic evaluation of stored chips

The prepared chips were stored in polyethylene bags (250 gauge) and laminated pouches and evaluated organoleptically using score card for different quality attributes like appearance, colour, flavour, texture, taste, crispness and overall acceptability. The evaluation was done initially and at an interval of 10 days for a period of one month of storage under ambient condition. Each product was ranked for all these quality attributes based on their mean rank scores.

The mean scores obtained for the organoleptic evaluation of salted and spiced chips for the different quality attributes, stored for a period of 30 days in polyethylene bags and laminated pouches are presented in table 7 and table 8 respectively. The data was statistically interpreted and is presented in Appendix II.

Table 7. Mean scores for organoleptic evaluation of salted chips

Storage period / Character	Polyethylene bags				Laminated pouches		
	Initial	10th day	20th day	30th day	10th day	20th day	30th day
Appearance	8.59	7.83	7.23	6.40	7.80	7.53	7.06
Colour	7.80	7.23	7.18	6.38	7.49	7.11	6.87
Flavour	7.49	7.48	6.87	6.43	7.34	7.07	7.02
Texture	7.67	7.38	6.82	6.43	7.35	7.04	6.87
Taste	7.77	7.33	7.09	6.30	7.33	7.05	6.85
Crispness	7.67	7.59	7.22	6.25	7.60	7.23	6.90
Overall acceptability	7.29	7.28	6.94	6.24	7.20	7.02	6.82
Total score	54.28	52.12	49.35	44.43	52.11	50.05	48.39

Mean score for appearance decreased with storage. Freshly prepared chips had a mean score of 8.59 for appearance which decreased to 6.40 at the end of 30 days of storage in polyethylene bags, whereas packing in laminated pouches attained a score of 7.06 at the end of 30 days of storage.

The colour of salted chips had a maximum initial score of 7.80 and a score of 6.38 on 30th day in polyethylene bag and 6.87 in laminated pouches. A slight increase in mean score for colour was observed in laminated pouches (6.87) when compared to chips packed in polyethylene bags (6.37).

A gradual decrease was observed in the mean score for flavour. The flavour decreased from initial mean score of 7.49 to 6.43 and 7.02 in polyethylene bags and laminated pouches respectively. The mean score for flavor was slightly higher for

chips packed in laminated pouches. A significant reduction in flavour on storage was observed, the reduction was highly significant in polyethylene bags.

Texture of salted chips scored a maximum of 7.67, which decreased to a minimum of 6.43 in polyethylene bags and 6.87 when stored in laminated pouches at the end of one month storage.

The mean score for taste of salted chips was 7.77 during initial stage. A gradual decrease was observed in the mean score for taste during storage in polyethylene bags (6.30) and laminated pouches (6.85). The chips stored in laminated pouches attained a higher score compared to polyethylene bags.

The crispness of salted chips had maximum initial score of 7.67 and a score of 6.25 on 30^{th} day in polyethylene bags and 6.90 in laminated pouches. There was a significant change in crispness of salted chips stored in polyethylene bags and laminated pouches with increase in storage period.

The overall acceptability of salted chips had an initial score of 7.29 and a score of 6.24 and 6.82 on 30^{th} day in polyethylene bags and laminated pouches respectively.

A comparatively high mean score for all organoleptic attributes were observed for chips packed in laminated pouches.

Salted chips packed in laminated pouches attained higher total scores (48.39) for organoleptic attributes compared to chips packed in polyethylene bags (44.43) during third month of storage.

The two factor analysis (Appendix – II) revealed that, there was no significant difference in appearance and texture, when stored in polyethylene bags. A significant change during storage was noticed for all organoleptic attributes, when stored in laminated pouches. A significant change in colour with the type of package was

observed. Chips packed in polyethylene bags had a significant difference in attributes like colour and flavour with days of storage compared to laminated pouches. A significant difference was noticed for crispness and overall acceptability when stored in laminated pouches compared to polyethylene bags.

Table 8. Mean scores for organoleptic qualities of chips prepared by adding salt along with pepper

Storage period / Character	Polyethylene bags				Laminated pouches		
	Initial	10th days	20th days	30th days	10th days	20th days	30th days
Appearance	8.28	7.78	7.44	7.04	7.82	7.64	7.13
Colour	7.61	7.24	7.03	7.11	7.33	7.19	7.15
Flavour	7.74	7.49	7.24	6.88	7.47	7.33	7.25
Texture	7.73	7.31	7.09	6.73	7.34	7.26	7.00
Taste	7.84	7.34	7.15	7.13	7.33	7.32	7.19
Crispness	7.86	7.56	7.29	6.67	7.55	7.44	7.32
Overall acceptability	7.73	7.28	6.81	6.89	7.21	7.20	6.89
Total score	54.79	51.99	50.05	48.45	52.05	51.38	49.93

Mean score for appearance, decreased with storage. Freshly prepared chips had mean score of 8.28, which decreased to 7.04 at the end of 30 days of storage in polyethylene bags. The mean score of 7.13 was noticed for appearance at the end of storage in laminated pouches.

The colour of chips prepared by adding salt along with pepper had a maximum initial score of 7.61 and a score of 7.11 and 7.15 on 30th day in polyethylene bags and in laminated pouches respectively. A significant difference in

colour was observed on storage using both type of packaging materials after 30 days of storage. A slight increase in mean score for colour was observed in laminated pouches (7.15) when compared to polyethylene bags (7.11).

A gradual decrease was observed in the mean score for flavour. The flavour decreased from an initial mean score of 7.74 to 6.88 and 7.25 in polyethylene bags and laminated pouches respectively.

Texture of chips flavoured with salt and pepper scored a maximum 7.73 which is decreased to a minimum of 6.73 in polyethylene bags and 7.00 when stored in laminated pouches at the end of one month of storage.

The mean score for chips flavoured with salt and pepper was 7.84 during initial stage and it was significantly lowered at the end of one month of storage in polyethylene bags and laminated pouches. A gradual decrease was observed in the mean score for taste during storage in polyethylene bags (7.13) and in laminated pouches (7.19).

The crispness of chips flavoured with salt and pepper had maximum initial score of 7.86 and a score of 6.67 on 30^{th} day in polyethylene bags and 7.32 in laminated pouches.

The overall acceptability of chips flavoured with salt and pepper had an initial score of 7.73 and a score of 6.89 on 30^{th} day in polyethylene bag and laminated pouches respectively.

The mean scores for salt along with pepper chips were higher after 30 days of storage when stored in laminated pouches compared to polyethylene bags. The overall acceptability score was same after 30 days of storage in both packaging materials.

A slightly higher mean score for all organoleptic attributes at the end of storage was observed for chips prepared by adding salt along with pepper and packed in laminated pouches.

Chips prepared by adding salt along with pepper and packed in laminated pouches attained higher total scores (49.93) for organoleptic attributes compared to chips packed in polyethylene bags (48.45) during third month of storage.

On statistical analysis (Appendix -II) a significant difference was observed for all organoleptic attributes during storage of chips salt with pepper in polyethylene bags and laminated pouches. A significant difference with storage was observed for all organoleptic attributes, except for the overall acceptability of chips prepared using salt along with pepper and packed in laminated pouches.

4.2. Standardisation of Grand Naine banana flour

4.2.1. Organoleptic qualities of banana flour

The prepared banana flour was evaluated organoleptically using score card for different quality attributes like appearance, colour, flavour, texture, taste, and overall acceptability. Each product was ranked for all these quality attributes based on their mean rank scores.

Table 9. Mean scores for organoleptic evaluation of banana flour

Parameters	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	W
Appearance	7.68 (5.37)	7.68 (5.33)	7.82 (6.17)	7.55 (5.7)	9.60 (5.67)	8.52 (10.53)	8.00 (7.67)	7.95 (7.6)	7.82 (6.53)	7.7 (6.57)	7.75 (6.0)	8.17 (10.07)	7.93 (7.8)	.210**
Colour	7.71 (5.20)	7.64 (3.90)	7.93 (7.63)	7.77 (5.03)	7.88 (5.63)	8.3 (10.83)	7.93 (6.90)	7.91 (6.53)	7.91 (6.50)	7.91 (6.70)	8.06 (8.23)	8.4 (10.70)	7.93 (7.20)	.293**
Flavour	7.64 (8.20)	7.24 (4.57)	7.35 (5.97)	7.55 (7.37)	7.53 (6.70)	8.04 (10.97)	7.47 (7.57)	7.51 (6.20)	7.51 (7.27)	7.42 (6.87)	7.24 (4.83)	8.2 (7.33)	7.51 (7.27)	.176**
Texture	7.8 (6.87)	7.8 (7.3)	7.82 (6.8)	8.04 (6.73)	7.9 (6.90)	8.17 (9.13)	7.8 (6.63)	7.86 (5.57)	7.86 (7.07)	7.8 (6.00)	7.68 (6.4)	7.86 (9.43)	7.75 (9.17)	.095*
Taste	7.53 (7.4)	7.17 (5.2)	7.31 (6.57)	7.44 (6.47)	7.57 (6.20)	8.02 (11.47)	7.53 (8.00)	7.17 (7.27)	7.17 (5.13)	7.31 (6.93)	7.04 (4.33)	7.6 (9.00)	7.4 (7.03)	.233**
Overall acceptability	7.83 (8.67)	7.49 (5.20)	7.56 (5.97)	7.62 (6.97)	7.68 (5.40)	8.6 (10.97)	7.65 (6.93)	7.58 (6.97)	7.58 (6.77)	7.72 (8.33)	7.3 (4.13)	7.9 (9.07)	7.53 (5.63)	.238**
Total score	46.19	45.02	45.79	45.97	48.16	49.65	46.38	45.98	45.85	45.86	45.07	48.13	46.05	

Values in parentheses are mean rank scores based on Kendall's W which was significant (** Significant at 1% level)

The mean scores for appearance of banana flour ranged from 7.55 (T_3) to 9.60 (T_4) with mean rank scores from 5.33 to 10.53. The highest appearance score was recorded for T_4 (9.60) followed by T_5 (8.52).

The mean scores for colour ranged from 7.64 to 7.93 with mean rank scores ranging from 3.90 to 10.70 respectively. The highest mean score of 8.4 for colour was recorded for T_{11} and the lowest mean score of 7.64 for colour was noticed in T_1.

The mean scores for flavour of banana flour ranged from 7.24 to 8.2 with the mean rank scores varying from 4.57 to 10.97. The lowest mean score of 7.24 was noticed in T_{10} and the highest score of 8.2 was noticed in T_{11}.

Among different treatments tried for the preparations of banana flour the highest mean score of 8.17 for texture was recorded for T_5 with mean rank score of 9.13 and the lowest mean score of 7.68 for texture was noticed in T_{10}.

The mean scores and mean rank scores for taste of banana flour ranged from 7.04 to 8.02 and 4.33 to 11.47 respectively. The highest mean score of 8.02 was noticed in T_5 and the lowest mean score was found to be in T_{10} (7.04).

Among the different treatments tried the highest mean score for overall acceptability was noticed in T_5 with the mean rank score of 10.97. The lowest mean score of 7.3 was recorded for T_{10}.

The treatment, T_4 scored the highest mean score for appearance followed by T_5 and in case of colour and flavour the highest score was observed for T_{11} followed by T_5.

Treatment T_5 attained higher total scores (49.65) for organoleptic attributes compared to other treatments. The lowest total score was observed in T_1 (45.02).

From the, organoleptic evaluation of different treatments, the best treatment were selected for further studies. Based on Kendall's (W) value, significant

agreement among judges was noticed in the evaluation of different quality attributes of banana flour. The treatment T_4 scored the highest for appearance followed by T_5 and in case of colour and flavour the highest score was observed for T_{11} followed by T_5.The organoleptic attributes such as texture, taste and overall acceptability was found to be higher in T_5. Based on this T_5 was adjudged as best treatment for preparation of banana flour.

Plate 7. Grand Naine Banana flour

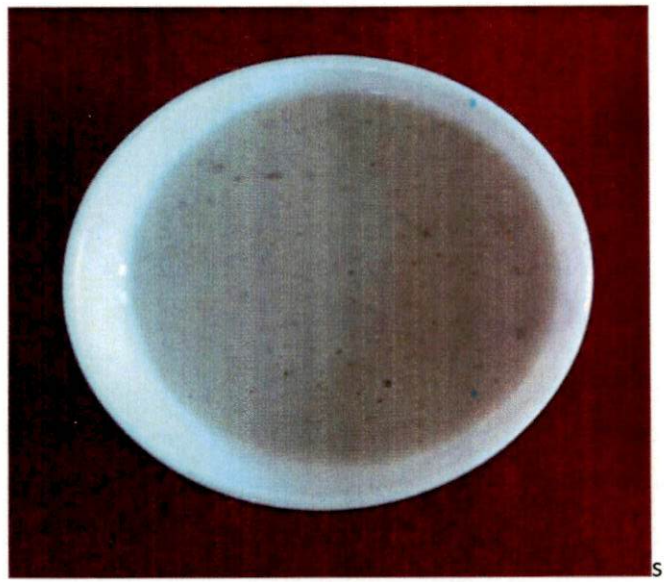


Plate 8. Banana porridge

Table 10. Mean score for organoleptic evaluation of Grand Naine banana porridge

Parameters	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	W
Appearance	7.88	7.93	7.86	7.75	7.82	8.2	7.91	7.8	7.84	7.6	7.8	8.2	7.9	.244**
	(6.23)	(7.27)	(6.73)	(5.27)	(6.9)	(10.8	(6.87)	(6.43)	(6.37)	(4.67)	(5.63)	(10.10)	(7.70)	
Colour	7.71	7.68	7.55	7.46	7.62	8.4	7.7	7.7	7.8	7.75	7.8	8.15	7.8	.249**
	(6.20)	(5.67)	(5.57)	(4.30)	(5.67)	(11.5	(6.63)	(6.70)	(7.20)	(7.00)	(7.50)	(9.53)	(7.53)	
Flavour	7.86	7.6	7.73	7.46	7.6	8.2	7.68	7.66	7.66	7.6	7.57	8.13	7.6	.249**
	(7.00)	(5.32)	(6.71)	(5.04)	(6.18)	(11.6	(6.82)	(6.68)	(6.25)	(5.93)	(6.61)	(10.25)	(6.20)	
Texture	7.88	7.7	7.57	7.71	7.6	8.33	7.71	7.53	7.66	7.51	7.82	8.15	7.6	.295**
	(7.53)	(6.90)	(5.50)	(7.07)	(5.77)	(11.2	(7.33)	(5.43)	(6.57)	(5.40)	(5.43)	(10.63)	(6.20)	
Taste	7.8	7.48	7.46	7.11	7.26	8.31	7.04	7.13	7.31	7.68	7.26	8.02	7.35	.394**
	(8.73)	(6.70)	(6.23)	(4.47)	(5.83)	(12.2	(5.87)	(4.10)	(5.30)	(8.43)	(6.00)	(10.53)	(6.57)	
Overall acceptability	7.9	7.52	7.56	7.43	7.54	8.37	7.51	7.34	7.58	7.7	7.3	8.06	7.56	.346**
	(8.8)	(5.87)	(6.30)	(5.03)	(6.17)	(12.1	(5.80)	(3.93)	(6.23)	(7.77)	(5.97)	(10.20)	(6.80)	
Total score	47.03	45.91	46.03	44.92	45.49	49.81	45.55	45.16	45.85	45.84	45.55	48.71	45.81	

Value in parentheses are mean rank scores based on Kendall's W which was significant (** Significant at 1% level)

The mean scores and mean rank scores for appearance of porridge prepared from banana flour ranged from 7.6 to 8.2 and 4.67 to 10.8 respectively. The appearance score was recorded highest for T_5 and the lowest mean score for appearance was obtained for T_9 (7.6).

Among the different treatments tried for the preparation of banana porridge the highest mean score for colour (8.4) was recorded for T_{11}. The lowest mean score of 7.46 for colour was noticed in T_3. The mean rank scores varied from 4.30 to 11.5.

The mean score and mean rank scores for flavour of banana porridge (banana dipped in 1 per cent ascorbic acid and 0.5 per cent citric acid and dried at 50^0C for 48 hours in hot air oven) ranged from 7.46 to 8.2 and 5.04 to 11.6 respectively. The lowest mean score of 7.46 was noticed in T_3 and the highest score of 8.2 was noticed in T_5.

Among different treatments tried for the preparations of banana porridge the highest mean score of 8.33 for texture was recorded for T_5. The lowest mean score of 7.51 for texture was noticed in T_9. The mean rank scores ranged from 5.40 to 11.2.

The mean scores for taste of banana porridge ranged from 7.04 (T_6) to 8.31(T_5) and 4.10 to 12.2 respectively. The highest mean score was noticed in T_5. Among the different treatments tried, the lowest mean score of 7.04 for taste was observed in T_6.

Among the different treatments tried for the banana porridge the highest mean score for overall acceptability was noticed in T_5 (8.37) followed by T_{11}. The lowest mean score of 7.3 was recorded for T_{10}. The mean rank scores ranged from 3.93 to 12.1.

Treatment T_5 attained higher total scores (49.65) for organoleptic attributes compared to other treatments. The lowest total score was observed in T_1 (45.02).

From the, organoleptic evaluation of different treatments, the best treatment was selected for further studies. Based on Kendall's (W) value, significant agreement among judges was noticed in the evaluation of different quality attributes of porridge.

The analysis of concordance resulted in a slightly higher scores for T_5. On the judgment that the base material is important for maintaining the quality of porridge T_5 was adjudged as best treatment.

4.2.2. Physico – functional properties of Grand Naine banana flour

The prepared Grand Naine banana flour was evaluated for the physico-functional properties like pH, moisture content, water holding capacity, oil absorption capacity and bulk density. The flour was stored in polyethylene bags for a duration of three months and was analysed at monthly intervals for a period of three months.

Table 11. Physico – functional properties of banana flour

Parameters	Initial	1st month	2nd month	3rd month	C.D
pH	4.00	4.36	4.48	5.03	NS
Moisture (g 100 g^{-1})	3.17	4.19	4.5	5.13	NS
Water holding capacity (g water/g flour)	3.00	3.54	4.07	4.29	NS
Oil absorption capacity (g oil/ g flour)	0.86	0.97	1.03	1.16	NS
Bulk density (g/ml)	1.87	1.56	1.47	1.40	NS

NS – Not significant

4.2.2.1. pH

The pH of freshly prepared Grand Naine banana flour was 4.00, which increased during storage and reached 5.03 within a period of three months of storage (Figure 4).

4.2.2.2. Moisture

Gradual increase in moisture content of unripe banana flour was observed during storage period (Figure 5). The initial moisture content of the flour was 3.17g 100 g^{-1} which increased to 4.19, 4.50 and 5.13 g $100g^{-1}$ during the end of first, second and third months of storage respectively.

4.2.2.3. Water holding capacity

The water holding capacity of freshly prepared Grand Naine banana flour was 3.00 g water/g flour (Figure 6). The water holding capacity of flour gradually increased with storage. It was 3.54, 4.07 and 4.29 g water/g flour at the end of first, second and third months of storage respectively.

4.2.2.4. Oil absorption capacity

The oil absorption capacity was found to be 0.86 g oil/ g flour initially. The oil absorption capacity showed an increasing trend from initial to the third month of storage. The values of 0.97, 1.03 and 1.16 g oil/g flour were observed at the end of first, second and third month respectively (Figure 7).

4.2.2.5. Bulk density

The bulk density of freshly prepared Grand Naine banana flour was 1.87 g/ml. The bulk density of flour gradually decreased with storage. It was 1.56, 1.47, 1.40 g/ml at the end of first, second and third month of storage respectively (Figure 8). There was no significant difference in physical analysis during storage period.

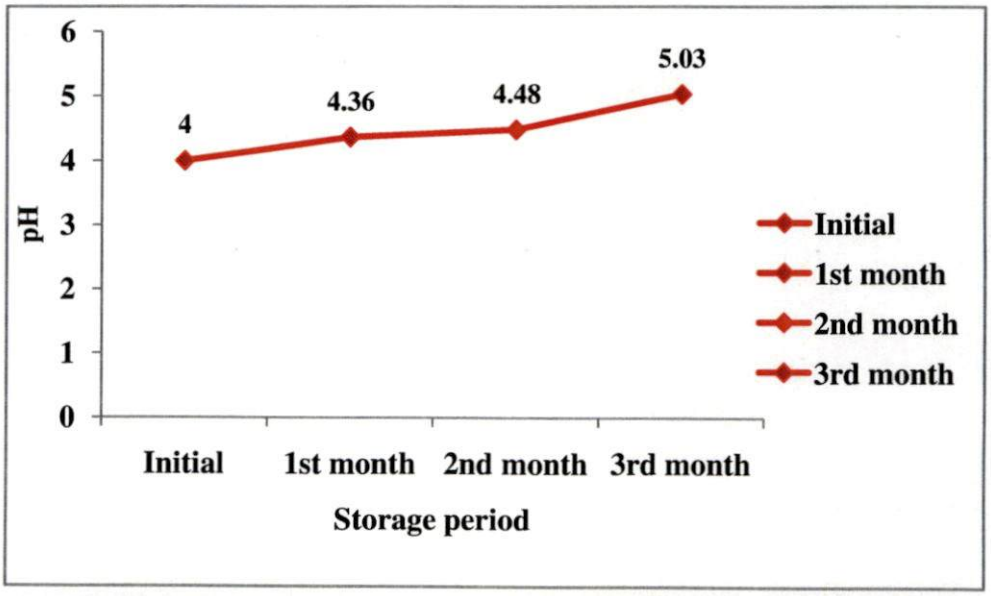


Figure 4. Effect of storage period on the pH of Grand Naine bananaflour

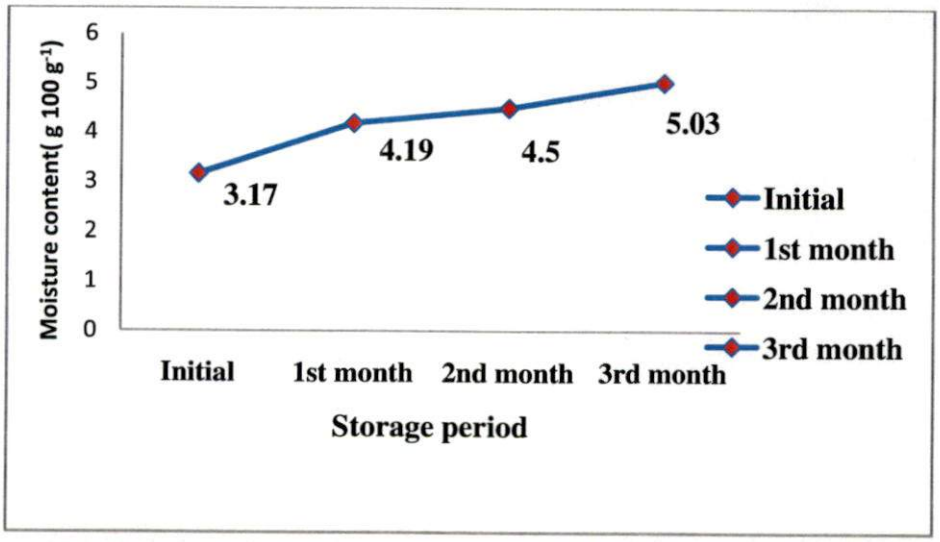


Figure 5. Effect of storage period on the moisture content of Grand Naine banana flour

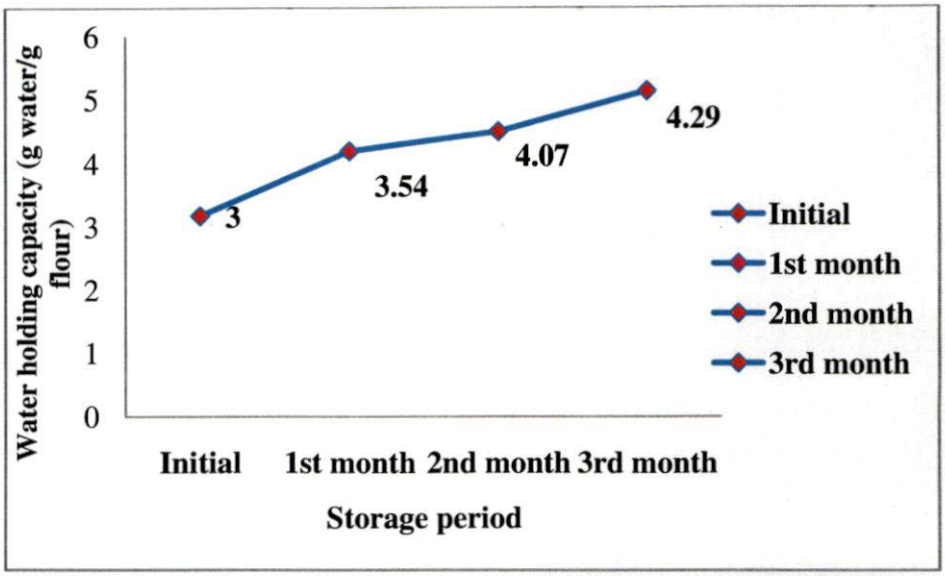


Figure 6. Effect of storage period on the water holding capacity of Grand Naine banana flour

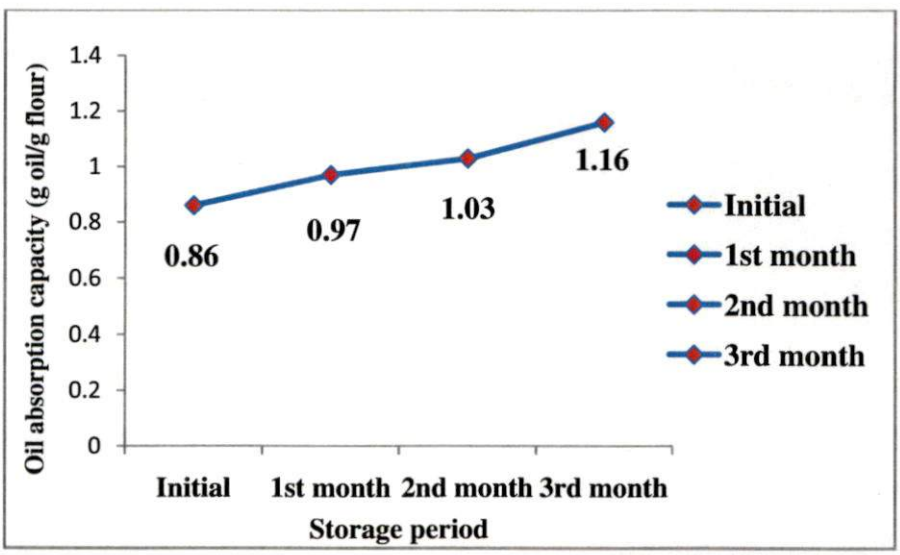


Figure 7. Effect of storage period on the Oil absorption capacity of Grand Naine banana flour

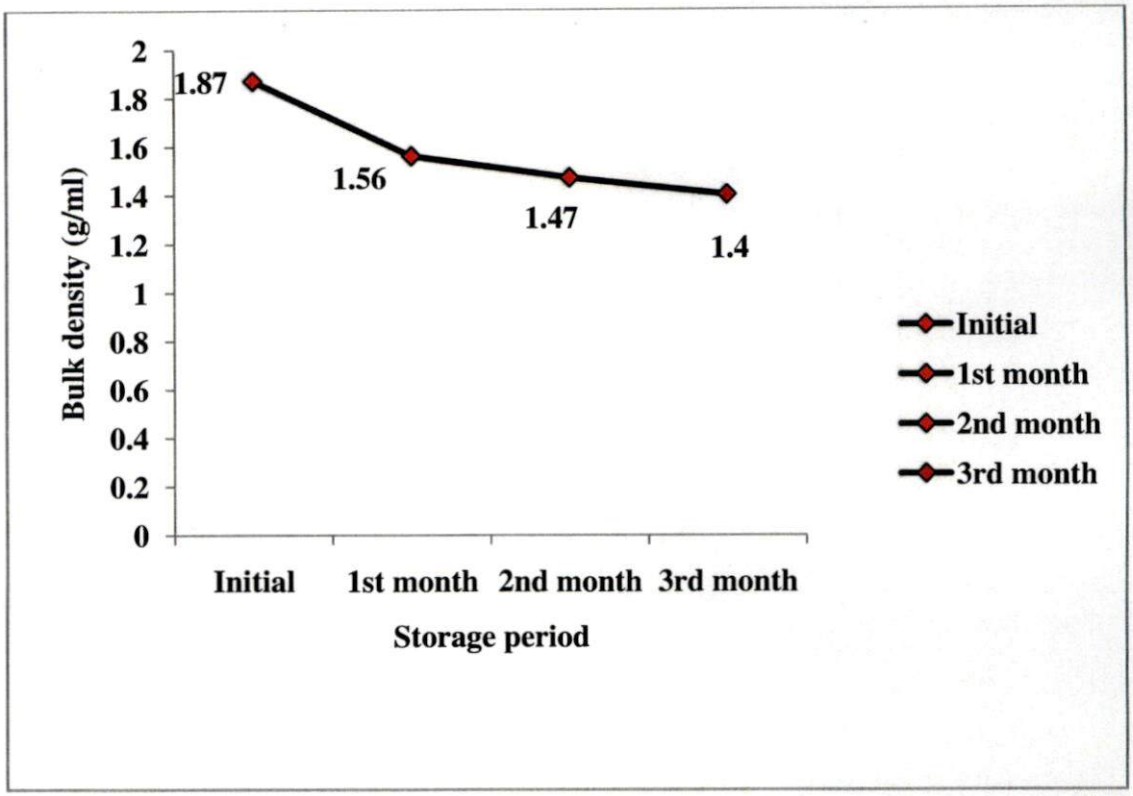


Figure 8. Effect of storage period on the bulk density of Grand Naine banana flour

4.2.3. Biochemical and nutritional properties of Grand Naine banana flour

The prepared Grand Naine banana flour was evaluated for the biochemical and nutritional properties like TSS, total sugar, reducing sugar, starch, protein, fibre, calcium, phosphorus, iron, potassium, *in vitro* digestibility of starch and *in vitro* availability of minerals. The flour was stored in polyethylene bags for a duration of three months and was analysed initially and at the end of three months of storage. The results are furnished in Table 12 and Figure 9 to Figure 15.

Table 12. Nutritional properties of Grand Naine banana flour

Constituents	Initial	Final	t value
TSS (^{0} brix)	4.03	5.10	21.00^{NS}
Total sugar (%)	1.73	2.02	29.00^{NS}
Reducing sugar (%)	1.26	1.43	5.66^{NS}
Starch (g 100 g^{-1})	70.00	66.8	5.667^{NS}
Protein (g 100 g^{-1})	3.6	3.4	2.00^{NS}
Fibre (g 100 g^{-1})	2.62	2.55	3.00^{NS}
In vitro digestibility of starch (%)	76.1	73	63.00^{NS}

NS – Non significant

4.2.3.1. Total soluble solids

The TSS of freshly prepared Grand Naine banana flour was 4.03^0 brix and it increased to 5.10^0 brix after the third month of storage. On statistical analysis, the difference was found to be non significant.

4.2.3.2. Total sugar

The total sugar content of freshly prepared Grand Naine banana flour was 1.73 per cent, which increased to 2.02 per cent after the storage period of three

months. Even though there was a slight increase in total sugar, the increase was found to be non significant.

4.2.3.3. Reducing sugar

The reducing sugar of Grand Naine banana flour was found to be 1.26 per cent initially. The reducing sugars showed an increasing trend from initial to the third month of storage. A reducing sugar content of 1.43 per cent was observed at the end of third month.

4.2.3.4. Starch

Gradual decrease in starch content of unripe banana flour was observed during storage period. The initial starch content of the flour was 70.00 g 100 g^{-1} which decreased to 66.8 g 100g^{-1} during the third month of storage.

4.2.3.5. Protein

The protein content of Grand Naine banana flour was found to be 3.6 g 100 g^{-1} initially. The protein content showed a decreasing trend from initial to third month of storage. The value of 3.4 g 100 g^{-1} was observed at the end of third month of storage.

4.2.3.6. Fibre

The fibre content of freshly prepared Grand Naine banana flour was 2.62 g 100 g^{-1} and it showed a decrease on storage with no significant difference. A fibre content of 2.55 g 100 $g^{-1}$was observed at the end of third month of storage.

4.2.3.7. *In vitro* digestibility of starch

The *in vitro* digestibility of starch content of freshly prepared Grand Naine banana flour was found to be 76.1 per cent and it decreased during storage to 73 per cent. On statistical analysis the decrease was found to be non significant.

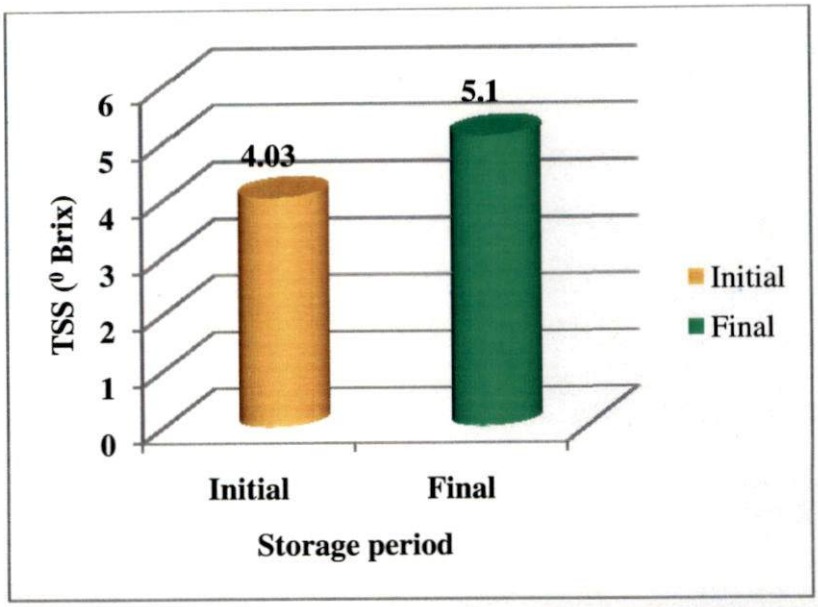


Figure 9 Effect of storage period on the TSS of Grand Naine banana flour

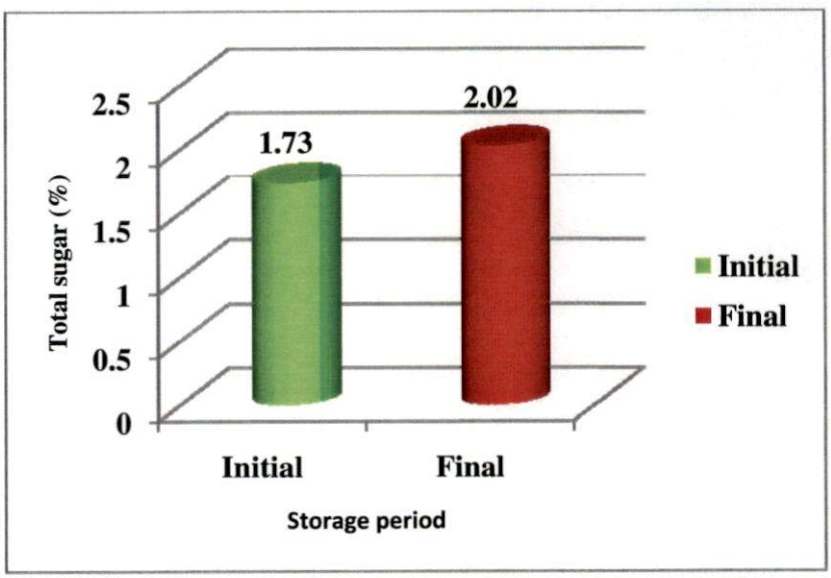


Figure 10. Effect of storage period on the total sugar content of Grand Naine banana flour

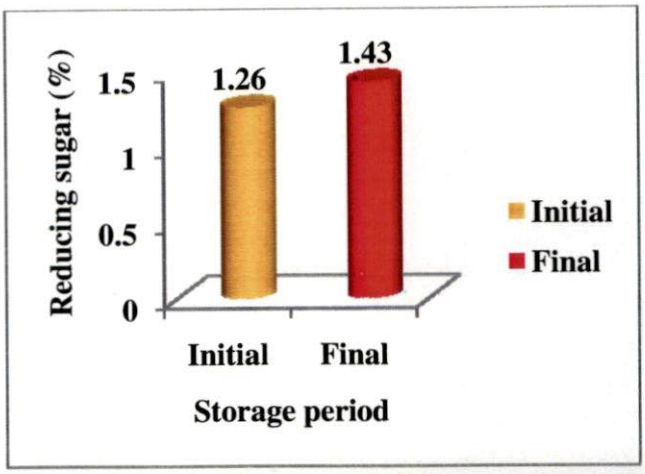


Figure 11 Effect of storage period on the reducing sugar content of Grand Naine banana flour

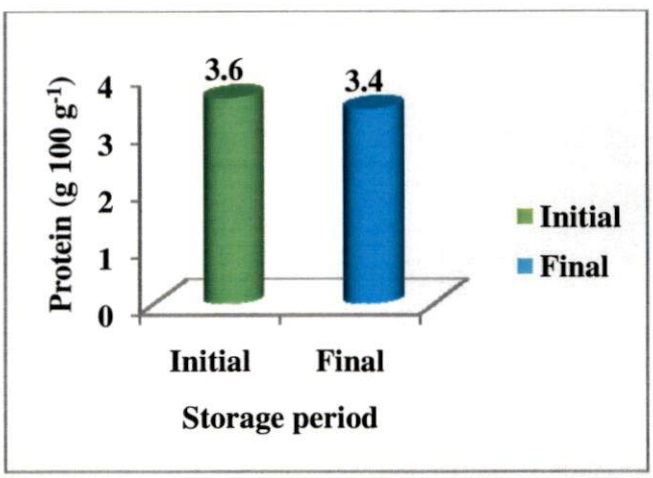


Figure 12 Effect of storage period on the protein content of Grand Naine banana flour

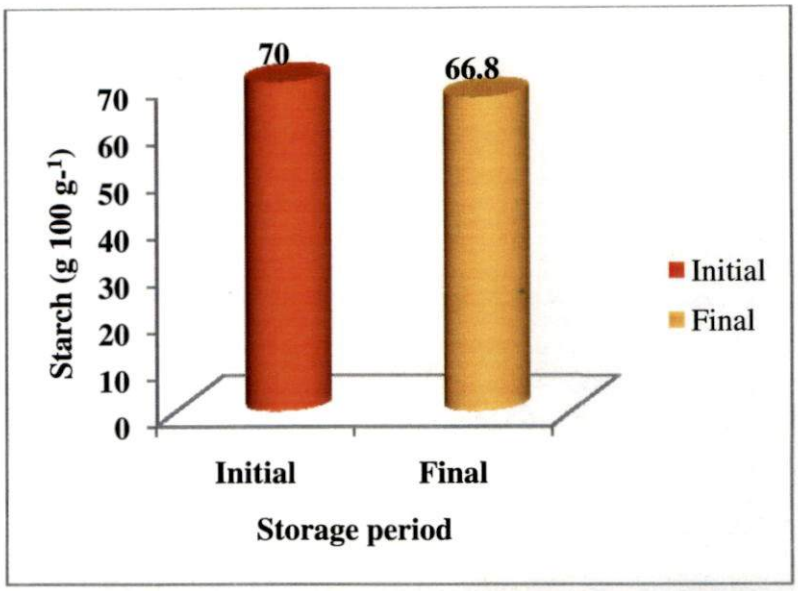


Figure 13 Effect of storage period on the starch content of Grand Naine banana four

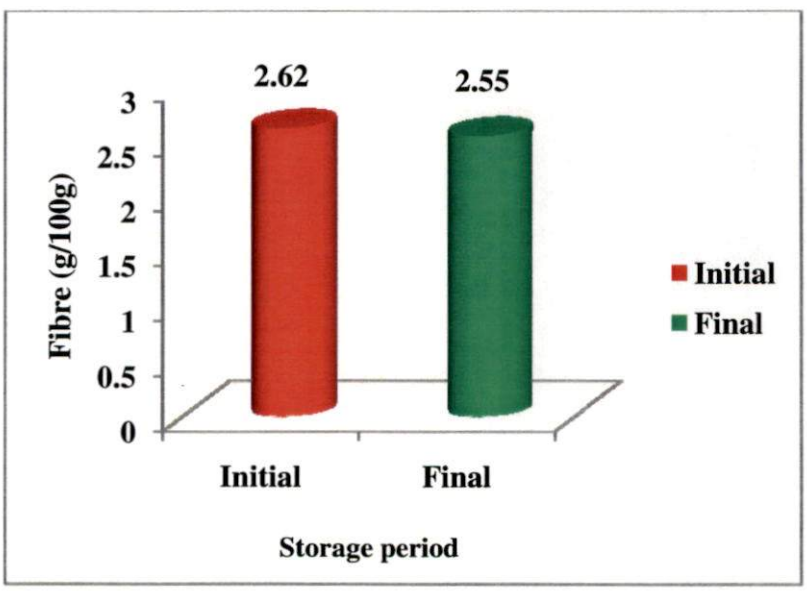


Figure 14 Effect of storage period on the fibre content of Grand Naine banana flour

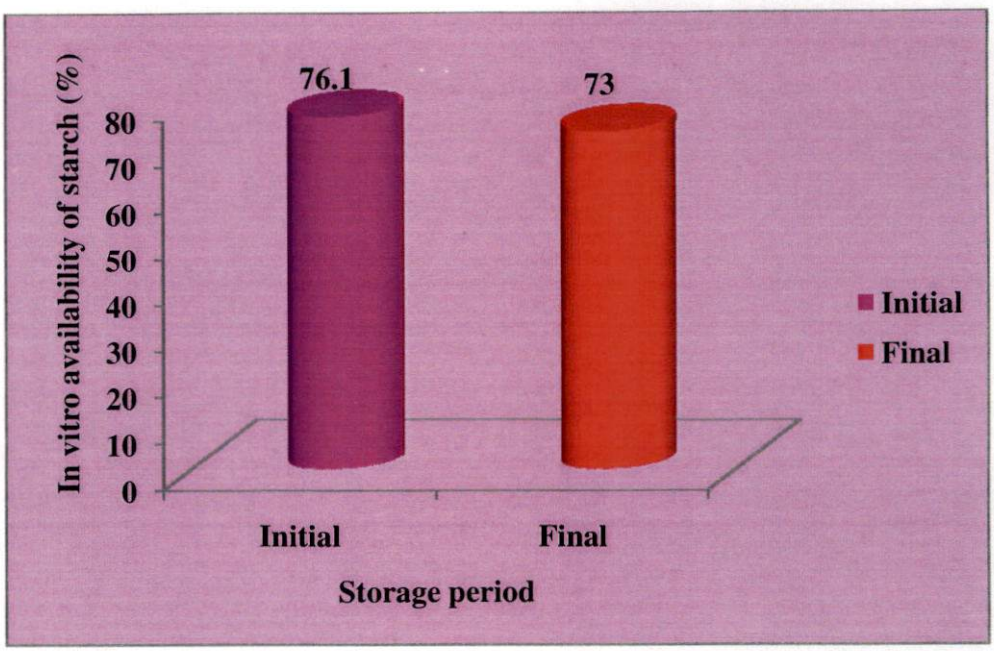


Figure 15 Effect of storage period on the *in vitro* digestibility of starch in Grand Naine banana flour

Table 13. Mineral content of Grand Naine banana flour

Minerals (mg 100 g^{-1})	Initial	Final	t value
Calcium	60.34	58.92	142.00^{NS}
Phosphorus	72.5	70.5	2.00^{NS}
Iron	6.75	6.54	2.158^{NS}
Potassium	410.5	396.0	29.00^{NS}

NS – Non significant

4.2.3.8. Calcium

The calcium content of freshly prepared Grand Naine banana flour was found to be 60.34 mg $100g^{-1}$. The calcium content decreased at the end of storage to 58.92 mg $100g^{-1}$ but there was no significant difference during storage.

4.2.3.9. Phosphorus

The phosphorus content of Grand Naine banana flour was found to be 72.5 mg 100 g^{-1}. The phosphorus content decreased to 70.5 mg $100g^{-1}$ at the end of storage. On statistical analysis the value was found to be non significant.

4.2.3.10. Iron

The iron content of freshly prepared Grand Naine banana flour was found to be 6.75 mg $100g^{-1}$, initially and it decreased after the third month of storage. An iron content of 6.54 mg $100g^{-1}$ was observed at the end of storage, but there was no significant difference on statistical analysis.

4.2.3.11. Potassium

The potassium content of freshly prepared Grand Naine banana flour was found as 410.5 mg $100g^{-1}$. A decrease in potassium content to a value of 396.0 $mg/100g^{-1}$ with no significant difference was observed at the end of third month of storage.

4.2.3.12. *In vitro* availability of minerals

The *in vitro* availability of minerals like calcium, phosphorus, iron and zinc were carried out and the results are presented in Table 14 and Figure 16.

Table 14. *In vitro* availability of minerals in Grand Naine banana flour

Minerals (%)	Initial	Final	t value
Calcium	30.22	28.63	159.00^{NS}
Phosphorus	56.5	54.24	226^{NS}
Iron	65.25	62.00	13.245^{NS}
Zinc	61.98	59.03	102.19^{NS}

NS – Non significant

In vitro availability of calcium in freshly prepared Grand Naine flour was found to be 30.22 per cent, which decreased to 28.63 per cent in Grand Naine banana flour during storage. Phosphorus content present in Grand Naine banana flour had an initial, *in vitro* availability of 56.5 per cent which decreased to 54.24 per cent at the end of storage. Both iron and zinc had comparatively higher *in vitro* availability of 65.25 per cent and 61.98 per cent respectively in freshly prepared Grand Naine banana flour. A decrease with no significant difference to a content of 62 per cent and 59.03 per cent was noticed for iron and zinc, respectively on storage.

4.2.4. Keeping quality

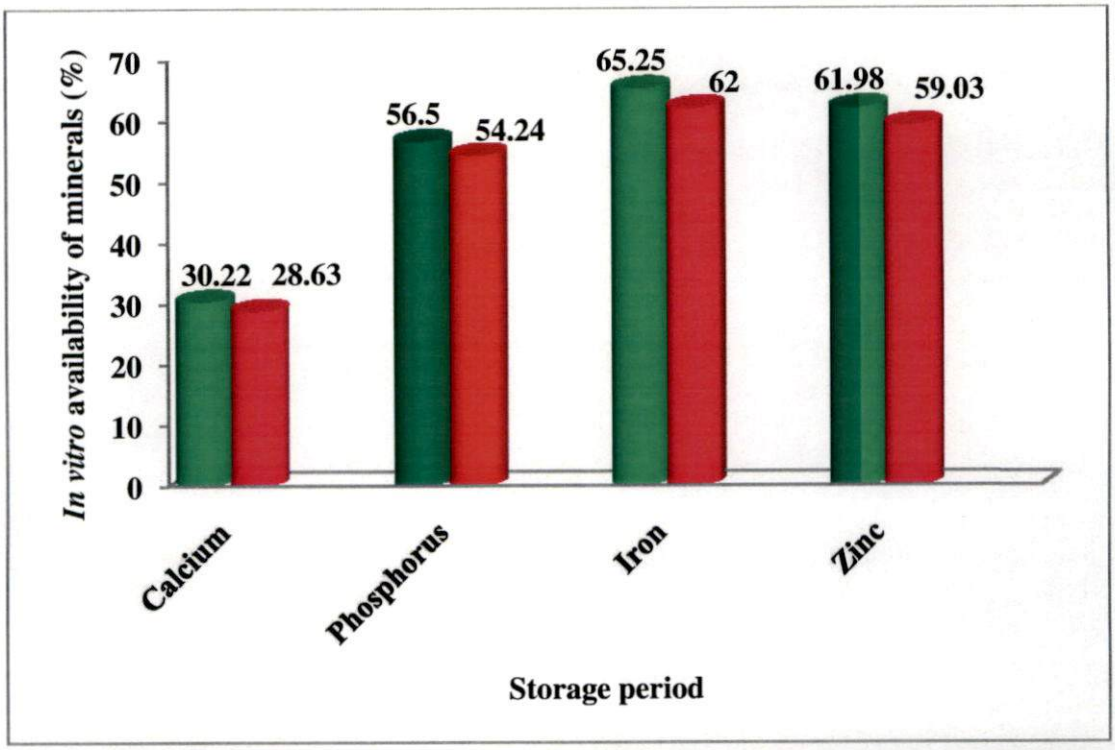


Figure 16 Effect of storage period on the *In vitro* availability of Minerals

Based on organoleptic qualities of Grand Naine banana flour T_5 was adjudged as the best treatment. The flour was stored in polyethylene bags for a period of three months.

Table 15 presents the data for the mean score obtained for organoleptic attributes of porridge prepared from freshly prepared Grand Naine banana flour and at monthly interval for a duration of three months.

Table 15. Mean score for organoleptic evaluation of banana porridge

Parameters	Initial	1 MAS	2 MAS	3 MAS
Appearance	8.73	8.52	7.33	6.60
Colour	8.46	8.3	7.60	6.53
Flavor	8.60	8.04	7.20	6.40
Texture	8.20	8.17	7.73	6.20
Taste	8.40	8.02	7.20	6.06
Overall acceptability	8.33	8.06	7.20	6.30
Total score	50.73	49.11	44.26	38.09

MAS – Month after storage

Grand Naine banana porridge attained a maximum initial score of 8.73 for appearance. The score for this attribute gradually decreased with storage. It was 8.52, 7.33 and 6.6 at the end of first, second and third month respectively.

The colour of the freshly prepared Grand Naine banana porridge had an initial score of 8.46. The colour of porridge decreased during storage period. It was 8.3, 7.6 and 6.53 at the end of first, second and third month respectively.

The mean score for the flavour also decreased with storage. The initial score obtained was 8.6 which gradually decreased to 8.04, 7.20 and 6.40 at the end of first, second and third month of storage respectively.

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The texture of porridge scored a maximum of 8.20 initially and it decreased to 6.2 after the third month of storage.

The taste of porridge attained a maximum initial score of 8.4 which decreased during the storage period. It was 8.02, 7.20 and 6.06 at the end of first, second and third month respectively.

The overall acceptability of porridge scored a maximum of 8.33, initially. It gradually decreased during third month of storage to a score of 6.30. A mean score of 8.06 and 7.20 was observed at the end of first and second month of storage.

The initial total score for banana porridge was 50.73 and it declined to 38.09 during third month of storage.

4.2.4.1. Microbial count in Banana flour

The microbial population of the banana flour was assessed initially and also at monthly intervals for a period of three months and the results are presented in Table 16.

Table16.Total microbial count of banana flour (cfu g^{-1})

Period of storage	Microbial population (cfu g^{-1})		
	Bacteria ($\times 10^6$)	Fungi ($\times 10^5$)	Yeast ($\times 10^5$)
Initial	0.59	ND	ND
1st month	2.02	ND	ND
2nd month	2.57	1.25	ND
3rd month	3.13	1.32	ND

ND – Not detected

ount was found to be 0.59×10^6 cfu g^{-1}, which increased gradually to 3.13×10^0 cfu g^{-1} during third month. Bacterial count during the first and second month was 2.02×10^6cfu g^{-1} and 2.57×10^6 cfu g-^{1} respectively.

Fungal growth was not detected during initial and first month of storage. During the end of second month, fungal growth of 1.25×10^5 cfu g^{-1} was detected and it was increased during third month of storage to 1.32 10^5 cfu g^{-1}.

Yeast growth was not detected throughout the storage period.

4.3. Standarisation of secondary product – *Payasam ada*

Ada was standardised by incorporating the selected Grand Naine banana flour (T_5) at different levels with rice flour. The drying temperature and the time for the above treatments was standardized by varying temperature of 60^0C, 65^0C and 70^0C until it attained a moisture content of 10 per cent .

Table 17.Time taken for drying of *payasam ada*

Treatments	Time (hrs)		
	60^0C	**65^0C**	**70^0C**
T_0 (100%RF)	6hr	4hr	2hr
T_1 (100%BF)	6.5hr	4.5hr	2.5hr
T_2 (80% BF+ 20%RF)	6.15hr	4.15hr	2.15hr
T_3(70%BF+30%RF)	6hr	4hr	2hr
T_4 (60% BF+40%RF)	6hr	4hr	2hr
T_5 (50%BF+50%RF)	6hr	4hr	2hr

(**RF** – Rice flour, **BF** – Banana flour)

The time taken for drying of *ada* at 60^0C and 65^0C varied from 6 to 6.5 hrs and 4 to 4.5 hrs respectively for various treatments. At a temperature of 70^0C, *ada* was dried within a time of 2 to 2.5 hrs.

4.3.1. Organoleptic evaluation of *payasam ada*

Ada was prepared in five different proportions with rice flour and banana flour at three different temperatures and the results of organoleptic evaluation are furnished in table 18.

The highest mean score for appearance of 8.22 was recorded for T_0 and T_{17}. The lowest mean score of 7.35 was observed in T_2.

Among different treatments tried for the preparation of *payasam ada,* the highest mean score for colour (8.11) was recorded for T_{17} and the lowest mean score of 7.37 for colour was noticed in T_1.

The mean score for flavour for *payasam ada* ranged from 6.95 -7.42. The lowest mean score of 6.95 was noticed in T_1 followed by T_{14} and T_{15} (70^0C) and the highest score of 7.42 was noticed in T_{17}.

Among different treatments tried for the preparation of *payasam ada* the highest mean score for texture (7.95) was recorded for T_{17}. The lowest mean score of 7.28 for texture was noticed in T_{13}.

The mean scores for taste of *payasam ada* ranged from 7.15 - 8.15 with highest score for T_{17}. Among the different treatments tried, the lowest mean score of 7.15 for taste was noticed in T_{13}.

Among the different treatments tried for *payasam ada* the highest rank score for overall acceptability (7.5) was noticed in T_{17}. The lowest mean score of 6.84 was recorded for T_9.

The mean rank scores for treatments, T_0 to T_{17} varied from 6.27 to 15.83 for appearance, 6.43 to 15.17 for colour, 6.67 to 14.9 for flavour, 6.6 to 14.03 for texture, 6.83 to 15.8 for taste and 6.8 to 15.07 for overall acceptability.

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Payasam ada prepared by blending rice flour and banana flour at a proportion of 50:50 and dried at 70^0C for 2 hours attained a maximum score for all organoleptic attributes. The treatment, T_{17} obtained a slightly higher total score of 47.35 compared to other treatments. The lowest score was observed in T_{15} (43.17). Hence the treatment T_{17} was adjudged as the best for the preparation of *ada* (Plate 9).

Plate 9. ***Payasam ada***

Table 18. Mean score for organoleptic evaluation of *payasam ada*

Treatments		Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
T_0(100%RF)	60°C	8.22 (14.8)	8.02 (14.4)	7.73 (14.9)	7.91 (12.9)	7.84 (12.9)	7.31 (12.43)	47.03
T_1(100%BF)		7.48 (8.47)	7.37 (6.9)	6.95 (7.1)	7.37 (6.6)	7.33 (7)	7.04 (9.13)	43.54
T_2(80% BF+20%RF)		7.35 (6.27)	7.46 (7.8)	6.95 (8.03)	7.51 (9.3)	7.46 (8.7)	7 (8.23)	43.73
T_3(70%BF+30%RF)		7.48 (8.27)	7.42 (7.23)	7.17 (11.13)	7.62 (10.23)	7.33 (6.83)	7.15 (10.9)	44.17
T_4(60%BF+40%RF)		7.48 (8.6)	7.42 (7.43)	7.24 (11.33)	7.55 8.93	7.6 (11.63)	7.04 (9.1)	44.33
T_5(50%BF+50%RF)		7.53 (8.83)	7.6 (9.37)	6.91 (6.67)	7.53 (9.43)	7.62 (11)	6.95 (8.37)	44.14
T_6(100%RF)	65°C	7.62 (9.63)	7.6 (9.97)	7.06 (8.4)	7.44 8.43	7.57 10.13	6.93 (8.33)	44.22
T_7(100%BF)		7.46 (7.77)	7.57 (9.03)	7 (7.73)	7..57 (10.03)	7.48 (9.4)	6.95 (8.23)	44.03
T_8(80%BF+20%RF)		7.73 (10.9)	7.6 (9.93)	7.11 (10.13)	7.55 (9.83)	7.51 (8.97)	6.97 (9.13)	44.47
T_9(70%BF+30%RF)		7.73 (11.17	7.62 (10.07)	7.13 (9.73)	7.44 (8.43)	7.4 (7.7)	6.84 (6.8)	44.16
T_{10}(60%BF+40%RF)		7.37 (7.77)	7.37 (6.43)	7.08 (9.8)	7.44 (8.2)	7.53 (9.37)	6.95 (7.6)	43.74
T_{11}(50%BF+50%RF)		7.4 (7.27)	7.62 (10.07)	7.06 (9.2)	7.48 (9.17)	7.46 (8.27)	7.06 (9.67)	44.08
T_{12}(100%BF)	70°C	7.48 (8.67)	7.68 (10.43)	7.08 9.87	7.51 (8.4)	7.48 9.13	7.11 (10.87)	44.34
T_{13}(100%RF)		7.68 (10.27)	7.55 (8.9)	7.02 (8.17)	7.28 (6.8)	7.15 (5)	7.06 (9.83)	43.74
T_{14}(80%BF+20%RF)		7.48 (8.3)	7.6 (9.63)	6.95 (7.13)	7.48 (9.1)	7.48 (9.3)	7.02 (9.17)	44.01
T_{15}(70%BF+30%RF)		7.46 (8.13)	7.4 (6.97)	6.95 (7.83)	7.6 (10.13)	7.35 (7.57)	6.95 (8.77)	43.17
T_{16}(60%BF+40%RF)		7.6 (10.07)	7.71 (11.27)	7.1 (9.83)	7.62 (11.03)	7.73 (12.3)	6.97 (9.37)	44.73
T_{17}(50%BF+50%RF)		8.22 (15.83)	8.11 (15.17)	7.42 *14)	7.95 (14.03)	8.15 (15.8)	7.5 (15.07)	47.35
W		.230**	.217**	.197**	.129**	.244**	.138**	

Value in parentheses are mean rank scores based on Kendall's W which was significant (** Significant at 1% level, * Significant at 5% level) **(RF – Rice flour, BF – Banana flour)**

Table 19.Mean score for organoleptic evaluation of milk based *payasam*

Treatments		Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
T_0(100%RF)	60°C	8.37 (17.00)	8.2 (16.83)	7.42 (16.40)	8.33 (15.80)	8.26 (15.17)	8.17 (16.37)	48.75
T_1(100%BF)		7 (3.57)	7 (4.13)	8.73 (3.83)	7.4 (3.63)	7.3 (14.07)	7.4 (3.37)	44.83
T_2(80% BF+20%RF)		7.04 (3.93)	7.04 (4.03)	6.8 (5.47)	7.31 (4.17)	7.3 (14.60)	7.42 (4.40)	42.91
T_3(70%BF+30%RF)		7.33 (6.93)	7.31 (8.27)	7.24 (6.93)	7.62 (6.70)	7.64 (7.30)	7.68 (7.53)	44.82
T_4(60% BF+40%RF)		7.12 (9.03)	7.11 (9.40)	7.6 (9.74)	7.44 (9.93)	7.42 (10.30)	7.51 (9.33)	44.2
T_5(50%BF+50%RF)		7.71 (13.17)	7.5 (12.47)	7.13 (10.70)	7.77 (11.47)	7.66 (10.66)	7.71 (10.83)	45.35
T_6(100%RF)	65°C	8.08 (16.13)	8.17 (16.20)	7.53 (15.57)	8.13 (15.20)	8.13 (14.73)	8.15 (15.97)	48.19
T_7(100%BF)		7.0 (5.43)	7 (4.53)	6.84 (4.53)	7.53 (4.17)	7.4 (2.97)	7.35 (3.23)	43.12
T_8(80%BF+20%RF)		7.02 (3.43)	7.08 (4.10)	6.84 (5.43)	7.48 (4.70)	7.42 (4.67)	7.46 (5.70)	43.3
T_9(70%BF+30%RF)		7.24 (8.43)	7.31 (7.87)	7 (8.10)	7.6 (8.97)	7.66 (6.47)	7.66 (8.20)	44.47
T_{10}(60%BF+40%RF)		7.37 (9.67)	7.31 (8.83)	7.04 (10.77)	7.66 (10.07)	7.53 (11.47)	7.55 (9.53)	44.46
T_{11}(50%BF+50%RF)		7.46 (13.10)	7.42 (14.37)	7.15 (14.10)	7.82 (14.53)	7.84 (15.93)	7.68 (14.73)	45.37
T_{12}(100%RF)	70°C	7.97 (13.70)	7.95 (14.30)	7.26 (15.73)	8.02 (15.37)	7.88 (14.03)	8.02 (14.70)	47.1
T_{13}(100%BF)		7.08 (5.47)	7 (5.03)	6.77 (4.87)	7.5 (4.83)	7.26 (4.27)	7.37 (5.30)	42.98
T_{14}(80%BF+20%RF)		7.06 (5.97)	7 (5.03)	6.75 (4.73)	7.42 (5.07)	7.26 (5.00)	7.22 (4.97)	42.71
T_{15}(70%BF+30%RF)		7.17 (8.57)	7.11 (8.20)	6.95 (5.57)	7.42 (7.87)	7.42 (8.50)	7.53 (9.40)	43.6
T_{16}(60%BF+40%RF)		7.37 (10.97)	7.22 (10.07)	7.08 (10.03)	7.5 (9.23)	7.53 (10.53)	7.62 (9.77)	44.32
T_{17}(50%BF+50%RF)		7.71 (15.23)	7.6 (15.67)	7.33 (14.00)	7.82 (11.87)	7.95 (13.57)	7.91 (13.60)	46.65
KendallsW		.760**	.783**	.784**	.802**	.821**	.766**	

Value in parentheses are mean rank scores based on Kendall's W which was significant

(** Significant at 1% level, * Significant at 5% level) **(RF – Rice flour, BF – Banana flour)**

Payasam was prepared and was evaluated organoleptically and the results are furnished in Table 19 and Table 20.

The highest mean score for appearance of milk based *payasam* prepared from the blend of rice flour and banana flour was recorded for T_5 and T_{17}.

Among different treatments tried for the preparation of milk based *payasam* the highest mean score for colour (7.6) on blending with banana flour was recorded for T_{17}. The lowest mean score of 7.0 for colour was noticed in T_1 followed by T_7, T_{13} and T_{14} respectively

The mean score for flavour for milk based *payasam* ranged from 6.75-8.73, the lowest mean score of 6.75 was noticed in T_{14} and the highest score (8.73) was noticed in T_1.

Among different treatments used for preparation of milk based *payasam* the highest mean score for texture (7.82) was recorded for T_{17}. The lowest mean score of 7.4 for texture was noticed in T_1.

The mean scores for taste of milk based *payasam* ranged from 8.26-7.26. The highest score for *payasam* prepared from blended ada (50% rice flour and 50% banana flour) was recorded for T_{17}. Among the different treatments tried, the lowest mean score of 7.26 for taste was noticed in T_{13} and T_{14}.

Among the different treatments tried for the milk based *payasam* prepared with blended *ada* the highest rank score for overall acceptability (7.91) was noticed in T_{17}. The lowest mean score of 7.22 was recorded for T_{14}.

The mean rank scores for treatments T_0 to T_{17} varied from 3.57 to 17.00 for appearance, 4.03 to 16.83 for colour, 3.83 to 16.40 for flavour, 3.83 to 14.03 for texture, 2.97 to 15.8 for taste and 6.8 to 15.37 for overall acceptability.

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The treatment T_{17} obtained a slightly higher total score of 46.65 compared to other treatments.

Among the various treatments used for the preparation, *payasam* prepared with *ada* from rice flour alone attained the maximum scores for all organoleptic attributes. It was observed that among the blended *ada, payasam* prepared from the *ada* blended at 1:1 proportion and oven dried at 70^0C for 2hrs attained the maximum score for appearance, colour, taste, texture and overall acceptability.

Table 20.Mean score for organoleptic evaluation of jaggery based *payasam*

Treatments		Appearance	Colour	Flavour	Texture	Taste	Overall acceptability	Total score
T_0(100%RF)	60°C	7.97 (13.13)	7.45 (14.50)	8 (13.63)	7.93 (13.60)	7.86 (12.63)	8 (14.27)	47.21
T_1(100%BF)		7.46 (6.87)	6.73 (5.87)	7.5 (6.87)	7.48 (7.20)	7.55 (9.10)	7.4 (7.07)	44.16
T_2(80% BF+20%RF)		7.35 (5.30)	6.85 (7.20)	7.6 (8.17)	7.44 (6.67)	7.46 (7.13)	7.51 (8.03)	44.21
T_3(70%BF+30%RF)		7.73 (10.33)	7.12 (10.57)	7.7 (10.97)	7.62 (9.27)	7.55 (8.53)	7.62 (9.10)	45.34
T_4(60% BF+40%RF)		7.64 (8.97)	7.19 (10.67)	7.7 (10.60)	7.73 (10.90)	7.71 (10.13)	7.75 (10.87)	45.72
T_5(50%BF+50%RF)		7.68 (9.47)	7.19 (10.80)	7.8 (11.03)	7.68 (10.07)	7.71 (10.50)	7.71 (10.43)	45.77
T_6(100%RF)	65°C	7.95 (13.63)	7.26 (12.17)	7.8 (11.20)	7.82 (12.27)	7.73 (10.70)	7.84 (11.90)	46.4
T_7(100%BF)		7.46 (6.43)	6.8 (15.60)	7.44 (6.70)	7.51 (7.77)	7.46 (7.30)	7.46 (7.03)	44.13
T_8(80% BF+20%RF)		7.35 (5.43)	6.85 (7.37)	7.55 (7.77)	7.42 (6.77)	7.46 (7.87)	7.48 (7.70)	44.11
T_9(70%BF+30%RF)		7.71 (10.20)	7.04 (8.60)	7.53 (7.43)	7.6 (9.13)	7.71 (10.57)	7.53 (8.17)	45.12
T_{10}(60%BF+40%RF)		7.75 (10.40)	7.05 (9.07)	7.57 (7.97)	7.64 (9.80)	7.55 (8.23)	7.62 (9.37)	45.18
T_{11}(50%BF+50%RF)		7.73 (10.17)	7.02 (8.93)	7.62 (8.50)	7.51 (7.73)	7.51 (8.03)	7.6 (9.17)	44.99
T_{12}(100%RF)	70°C	7.84 (11.63)	7.16 (11.00)	7.8 (11.53)	7.57 (8.43)	7.53 (8.20)	7.62 (8.67)	45.12
T_{13}(100%BF)		7.57 (8.43)	6.92 (7.27)	7.5 (7.30)	7.6 (8.80)	7.55 (8.53)	7.46 (7.23)	44.6
T_{14}(80%BF+20%RF)		7.48 (6.87)	6.90 (7.33)	7.64 (9.13)	7.55 (8.27)	7.51 (7.97)	7.53 (7.50)	44.61
T_{15}(70%BF+30%RF)		7.53 (7.43)	7.05 (9.13)	7.53 (7.13)	7.62 (8.87)	7.6 (10.27)	7.57 (8.70)	44.9
T_{16}(60%BF+40%RF)		7.82 (11.33)	7.12 (10.23)	7.86 (12.30)	7.71 (10.57)	7.73 (11.03)	7.71 (10.37)	45.95
T_{17}(50%BF+50%RF)		8.11 (14.97)	7.49 (14.70)	8(12.77)	8.08 (14.90)	8.06 (14.27)	8.11 (15.43)	47.85
W		**.299****	**.262****	**.203****	**.201****	**.144****	**.226****	

Value in parentheses are mean rank scores based on Kendall's W which was significant

(** Significant at 1% level) **(RF – Rice flour, BF – Banana flour)**

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The highest mean score for appearance of jaggery based *payasam* was 8.11 for T_{17} and lowest mean score of 7.35 was noticed in T_2 and T_8.

Among different treatments tried for the preparation of jaggery based *payasam* the highest mean score for colour (7.49) was recorded for T_{17}.The lowest mean score of 6.73 for colour was noticed in T_1.

The mean score for flavour for jaggery based *payasam* ranged from 7.44 - 8. The lowest mean score of 7.44 was noticed in T_7 and the highest score (8.0) was noticed in T_{17} and T_0.

Among different treatments tried for the preparation of jaggery based *payasam* the highest mean score for texture (8.08) was recorded for T_{17}. The lowest mean score of 7.42 for texture was noticed in T_8.

The mean scores for taste of jaggery based *payasam* ranged from 7.46 - 8.06 with highest score for T_{17}. Among the different treatments tried, the lowest mean score of 7.46 for taste was noticed in T_7.

Among the different treatments tried for jaggery based *payasam* the highest rank score for overall acceptability was noticed in T_{17} (8.11). The lowest mean score of 7.46 was recorded for T_7.

The mean rank scores for treatments T_0 to T_{17} varied from 5.30 to 14.97 for appearance, 5.87 to 15.60 for colour, 6.70 to 13.63 for flavour, 6.67 to 14.90 for texture, 7.13 to 14.27 for taste and 7.4 to 15.43 for overall acceptability.

The treatment T_{17} obtained a slightly higher total score of 47.85 compared to other treatments.

In the preparation of jaggery based *payasam* it was observed that *payasam* prepared from blended *ada* (50% rice flour and 50% banana flour) dried at 70°C for 2 hrs attained a score higher than the *payasam* prepared with rice flour alone.

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The treatment T_{17} was selected as the best treatment, from the mean score attained through the organoleptic evaluation of *ada*, milk based *payasam* and jaggery based *payasam* (Plate 10 and 11). Hence, treatment (T_{17}) was subjected for shelf life studies.

4.3.2. Keeping quality

Ada from treatment T_{17} was prepared and stored in polyethylene bags for three months.

4.3.2.1. Moisture content of *payasam ada*

The moisture content of stored *payasam ada* are given in the table 21.

Table 21. Moisture content of stored *payasam ada*

Storage period in days	Moisture $g100g^{-1}$
Initial	10.01
1st month	10.35
2nd month	11.22
3rd month	11.63

As observed in the table 21 the moisture content of *payasam ada* gradually increased with storage period. The initial moisture content of *payasam ada* was 10.01 g $100g^{-1}$. With the storage period of three months the moisture content increased to 11.63 g $100g^{-1}$.

The mean score obtained for the organoleptic evaluation of milk based *payasam* at monthly intervals for a period of 30 days are furnished in Table 22.

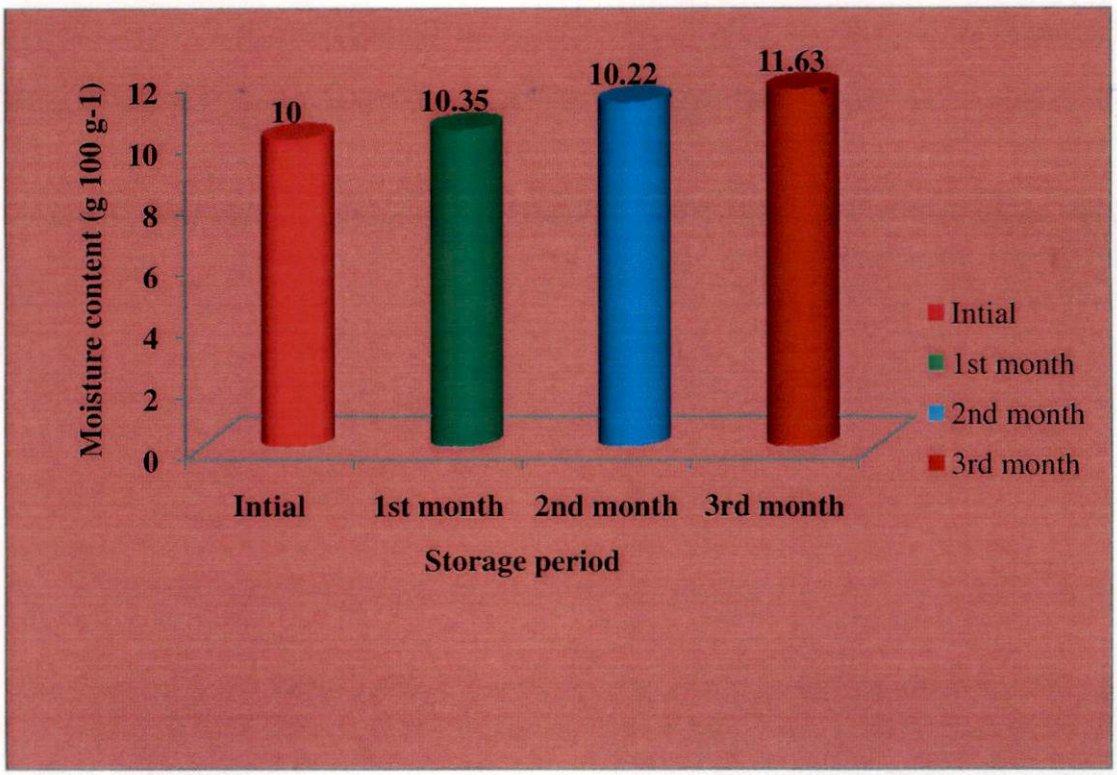

Figure 17.Effect of storage period on the moisture content of *payasam ada*

Plate 10. Jaggery based *payasam*

Plate 11. Milk based *payasam*

Table 22. Mean scores for organoleptic qualities of milk based *payasam* at monthly intervals

Parameters	Initial	1st month	2nd month	3rd month
Appearance	7.71	7.75	7.80	7.85
Colour	7.49	7.53	7.60	7.80
Flavor	7.33	7.50	7.65	7.70
Texture	7.82	7.83	7.85	7.86
Taste	7.95	7.99	8.0	8.30
Overall acceptability	7.91	8.0	8.1	8.19
Total score	46.21	46.6	47	47.7

Milk based *payasam* attained a maximum initial score of 7.71 for appearance. The score for this attribute gradually increased with storage. It was 7.75, 7.80 and 7.85 at the end of first, second and third month respectively.

The colour of the milk based *payasam* attained an initial score of 7.49. The colour of *payasam* increased during storage period. It was 7.53, 7.60 and 7.80 at the end of first, second and third month respectively.

The mean score for the attribute flavour also increased with storage. The initial score obtained was 7.33 which gradually increased to 7.50, 7.65 and 7.70 at the end of first, second and third month of storage respectively.

Texture of milk based *payasam* scored a maximum of 7.82 initially; it increased to 7.86 in after the third month of storage.

The taste of milk based *payasam* attained a maximum initial score of 7.95 which increased during the storage period. It was 7.99, 8 and 8.30 at the end of first, second and third month respectively.

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The overall acceptability of milk based *payasam* scored a maximum of 7.91, initially. It gradually increased during third month of storage to a score of 8.19. A mean score of 8.0 and 8.1 was observed at the end of first and second month of storage respectively.

The initial total score for milk based *payasam* was 46.21 and it gradually increase to 47.7 during storage.

Table 23. Mean scores for organoleptic qualities of jaggery based *payasam* at monthly intervals

Parameters	Initial	1st month	2nd month	3rd month
Appearance	8.11	8.15	8.20	8.32
Colour	7.60	7.8	7.81	7.83
Flavor	8.0	8.25	8.3	8.43
Texture	8.08	8.10	8.25	8.31
Taste	8.06	8.15	8.20	8.36
Overall acceptability	8.11	8.23	8.33	8.42
Total score	47.96	48.68	49.09	49.67

Jaggery based *payasam* attained a maximum initial score of 8.11 for appearance. The score for this attribute gradually increased with storage. It was 8.15, 8.20 and 8.32 at the end of first, second and third month respectively.

The colour of the jaggery based *payasam* attained an initial score of 7.60. The colour of *payasam* increased during storage period. It was 7.80, 7.81 and 7.83 at the end of first, second and third month respectively.

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The mean score for the attribute flavour also increased with storage. The initial score obtained was 8.0 which gradually increased to 8.25, 8.30 and 8.43 at the end of first, second and third month of storage respectively.

Texture of jaggery based *payasam* scored a maximum of 8.08 initially; it increased to 8.31 after the third month of storage.

The taste of jaggery based *payasam* attained a maximum initial score of 8.06 which increased during the storage period. It was 8.15, 8.20 and 8.30 at the end of first, second and third month respectively.

The overall acceptability of jaggery based *payasam* scored maximum of 8.11, initially. It gradually increased during third month of storage to a score of 8.42. A mean score of 8.23 and 8.33 was observed at the end of first and second month of storage.

The initial total score for jaggery based *payasam* was attained 47.96 and it was increased during third month of storage (49.67)

4.3.2.2. Microbial count in *payasam ada*

The microbial population of the *payasam ada* was assessed at monthly intervals for a period of three months and the results are presented in Table 24.

Table 24.Total microbial count of *Payasam ada* (cfu g^{-1})

Period of storage	Microbial population (cfu g^{-1})		
	Bacteria ($\times 10^6$)	Fungi ($\times 10^5$)	Yeast ($\times 10^5$)
Initial	1.00	ND	ND
1st month	1.3	ND	ND
2nd month	2.00	ND	ND
3rd month	2.53	1.20	ND

ND - Not detected

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The initial bacterial count was found to be 1.00×10^6 cfu g^{-1}, which increased gradually to 2.53×10^6 cfu g^{-1} during the end of third month. The first and second month had 1.3×10^6cfu g^{-1} and 2.00×10^6 cfu g^{-1} respectively.

The fungal growth was not detected in initial, first month and second month of storage. During 3rd month a fungal growth of 1.20×10^5 cfu g^{-1} was detected.

Yeast growth was not detected throughout the storage period.

4.4. Cost of production of selected products

The cost of production of Grand Naine banana chips, Grand Naine banana flour and *payasam ada* was estimated per 1 kg of finished product and the details are furnished in Table 25 and Appendix III.

The cost of production of Grand Naine banana products are presented in table 25.The cost varied from Rs. 200 to Rs. 230 / k g for Grand Naine banana chips. The cost incurred for the production of Grand Naine banana flour was Rs. 230/ kg and the cost for the *payasam ada* was found to be 204 /kg.

Table 25. Cost of production of Grand Naine banana products

Products	**Cost (Rs/kg)**
Grand Naine chips (salt)	200.00
Grand Naine chips (salt + pepper)	230.00
Banana flour	230.00
Payasam ada	204.00

DISCUSSION

5. DISCUSSION

The results of the study entitled Nutritional and organoleptic qualities of value added products from banana . *Musa* (AAA Group) 'Grand Naine' are discussed under the following headings.

5.1. Preparation of Grand Naine banana chips

5.1.1. Physical analysis

5.1.2. Organoleptic evaluation

5.1.3. Keeping quality

5.2. Standardisation of Grand Naine banana flour

5.2.1. Organoleptic evaluation of banana flour

5.2.2. Physico – functional properties of selected flour

5.2.3. Nutritional properties of flour

5.2.4. Keeping quality of banana flour

5.3. Standarisation of secondary product – *Payasam ada*

5.3.1. Organoleptic qualities of the products

5.3.2. Keeping quality

5.4. Cost of production of selected products

5.1. Preparation of Grand Naine banana chips

Fully mature unripe banana was washed in clean water. It was peeled manually and the fruits were cut into uniform size of 2 mm thickness. After slicing they were divided into two lots and were fried in refined oil. One lot was salted and the other was salted and spiced (3g pepper powder /100g).

5.1.1 Physical analysis of Grand Naine banana chips

The physical analysis like frying time, oil content, moisture content, weight gain and product recovery of fresh Grand Naine banana chips were analysed.

The frying time for Grand Naine banana chips was 3 minutes. Molla *et al.*, (2009) reported a similar frying time of 3 minutes for different banana varieties (BARI Kola -1, BARI Kola – 2 and Sabari Kola) The rate of water removal depends

on frying time and temperature. The required frying time was 10 minutes at 170^{0}C for attaining a moisture content of 4 per cent in jackfruit chips (Molla *et al.*, 2008).

The intimate contact between the frying oil and the surface of slices ensures high heat and mass transfer rate. Chips with low oil uptake are considered to be of good quality, oil content of freshly prepared Grand Naine banana chips for salted (T_1) and spiced chips (T_2) were found to be 38.67 and 39.74 per cent respectively. The oil content of banana chips for BARI Kola -1, BARI Kola – 2 and Sabari Kola was found to be 29 per cent, 35 per cent, and 38 per cent respectively (Molla *et al.,* 2009). Oil content of Nendran banana chips was found to be 40.34 per cent. Treating with anti oxidants like sodium ascorbate, tocopherol acetate and dried curry leaf powder reduced the oil content of Nendran chips during storage to 31.60, 31.10 and 30.25 per cent respectively (Adrika *et al.*, 2015). Ufheil and Escher (1996) reported a final oil content of 35 per cent in potato chips. The oil content of freshly prepared jack fruit chips was found as 45 per cent at 170^o C (Molla *et al.,* 2008). Similar observation was found in papaya chips also (Rahman and Shamsuddin, 2003).

The moisture content of chips is dependent on relative humidity of the storage structure and method of processing. The salted chips had slightly higher moisture content (2.43 g 100g^{-1}) than chips prepared by adding salt along with pepper (2.28 g 100 g-1), but there was no significant difference. Adrika *et al.*, (2015) reported that the addition of different pretreatments reduced the moisture content compared to untreated chips. Sharon (2003) has reported that the moisture content of bread fruit chips was found to be 3.94 g 100 g^{-1} and after blanching and frying, moisture content lowered to 2.02 g 100 g^{-1}. Molla *et al.* (2009) and Ufheil and Escher (1996) reported a moisture content of 5 per cent in banana chips and 4 per cent in potato chips respectively.

Fried foods shrink when the moisture is lost and the food cells collapse as a consequence of heating and evaporation during frying. Decrease in the product dimension occurs when heat induced evaporation occurs (Krokida, 2000).The product

recovery of Grand Naine banana chips was found to be 39.86 per cent in salted chips and 39.66 per cent in chips prepared using salt along with pepper. Nendran banana treated with different antioxidants (66 – 64 per cent) had lower product recovery compared to untreated chips (70 per cent) due to lower oil uptake and moisture content (Adrika *et al.*, 2015).

5.1.2. Organoleptic evaluation of Grand Naine chips

The treatments (T_1 and T_2) secured mean score of more than 7 for all organoleptic attributes. The treatment T_2 attained highest score for five attributes like flavor, texture, taste, crispiness and overall acceptability. The highest score for appearance and colour was obtained by T_1. A slightly higher total score was attained for Grand Naine banana chips flavoured with pepper powder. Sonia *et al.* (2015) also prepared that flavoured banana chips and found that powdered form of spices is imparting superior sensory qualities. Tarko *et al.* (2010) conducted a study on production of flavoured apple chips and reported that pepper flavoured chips was more acceptable in comparison to apple chips of garlic, onion and ginger flavour.

5.1.3. Keeping quality

5.1.3.1. Peroxide value

Peroxide value represents the rancidity factors of deep fat dried products. A low peroxide value considered to be the criteria for good quality chips. The initial peroxide value of T_1 and T_2 were 6.025 and 6.133meq/O_2/kg respectively. Sonia *et al.* (2015) also reported comparatively same peroxide value in nendran type banana chips (6.27meq/O_2/kg). An increase in peroxide value was observed for chips packed and stored in polyethylene bags and laminated pouches. At the end of storage, spiced chips packed in laminated pouches had least peroxide value compared to salted chips in polyethylene bags. Sonia *et al.* (2015) reported that banana peel added chips had lower peroxide value compared to untreated chips throughout the storage period. After 90 days of storage banana peel treated banana chips in modified atmospheric

package had least peroxide value whereas untreated chips in low density polyethylene had highest peroxide value. Peroxide value of fresh oils is less than10 milliequivalents/ kg. When the peroxide value is between 30 and 40 milliequivalents/ kg a rancid taste is noticeable (FSSAI, 2003). Tarko *et al.* (2010) observed a considerably higher antioxidant activity for apple chips of pepper flavour compared with chips of garlic, onion and ginger flavour.

A comparatively low peroxide value was noticed for chips flavoured with pepper compared to T_1 and T_3 (salted chips packed in laminated pouches). This may be attributed to the antioxidant potential of pepper. Spicy chips are becoming popular in our market and several spices are added during chips preparation to enhance flavor and to create variability. Garlic (Imai *et al.*, 1994), black pepper (Agbor *et al.*, 2006), curry leaf (Biswas *et al.*, 2006) coriander leaves (Wangensteen, *et al.*, 2004) are reported to have potent antioxidant activity.

5.1.3.2. Moisture content

Moisture content of chips depend upon the relative humidity and processing methods. The salted chips expressed higher moisture content (2.43 $g100g^{-1}$) than salted along with pepper chips (2.28 $g100g^{-1}$). This can be explained, by the fact that addition of pepper powder to chips lowered moisture content compared to salted chips. During one month of storage the lowest moisture content (5.463 $g100g^{-1}$) was observed in spiced chips packed in laminated pouches.

Molla *et al.* (2009) observed that fried banana chips had a moisture content of 4 g/100g. They also reported that during two month of storage period moisture content increased in chips and the lowest moisture content of 5.4g/100g was observed in chips packed in metalex foil pouches. On the other hand chips packed in low density polypropylene pouches obtained the highest moisture content (5.9 g/100g). Moisture content of chips packed in both packaging materials showed a gradual increase during storage and this was in agreement with results of Adrika *et al.* (2015)

who had recorded a gradual increase in moisture content during storage in laminated pouches. Moisture content of chips packed a pouch is dependent on the relative humidity of the surroundings. The chips absorbed moisture from the storage atmosphere. Sonia *et al.* (2015) reported that addition of banana peel was effective in improving the quality of chips. Banana peel treated chips packed under MAP in laminated pouches showed low moisture (6.83 g/100g) at 90 days of storage.

5.1.3.3. Organoleptic evaluation of stored Grand Naine chips

The organoleptic evaluation of stored Grand Naine chips revealed that the mean scores for all organoleptic attributes decreased with days of storage in both type of chips and for both packaging materials.

Molla *et al.* (2008) found significant variation in sensory attributes of jack fruit chips in different packaging materials for 60 days of storage. The gradual decrease in colour score during storage may be attributed to fading of samples acquiring dull appearance (Patil, 2003) or might be due to browning of chips during storage (Roopa *et al.*, 2006). A significant change in the colour of bread fruit chips after 45 days of storage was observed by Sharon (2003). The flavour of chips decreased from 7.49 to 6.43 and 7.49 to 7.02 when stored in polyethylene bags and laminated pouches respectively. In spiced chips it decreased from 7.74 to 6.88 and 7.74 to 7.25 respectively. The decrease in flavour score might be due to some changes in chemical constituents like sugar during storage and may also occur due to the formation of free fatty acids from oil used for frying (Patil, 2012). The significant decrease in organoleptic score of the product during storage might be due to the decline in flavouring and chemical constituents of products.

A slightly higher total mean score was attained for Grand Naine banana chips packed in laminated pouches after 30 days of storage. Molla *et al.* (2008) found significant variations in sensory attributes of jack fruit chips in different packaging materials for 60 days of storage. The colour, flavour and overall acceptability of chips

were found good in metalex foil pouch upto two months of storage. Laminated pouches are considered to be more score intact and act as good barrier to all gasses and moisture.

5.2. Standardisation of Grand Naine banana flour

The mature Grand Naine banana was peeled under water and dipped in a solution of ascorbic acid and citric acid for two time periods. Then it was sliced to an average thickness of 1 cm. The slices were dried at 50°c for 48 hrs in a hot air oven. The dried chips was ground and sieved to get an uniform flour. Abbas *et al.* (2009) reported that banana flour weighing, 183.4 and 274.3 g were obtained from Cavendish and Dream banana respectively. The average yields of Grand Naine banana flour were 130 – 135 g/kg of banana respectively. Loypimai and Moongngarm (2015) prepared banana flour, by dipping banana in citric acid solution for 10 minutes to reduce enzymatic browning. Selvamani *et al.* (2009) also prepared banana flour; by treating banana with 0.05 per cent sodium metabisulphite and drying at 50^0c for 48hr in air oven. Joshi and Varma (2015) prepared banana flour by treating banana with 0.05 per cent sodium metabisulphite for 5 minutes and drying in oven at 60°C for 18 hrs. Ascorbic acid along with citric acid help to reduce the browning reaction.

5.2.1. Organoleptic evaluation of banana flour

Banana flour was prepared and evaluated organoleptically by preparing porridge. Among different treatments tried for preparing banana flour, the organoleptic attributes such as colour, flavour, texture were found to be higher in T_5 and had good taste and overall acceptability. The treatment T_{10} has lowest score for flavour, texture, taste and overall acceptability. The treatment T_4 scored the highest for appearance and colour. The treatment T_1 has comparatively low score for colour because it had no blanching procedure. The treatment T_1 had slightly brown colour due to the enzymatic browning and it had slight astringent taste due to the presence of

tannins and polyphenols. Ardiansyah (2005) reported that the fading of colour in banana flour was due to maillard reaction.

The organoleptic attributes such as texture, taste and overall acceptability were found to be higher in T_5. For any porridge the base material is the flour of the corresponding ingredient is important. The cohesion and visocity of the porridge is totally dependent on the physical properties of the flour of which texture is of utmost importance followed by taste and flavour. Based on this T_5 was adjudged as best with regarding to banana flour. Pragathi *et al.* (2014) reported a good sensory acceptability for banana flour. Nasheeda (2006) prepared porridge from 11 banana varieties. The total scores for porridge ranged from 11.68 to 22.52 and the overall acceptability from 2.94 to 7.62 for Matti and Nendran respectively. Lakshmy (2003) observed the sensory quality of varieties of Nendran banana flour porridge. The score for appearance and colour of the porridge prepared from the flour of Nendran type Chengalikodan and Kaliethan respectively was very low due to the slight ash colour of porridge prepared from these varieties, which might be due to because of the presence of browning compounds. Mary (2005) reported that the flavor, texture and overall acceptability of drum dried and spray dried banana powder were on par with other organoleptic qualities. The spray dried banana powder colour (4.8) was very good compared to drum dried powder.

5.2.2. Physico – functional properties of Grand Naine banana flour

Based on organoleptic evaluation T_5 (Banana slices dipped in 1 per cent ascorbic acid and 0.5 per cent citric acid and dried at 50^0C for 48 hour) was selected for further studies. The selected banana flour was evaluated for the physico – functional properties like pH, moisture content, water holding capacity, oil absorption capacity and bulk density. The flour was stored in polyethylene bags for duration of three months and was analysed at monthly intervals.

The numeric scale used to specify the acidity or basicity of aqueous solution is pH. The pH value of freshly prepared Grand Naine banana flour was 4, which increased during storage and reached 5.03 within a period of three months of storage. A lower pH could be attributed to the presence of organic acids (Wyman and Palmer, 1964). Abbas *et al.* (2009) reported that the average pH of Cavendish banana flour (4.77) was slightly lower than that of Dream banana (4.63). Borges *et al.* (2009) reported that the pH of green banana flour as 5.30. Borba (2005), found a pH of 5.70 for sweet potato flour.

Fernandes (2006) studied the composition of flour from potato peel and found a pH of 4.96. Sahoo *et al.* (2015) found that pH remained constant throughout the storage period. The effect of different drying methods on pH of banana powder was recorded and it was observed that solar dried banana powder showed a pH of 5.78 and cabinet dried banana flour recorded a pH of 5.66.

Gradual decrease in moisture content of Grand Naine banana flour was observed during storage. The initial moisture content of the flour was 3.17g 100 g^{-1} which increased to 4.19, 4.5 and 5.13 g $100g^{-1}$ during the end of first, second and third months of storage respectively. The increase moisture in content is attributed to the hygroscopic nature of the flour. Pragathi *et al.* (2004) reported that the moisture content of ripe Cavendish banana and unripe Cavendish banana flour was 8.9 and 9.11 g $100g^{-1}$ respectively. Unripe banana flour contains high amount of starch which has crystalline structure containing amylase (1.4 α glycosidic linkage) and amylopectin (branched structure 1-4 α glycosidic linkage) and does not readily participate in hydrogen bonding with water molecules. Maximum moisture obtained by ripe and unripe banana flour was 11.02 and 11.18 per cent respectively, which is below the recommended value of fruit powders (13per cent) and is stable from microbial deterioration (Potter and Hotchkiss, 1995)

The water holding capacity of freshly prepared Grand Naine banana flour was 3g water/g flour. The water holding capacity of flour gradually increased after the third month of storage to 4.29g water/g flour. These values are higher than those reported in water holding capacity of Cavendish banana flour ranged from 0.85 – 2.57 g water/g dry sample and the dream banana flour ranged from 0.52 – 2.68 g water/g flour. Abbas *et al.* (2009) reported a similar result for water holding capacity of fibre rich unripe banana flour (2.5 g water/g flour) (Ambriz *et al.* 2008). Larrauri *et al* (1996) reported that the water holding capacity of mango dietary fibre was 11 g water /g sample. Water activity of the unripe banana flour increased with time due to hygroscopic nature of flours. Hygroscopicity is due to the attainment of equilibrium between product and surrounding environment at particular relative humidity and temperature conditions. Water holding capacity is related to physical state of starch, fibre and protein of the flour during storage. It was the release of amylase which has the capacity to effectively bind water molecules yielded higher water holding capacity (Ambriz, 2008). Good water holding capacity of banana flour can be utilized as a thickener for use in liquid and semi liquid foods (Abbas *et al.*, 2009).

Oil absorption capacity is an important functional property of banana flour and an increase during storage was also observed in Grand Naine banana flour ranging from 0.86 – 1.15g oil/g flour. These values are slightly similar to that reported for Cavendish banana flour (0.93 – 0.99 g oil/g flour) and Dream banana flour (0.84 – 1.05 g oil/g flour) by Abbas *et al*, (2009). These values are slightly lower than that reported in fibre rich banana powder that could hold 2.2 g oil/g flour (Ambriz, 2008). Oil absorption capacity is related to the hydrophilic character of starch which is abundant in banana flour and fibre rich powder of banana flour (Ambriz, 2008). Good oil absorption capacity of the flour makes it useful in food preparations that involve oil mixing, such as in bakery products (Abbas *et al.*, 2009).

Bulk density is the ratio of the mass of the particle to the volume of the particle. It affects the flowability of the green banana flour; therefore it can affect the

conveying and storage properties. Pragathi *et al.* (2014) reported the bulk density of freshly prepared Grand Naine banana flour as 1.87g/ml. The bulk density of flour gradually decreased with storage. Pragathi *et al.* (2014) also observed that the bulk density of unripe Cavendish banana flour was found to be 0.67g/ml and after 60 days it was decreased to 0.65g/ml. Pragathi *et al.* (2014) reported that the ripe Cavendish banana flour contain higher bulk density (0.72 g/ml) was compared to unripe banana flour which might be due to higher water activity of ripe banana powder.

The prepared Grand Naine banana flour was evaluated for the nutritional properties like TSS, total sugar, reducing sugar, starch, protein, fibre, calcium, phosphorus, iron, potassium, *in vitro* digestibility of starch and *in vitro* availability of minerals. The flour was stored in polyethylene bags for duration of three months and was analysed initially and at the end of three months of storage.

The TSS of freshly prepared Grand Naine banana flour was 4.03^0 brix and it increased to 5.1^0 brix after the third month of storage which is similar to the findings of Abbas *et al.,* (2009), who reported that the Cavendish banana has a TSS of 4.79^0 brix and Dream banana flour had 5.03 ^{0}brix. TSS of banana fruits increased with the increase in storage duration, due to conversion of complex polymers into simple substance. (Sarode and Tayade 2009). Swami *et al.* (2012) reported that Grand Naine banana flour had high TSS (5.75 ^{0}brix) compared to other banana varieties like Rasthali, Saba, Bluggoe, Rajapuri,Chandrabali and Udhyam due to fruit pulp varietal characters. Sharon (2003) reported that the TSS of the bread fruit flour was 5.53 ^{0} brix.

The total sugar content of freshly prepared Grand Naine banana flour was 1.73 per cent, which increased to 2.02 per cent after the storage period of three months. Joshi and Varma (2015) reported a higher value of 4.62 per cent in Grand Naine banana flour. Sahoo *et al.* (2015) reported that there was a significant increase in total sugar content of banana powder at ambient storage condition. The solar dried

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banana flour contained 1.60 per cent and cabinet dried banana flour had a total sugar content of 1.86 per cent. It increased to 2.80 and 2.39 per cent respectively during storage. The increase in total sugars with storage may be attributed to the breakdown of insoluble polysaccharides into simple sugars like hydrolysis of pectin and starch into simple sugars (Mulla, 2007; Relekar *et al.*, 2011).

The reducing sugar content of Grand Naine banana flour was found to be 1.26 per cent initially and 1.43 per cent was observed at the end of third month. Sahoo *et al.* (2015) reported that the reducing sugar content of solar dried banana flour and cabinet dried banana flour ranged from 1.00 percent and 1.21 per cent and it increased to 1.34 and 1.75 respectively during storage. The reducing sugar content of banana flour also follows an increasing trend with days of storage which may be due to hydrolysis of non reducing sugars due to the presence of organic acid, which might have resulted in degradation of disaccharides to monosaccharides as described by Mulla, (2007)

Gradual decrease in starch content of banana flour was observed during storage period. The initial starch content of the flour was 70.00 g 100 g^{-1} which decreased to 66.8 g 100g^{-1} during the third months of storage. Starch content of banana flour prepared from nendran banana varieties varied from 61.9 g 100g-1 to 64.6 g 100g^{-1}(Lakshmy, 2003). The starch content decreased during storage time because the starch molecules are converted to simple sugars and the conversion depends upon time and temperature of storage period. Sharon (2003) also reported that the starch content in bread fruit flour decreased during storage and ranged from 63.53 to 65.67 g 100 g^{-1}.

The protein content of freshly prepared Grand Naine banana flour was found to be 3.6 g 100 g^{-1}. The protein content showed a decreasing trend from initial to third month of storage. A protein content of 3.4 g 100 $g^{-1}$was observed at the end of third month storage These values were lower than those reported in Nendran

banana varieties (4.20 to 4.48 g /100g) (Lakshmy, 2003). During storage certain amino acids (e.g. lysine) chemically bind with simple sugars to form brown pigments through maillard reaction. The reaction affects the nutritional value of the food because it causes the essential amino acid to become physiologically unavailable (Hurst *et al.,* 1993).

The fibre content of freshly prepared Grand Naine banana flour is 2.62 g 100 g-1 and it decreased on storage with no significant difference. A fibre content of 2.55 g100 g-1 was observed at the end of third month of storage. The gradual decrease of fibre during storage is due to the degradation of polysaccharide into simple form. These values were higher than those reported in banana flour of different Nendran varieties (0.08 – 0.14 g/100g) (Lakshmy, 2003).

The *in vitro* digestibility of starch content of freshly prepared Grand Naine banana flour was found to be 76.1 per cent and it decreased during storage to 73 per cent. It may be due to the result of Maillard reaction, in which free amino group of protein and carbonyl group of reducing sugar form a complex intermediate compounds. The complex compounds might have inhibited the activity of proteiolytic and amylolytic enzymes causing reduction of starch digestibility during storage (Marshall and Chrastil, 1992).Vatanasuchart *et al,* (2012) reported that the *in vitro* digestibility of different banana cultivars (Kluai Hom (AAA) Kluai Khai (AA), Kluai Lebmuenang (AA),Kluai Namwa (ABB),Kluai Hakmuk (ABB),Kluai Hin (BBB) ranged from 52 – 68 percent.

Minerals are considered essential for human nutrition and generally, minerals from plant sources are less bioavailable than those from animal sources (Lopez *et al.,* 2002). Banana flour contains different minerals. The calcium content of freshly prepared Grand Naine banana flour was found to be 60.34 mg $100g^{-1}$. The calcium content decreased at the end of storage to 58.92 mg $100g^{-1}$. Lakshmy (2003) observed that the calcium content of different Nendran varieties of banana flour were

57.3 mg 100g-1 at the initial stage and reached 51.9 mg 100 g^{-1} at the end of storage (Nasheeda, 2006). Afoakwa and Dedeh (2001) reported that the *in vitro* availability of calcium for Dioscorea tubers as 53.1 and 57.8 mg 100 g^{-1} for yellow and white tubers respectively. Oduje *et al* (2015) reported that the unripe banana peel flour contain high amount of calcium that is 100 mg /g compared to ripe plantain banana peel flour (86 mg/g) and over ripe plantain banana peel flour (59 mg/g).

The mean phosphorus content of Grand Naine banana flour ranged from 70.5 mg $100g^{-1}$ to 72.5 mg100 g^{-1}. Highest phosphorus content was seen in the initial day of storage. Lakshmy (2003) reported that the phosphorus content of Nendran varieties of banana flour was found to be 63.9 to 69.4 mg $100g^{-1}$. The phosphorus content (360 mg/g) was high in unripe banana peel flour compared to ripe banana pulp flour (Oduje *et al.*, 2015).

The iron content of freshly prepared Grand Naine banana flour was found to be 6.75 mg$100g^{-1}$ initially and it decreased after the third month of storage to 6.54 mg$100g^{-1}$. Lakshmy (2003) analysed the iron content of different Nendran varieties of banana flour. The range of iron content was 4.9 to 6.1 mg $100g^{-1}$. A gradual decrease in iron content was noticed during storage period. The iron content of Cavendish and Dream banana flour was 1.21 and 1.04 mg/100g respectively.

The potassium content of freshly prepared Grand Naine banana flour was found as 410.5 mg $100g^{-1}$. A decrease in potassium content to a value of 396.0 mg/$100g^{-1}$ was observed after the third month of storage. Lakshmy (2003) reported that the potassium content of Nendran banana flour as 591.3 mg 100g-1 at the initial stage and 553.2 at the end of storage. Anhwange (2008) reported that banana varieties contain high amount of potassium 78.1 mg $100g^{-1}$. The result agree with Akinyoye (1991) that banana fruit has high amount of potassium. Oduje (2015) observed that the potassium content of Cavendish banana peel flour and dream banana peel flour as 679.71 and 699.56 mg 100 g^{-1} respectively.

Mineral losses can occur by heat induced chemical reaction between reducing sugars and amino acids and or proteins to form compounds that bind minerals (Dandago, 2009). These reaction products are more resistant to digestion and hence capable of having their mineral binding properties to remain intact. Considerable amounts of some soluble minerals are dissolved in water and leads to mineral loss during processing and storage due to hygroscopic nature of the product.

The bioavailability of a mineral or trace element is defined as the fraction of the ingested nutrient that is absorbed and subsequently utilised for normal physiological functions (Susan and Hurrell, 1996). Mineral availability depends on its solubility and mobility and also on availability of water (free water). *In vitro* availability of calcium in freshly prepared Grand Naine flour was found to be 30.22 per cent, which decreased to 28.63 per cent in Grand Naine banana flour during storage. Phosphorus content present in Grand Naine banana flour had an initial, *in vitro* availability of 56.50 per cent which decreased to 54.24 per cent at the end of storage. Both iron and zinc had comparatively higher *in vitro* availability of 65.25 per cent and 61.98 per cent respectively in freshly prepared Grand Naine banana flour. Amiri and Arzani (2006) reported that the *in vitro* availability of calcium content in Cavendish banana was 40-77 percent, the available phosphorus content is 69 -89 percent and the availability of iron and zinc were 55 – 97 per cent and 66 – 86 per cent respectively. Neethu (2012) reported the *in vitro* availability of minerals present in germinated rice. During germination process the bioavailability of minerals like calcium, iron and phosphorus is increased compared to initial stage due to the absence of phytate and antinutritional factors. The presence of antinutrional factors and phytate content reduce the availability of minerals.

5.2.4. Keeping quality

Based on organoleptic qualities of Grand Naine banana flour T_5 was adjudged as the best treatment. The flour was stored in polyethylene bags for a period of three months. A slight brown colouration was observed which may be due to maillard reaction and increase in moisture content. Porridge was prepared from the flour at monthly intervals for duration of three months and was subjected to organoleptic evaluation. Decreases in mean scores for all the organoleptic attributes with storage were noticed. Lakshmy (2003) observed the sensory quality of varieties of Nendran banana flour by preparing porridge. The score for appearance and colour of the porridge prepared from the flour of *nendran* type *chengalikodan* and *kaliethan nendran* respectively were very low due to the slight ash colour of porridge prepared from these varieties. Nasheeda (2006) prepared porridge from 11 banana varieties. The total scores for porridge ranged from 11.68 to 22.52 and the overall acceptability from 2.94 to 7.62 for matti and nendran respectively. Pragathi *et al* (2014) Sensory properties of banana flour were evaluated at monthly intervals and significant decrease was observed in aroma of unripe banana flour and ripe banana flour due to various deteriorative reaction such as accumulation of moisture, lipid oxidation, leaching of minerals and increase in TPC (Total Plate count) during storage. Mary (2005) reported that the banana powder can be stored for one year under ambient conditions without deterioration when packed in aluminium pouches with nitrogen.

5.2.4.1. Microbial count in banana flour

The quality of banana flour depends on different factors. In this study banana flour was stored in polyethylene bags and evaluated for microbial contamination. The microbial population of the banana flour was assessed at monthly intervals for a period of three months.

The initial bacterial count was found to be 0.59×10^6 cfu g^{-1}, which increased gradually to 3.13×10^6 cfu g^{-1} during third month. The first and second month had a

bacterial count of 2.02 $\times 10^6$ cfu g^{-1} and 2.57 × 106 cfu g^{-1} respectively. The fungal growth was not detected in initial and first month of storage. During the end of a second month fungal growth of 1.25×10^5 cfu g^{-1} was detected and it was increased during third month of storage to 1.32 10^5 cfu g^{-1}. Pragathi *et al.,* (2014) reported that microbial population of unripe banana flour and ripe banana flour increased with increase in storage period. It shows that ripe banana flour is more prone to microbial infections as it contains sugars. Total plate Count (TPC) of unripe banana flour and ripe banana flour was upto 23333 CFU/ml and 30333 CFU/ml respectively in the storage period of 60 days. Babajide *et al.* (2010) reported that bacterial and fungal growth decreased on packing in high density polyethylene (HDPE) compared to polyethylene bags.

5.3. Standarisation of secondary product – *Payasam ada*

Ada was standardized by incorporating the banana flour at different levels with rice flour. The dough prepared with the flour was used to make *payasam ada* by traditional method. The drying temperature and time for all treatment was standardized by varying temperature to 60^0C, 65^0C and 70^0C until a moisture content of 10 per cent is attained. When *ada* was dried at 70^0c a drastic reduction in time was observed. Khandker *et al.* (1986) also reported that cooking time and cooking loss of rice vermicelli extruded at 35 per cent moisture content at 55^0C temperature were 3 minutes. Sarah (2017) prepared vermicelli substituting wheat flour with different levels of unripe banana flour.

5.3.1. Organoleptic evaluation of *payasam ada*

Ada was prepared in different proportion with rice flour and banana flour at three different temperatures. *Payasam ada* prepared by blending rice flour and banana flour at a proportion of 50:50 and dried at 70^0C for 2 hours attained a maximum score for all organoleptic attributes. Hence the treatment T_{17} (50 per cent banana flour and 50 per cent rice flour dried at 70^0C for 2 hr) was adjudged as the

best for the preparation of *ada*. A slight discolouration was noticed in all treatments. The brown colour of the *ada* may be due to maillard reaction. Blending 50 per cent rice flour and banana flour attained highest score for colour and good texture compared to other treatments. Sarah (2017) reported 50:50 blend of vermicelli with wheat flour and banana flour attained the maximum score for overall acceptability.

Payasam, the south Indian counterpart of kheer is made in several variations with distinct characteristic attributed to area specific traditional methods of preparation (Unnikrishnan *et al.,* 2000). Among the different treatments tried for the milk based *payasam* the highest rank score for overall acceptability (7.91) was noticed in T_{17}. The lowest mean score of 7.22 was recorded for T_{14}. Prajeesha (2015) reported good sensory qualities for bamboo seed *payasam* prepared from cow milk. Milk proteins are known to stabilize food systems and enhance consistency and viscosity (Parry, 1974).

Among the different treatments tried for jaggery based *payasam* the highest rank score for overall acceptability was noticed in T_{17} (8.11). The lowest mean score of 7.46 was recorded for T_7. The treatment T_{17} was selected as the best treatment, from the mean score attained through the organoleptic evaluation of *ada*, milk based *payasam* and jaggery based *payasam*. The treatment T_{17} contains 50 per cent rice flour incorporated with 50 per cent banana flour.

5.3.2. Keeping quality

Ada of treatment T_{17} was prepared and stored in polyethylene bags for three months. The total organoleptic scores of milk based *payasam* prepared before the storage study was 46.21. Increases in mean score for all the organoleptic attributes were observed with storage. The same trend was seen in the preparation of jaggery based *payasam*. The total mean score for organoleptic attributes of jaggery based *payasam* increased from 46.21 to 47.7. Divaker *et al* (2014) also reported that the overall acceptability of nendran banana *payasam* mix did not vary with increase in

storage time. Pandey (2013) reported that the foxtail millet based vermicelli was stored in polypropylene bags for 6 months at ambient temperature. There was no significant change in the organoleptic characteristics at the end of the storage period. Similar studies have been reported by Gaurkirat *et al.,* (2012), who found that storage of bran enriched pasta for 4 months did not affect its overall acceptability. This may be due to the change in the amylose to amylopectin ratio. With increase in the duration of storage, straight chain amylose gets converted to amylopectin which is resistant to leaching upon cooking.

5.3.2.1. Moisture content of *payasam ada*

The moisture content of *payasam ada* gradually increased with storage period. The initial moisture content of *payasam ada* was 10.02 g 100 g^{-1}. With the storage period of three months the moisture content increased to 11.630 g 100 g^{-1}. Moisture content increased due to hygroscopic nature of the product. Developed *payasam ada* can be stored for more than three months without affecting sensory qualities.

5.3.2.2. Microbial count in *payasam ada*

The microbial population of the *payasam ada* was assessed at monthly intervals for a period of three months. The initial bacterial count was found to be 1.00×10^{6}cfu g^{-1}, which increased gradually to 2.53×10^{6} cfu g^{-1} during third month. The first and second month had 1.3×10^{6} cfu g^{-1} and 2.00×10^{6} cfu g-^{1} respectively. The fungal growth was not detected in initial, first month and second month of storage. During 3rd month a fungal growth of 1.20×10^{5} cfu g^{-1} was detected. Generally, fungal count increased throughout the storage period, probably due to storage conditions. The microbial count increased during storage because high moisture content. Products with moisture content more than 13 per cent to microbial growth and deterioration in short time (Sarah, 2017). This could also be attributed to their relative permeability to atmospheric gases such as oxygen, carbon dioxide and water vapour. .

The cost of production of Grand Naine banana chips was Rs 200 to Rs 230/kg, whereas for Nendran chips, it was Rs 350 to Rs 400/kg. The cost incurred for the production of Grand Naine banana flour was Rs 230/ kg which was low compared to commercially available banana flours. *Kunnankaya* powder is commercially available at a price of Rs 650/kg and Nendran banana flour at Rs 720/kg. The cost for *payasam ada* prepared by blending banana flour and rice flour at 1:1 ratio was Rs 204/ kg and the existing market price for rice *ada* was Rs 182/kg.

SUMMARY

6. SUMMARY

The study on the Nutritional and organoleptic qualities of value added products from banana . *Musa* (AAA Group) 'Grand Naine' was aimed to standardise value added products from Grand Naine banana and evaluate the quality attributes and shelf life of the products.

Fully mature unripe Grand Naine banana was collected from the Banana Research Station, Kannara and demonstration farm of Centre for Plant biotechnology and Molecular biology (CPBMB), Kerala Agricultural University. Grand Naine banana chips were prepared from fully mature unripe banana. It was washed in clean water, peeled manually and cut into an uniform size of 2 mm thickness. After slicing they were divided into two lots and were fried in refined oil. One lot was salted (T_1) and other was prepared by adding salt along with pepper (T_2) (3 g pepper powder/100g).

The physical analysis like frying time, oil content, moisture content, product recovery of fresh chips were determined by standard procedures. The frying time of Grand Naine chips was found to be 3 minutes. An oil content of 38.67 per cent and 39.74 per cent was observed for treatments T_1 and T_2 respectively. A moisture content of 2.43 g 100 g^{-1} was noticed in T_1, whereas T_2 had a moisture content of 2.28 g 100 g^{-1}. A slightly higher product recovery of 39.86 per cent was observed in T_1 compared to T_2 (39.66 %), but was not significant.

The prepared chips were evaluated organoleptically using score card for different quality attributes like appearance, colour, flavour, texture, taste, crispness and overall acceptability. The treatment T_2 (salt + pepper) obtained a slightly higher total score of 54.84 and T_1 had a score of 54.24 (salted chips). Both the treatments had a mean score of more than 7.5 for all organoleptic attributes.

The prepared chips were stored in polyethylene bags (250 gauge) and laminated pouches for one month. Peroxide value, moisture content was evaluated

initially and at a monthly interval of 10 days for duration of 30 days. The peroxide value increased with days of storage. The chips had an initial peroxide value of 6.025 meq/O_2/kg and 6.113 meq/O_2/kg for salted and salted along with pepper chips, respectively. During storage the peroxide value increased to 11.575 and 11.128 meq/O_2/kg for salted chips stored in polyethylene bags and laminated pouches, respectively. In chips prepared by adding salt along with pepper, peroxide value increased to 10.903 and 9.290 meq/O_2/kg when stored in polyethylene bags and laminated pouches respectively. Chips stored in laminated pouches had comparatively low peroxide value than polyethylene bags.

The initial moisture content of salted chips was 2.43 g $100g^{-1}$. After a storage period of 30 days the moisture content increased upto 6.405 g $100g^{-1}$ and 6.388 g $100g^{-1}$ when stored in polyethylene bags and laminated pouches, respectively. Chips prepared by adding salt along with pepper had a lower moisture content of 2.28 g $100g^{-1}$ which increased to 5.993 and 5.463 g $100g^{-1}$ when stored in polyethylene bags and laminated pouches respectively.

The organoleptic attributes like appearance, colour, flavour, texture, taste, crispiness and overall acceptability were evaluated. All the organoleptic attributes for both salted and chips prepared by adding salt along with pepper packed in polyethylene bags and laminated pouches attained a mean score of more than six during the entire storage period. Salted chips packed in laminated pouches attained higher total scores for organoleptic attributes throughout the period of study. The same trend was observed for chips prepared by adding salt along with pepper. A significant difference was observed after storage for chips packed in both polyethylene bags and laminated pouches. Hence chips prepared by adding salt along with pepper and packed in laminated pouches were more acceptable than other treatments.

Mature Grand Naine banana was peeled under water and dipped in different concentration of ascorbic acid and citric acid for two time periods and were dried at

50°c for 48 hrs in a hot air oven. It was ground and sieved to get an uniform flour. The organoleptic attributes such as texture, taste and overall acceptability was found to be higher in T_5 for banana flour. The treatment T_5 obtained a higher total score of 49.65 compared to other treatments. Grand Naine banana porridge was prepared using the standard procedure using all the treatments (T_0 – T_{11}). Organoleptic attributes attained a score of more than seven for all treatments. The analysis of concordance resulted in a higher score for T_5 compared to other treatments. The cohesion and viscocity of the porridge is totally dependent on the physical properties of the flour of which texture is of utmost importance followed by taste and flavour. Based on this T_5 was adjudged as best with regard to banana flour.

The prepared Grand Naine banana flour was stored for three months and evaluated for the physico functional properties, nutritional properties and keeping qualities. The pH of freshly prepared Grand Naine banana flour was 4.0 which increased during three months of storage to 5.03. Moisture content increased from 3.17 g 100 g-^{1} to 5.13 g 100 g^{-1}. An increasing trend in water holding capacity (3 to 4.29 g water/ g flour) and oil absorption capacity (0.86 g to 1.16 oil /g flour) with days of storage was observed. An increase in bulk density (g/ml) of the flour, from an initial value of 1.87 to 1.40 was observed. On statistical interpretation there was no significant difference in the physico functional properties during the storage period.

The nutritional properties of Grand Naine banana flour was evaluated initially and at the end of storage. The TSS of freshly prepared Grand Naine banana flour was 4.03^{0} brix and it increased to 5.1^{0} brix after third month of storage. Total sugars (1.73 – 2.02 %) and reducing sugar content (1.26 – 1.43 %) of flour increased during storage. A gradual decrease in starch (70 to 66.8 g 100g^{-1}) and protein content (3.6 g 100 g^{-1} to 3.4 g 100 g^{-1}) was observed during the same period. The fibre content of freshly prepared Grand Naine banana flour was 2.62 g 100 g^{-1} and it was decreased to 2.55 g 100g^{-1} at the end of the third month of storage. No significant difference was observed for TSS, sugar content, starch, protein and fibre content of flour on storage.

A non significant difference in mineral contents of Grand Naine banana flour was observed during the storage. The calcium content was 60.34 mg 100 g^{-1} which decreased to 58.92 mg $100g^{-1}$ after storage. The phosphorus content varied from 72.5 to 70.5 mg 100 g^{-1} and iron content from 6.75 to 6.54 mg 100 g^{-1} during storage. An initial potassium content of 410.5 mg $100g^{-1}$ was noticed in Grand Naine banana flour which decreased to 396 mg $100g^{-1}$ in storage

The *in vitro* digestibility of calcium, phosphorus, iron and zinc were 30.22 per cent, 56.5 per cent and 61.98 per cent respectively. A slight difference in mineral content with a non significant difference was observed for the *in vitro* availability at the end of storage period.

The Grand Naine banana flour was stored in polyethylene bags for three months and was subjected to organoleptic and microbial evaluation. A gradual decline in mean scores was obtained for all organoleptic attributes of banana porridge on storage. An organoleptic score of more than 6 was observed for all attributes even at the end of third month of storage.

Microbial enumeration of flour was done for three months. The presence of bacteria and fungi was detected at the end of third month of storage, but was found to be within the permissible limit.

Ada was prepared by incorporating the Grand Naine banana flour at different levels with rice flour. *Ada* (T_{17}) prepared by blending rice flour and banana flour at a proportion of 50:50 and dried at 70^0C for 2 hours attained a maximum score for all organoleptic attributes.

Milk based *payasam* and jaggery based *payasam* was prepared with all the treatments and were subjected to organoleptic evaluation. The treatment T_{17} attained the maximum score, Hence this treatment was selected for shelf life studies.

The initial moisture content of *payasam ada* was 10.21 g $100g^{-1}$. With the storage period of three month the moisture content increased to 11.63 g $100g^{-1}$. Organoleptic scores of milk based *payasam* and jaggery based *payasam* gradually increased during storage period. The mean score of all organoleptic attributes of *payasam* gradually increased with storage period. The jaggery based *payasam* obtained a higher total score of 49.67 and milk based *payasam* had score of 47.7.

The microbial population of the *payasam ada* was assessed at monthly intervals for a period of three months. At the end of third month of storage a microbial population of 2.53×10^6 and $1.2\ 1\times 10^5$ was observed for bacteria and fungi respectively. No yeast growth was detected throughout the storage period.

Hence, from the study it can be concluded that Grand Naine banana chips both salted and chips prepared by adding salt along with pepper were organoleptically acceptable. Chips flavoured with pepper powder and packed in laminated pouches had low peroxide value and moisture content at the end of storage. Grand Naine banana flour is a good source of starch and can be used for preparing porridge and as composite flour. Banana flour prepared by dipping banana slices in 1 per cent ascorbic acid and 0.1 per cent citric acid for 5 minutes and drying at 50^0C for 48 hours attained a highest total score for organoleptic attributes. Among the different combinations the treatment T_5 was selected as the best for preparation of banana flour and porridge. Banana flour packed in polyethylene bags was shelf stable upto three months. *Ada* was prepared in different proportion with rice flour and banana flour at three different temperatures. Among the different combinations of *ada* T_{17} (50 per cent rice flour incorporated with 50 per cent banana flour dried at 70^0C for 2 hrs) was the best. Milk based *payasam* and jaggery based *payasam* prepared with this *ada* had acceptable organoleptic scores till the end of storage studies, which was carried out for a period of three months.

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APPENDICES

APPENDIX I

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKKARA, THRISSUR

Score card for assessing the organoleptic qualities of "Grand Naine" banana chips

No	Parameters	Treatments	
		T_1	T_2
1	**Appearance**		
2	**Colour**		
3	**Flavour**		
4	**Texture**		
5	**Taste**		
	Crispness		
6	**Overall acceptability**		

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date: **Signature:**

Name:

Score card for assessing the organoleptic qualities of "Grand Naine" banana chips

No	Parameters	Treatments			
		T_1	T_2	T_3	T_4
1	**Appearance**				
2	**Colour**				
3	**Flavour**				
4	**Texture**				
5	**Taste**				
6	**Crispiness**				
7	**Overall acceptability**				

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date: **Signature:**

Name:

Score card for assessing the organoleptic qualities of "Grand Naine" banana flour and porridge

No	Parameters	Treatments												
		T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}
1	Appearance													
2	Colour													
3	Flavour													
4	Texture													
5	Taste													
6	Overall acceptability													

9 Point Hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Date **Signature:**

Name:

Score card for assessing the organoleptic qualities of milk based *payasam ada*, Milk based *payasam and* jaggery based *payasam*

Name:

Date:

Sl No	Parameters	Temperature																	
		60°C						65°C						70°C					
		Treatments						Treatments						Treatments					
		T_0	T_1	T_2	T_3	T_4	T_5	T_0	T_1	T_2	T_3	T_4	T_5	T_0	T_1	T_2	T_3	T_4	T_5
1	Appearance																		
2	Colour																		
3	Flavour																		
4	Texture																		
5	Taste																		
6	Overall acceptability																		

9 point hedonic scale

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Signature

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APPENDIX – II

Relative per cent changes of peroxide value over storage

	Polyethylene bags				Laminated pouches			CD value
	Phase 1	**Phase 2**	**Phase 3**		**Phase 1**	**Phase 2**	**Phase 3**	
T_1	1.97	20.27	12.07	T_3	1.79	3.27	11.96	2.369
	CD value – 3.254				**CD value – 3.97**			
T_2	0.423	13.03	15.90	T_4	0.40	10.40	15.83	1.143
	CD value – 1.411				**CD value – 2.035**			

Days of observations taken at specific days of storage 10, 20, 30 days

Observed phases of change

Phase 1: 0-10

Phase 2: 10-20

Phase 3: 20 - 30

Relative per cent changes of moisture content over storage

	Polyethylene bags				Laminated pouches			CD value
	Phase 1	**Phase 2**	**Phase 3**		**Phase 1**	**Phase 2**	**Phase 3**	
T_1	1.06	1.53	1.41	T_3	1.12	1.89	2.12	0.069
	CD value – 0.118				**CD value – 0.139**			
T_2	1.10	1.50	1.71	T_4	1.15	1.97	2.05	NS
	CD value – 0.359				**CD value – 0.166**			

Days of observations taken at specific days of storage 10, 20, 30 days

Observed phases of change

Phase 1: 0-10, Phase 2: 10-20, Phase 3: 20 – 30

Relative per cent changes of organoleptic qualities of salted chips over storage

Storage period / Character	Polyethylene bags			Laminated pouches			CD value
	Phase I	**Phase II**	**Phase III**	**Phase I**	**Phase II**	**Phase III**	
Appearance				8.23	8.09	4.28	**0.855**
	CD value – NS			**CD value -1.853**			
Colour	7.07	4.63	1.24	4.63	1.24	4.14	**NS**
	CD value -1.100			**CD value -1.232**			
Flavour	1.03	1.84	7.83	1.84	7.83	2.80	**0.683**
	CD value -1.025			**CD value -1.267**			
Texture	2.63	2.47	3.83	2.47	3.83	4.27	**0.734**
	CD value –NS			**CD value -1.251**			
Taste	4.87	4.16	2.49	4.16	2.49	4.41	**1.589**
	CD value -1.163			**CD value -1.137**			
Crispness	1.59	0.52	4.21	0.52	4.21	4.07	**0.44**
	CD value -1.109			**CD value -0.648**			
Overall acceptability	0.61	1.71	4.58	1.71	4.58	2.33	**0.628**
	CD value -0.925			**CD value -0.907**			

Days of observations taken at specific days of storage 10, 20, 30 days

Observed phases of change

Phase 1: 0-10

Phase 2: 10-20

Phase 3: 20 – 30

Relative per cent changes of organoleptic qualities of flavoured chips over storage

Storage period / Character	Polyethylene bags			Laminated pouches			CD value
	Phase I	**Phase II**	**Phase III**	**Phase I**	**Phase II**	**Phase III**	
Appearance	6.68	5.23	4.3	5.23	4.31	2.61	**0.317**
	CD value –0.775			**CD value -0.743**			
Colour	3.67	1.08	1.94	1.00	1.90	4.50	**0.293**
	CD value -0.509			**CD value -0.728**			
Flavour	3.26	3.09	1.90	3.09	1.90	4.50	**NS**
	CD value -0.462			**CD value -0.891**			
Texture	4.8	3.31	1.09	3.31	1.09	4.63	**0.704**
	CD value –0.488			**CD value -0.821**			
Taste	3.7	0.86	3	0.869	4.16	0.74	**0.483**
	CD value -0.878			**CD value -1.112**			
Crispness	5.99	1.19	4.16	1.19	4.16	0.74	**0.716**
	CD value -1.628			**CD value -1.648**			
Overall acceptability	1.65	5.43	5.43	5.43	4.43	5.99	**0.699**
	CD value -1.175			**CD value -NS**			

Days of observations taken at specific days of storage 10, 20, 30 days

Observed phases of change

Phase 1: 0-10

Phase 2: 10-20

Phase 3: 20 – 30

APPENDIX III

Cost of Production

Grand Naine banana chips (salt)

No	Items	Quantity used	Cost (Rs/kg)
1	**Raw materials**		
	Grand Naine banana	2.5 kg	65.5
	Refined oil	1 L	100
	Salt	10 g	0.08
2	**Other items**		
	Fuel charges	1 hr	7
	Labour charges	1 hr	27
	Total		200

Grand Naine chips (Salt + pepper)

No	Items	Quantity used	Cost (Rs/kg)
1	**Raw materials**		
	Grand Naine banana	2.5 kg	65.5
	Refined oil	1 L	100
	Salt	10 g	0.08
	Pepper powder	30g	30
2	**Other items**		
	Fuel charges	1 hr	7
	Labour charges	1 hr	27
	Total		230

Banana flour

No	Items	Quantity used	Cost (Rs/kg)
1	**Raw materials**		
	Grand Naine banana	8 kg	200
2	**Other items**		
	Electricity charges	5 hr	2.90
	Labour charges	1 hr	27
	Total		230

Payasam ada

No	Items	Quantity used	Cost (Rs/kg)
1	**Raw materials**		
	Grand Naine banana flour	530	121.9
	Rice flour	530	51.94
2	**Other items**		
	Electricity charges	2 hr	2.90
	Labour charges	1 hr	27
	Total		204

NUTRITIONAL AND ORGANOLEPTIC QUALITIES OF VALUE ADDED PRODUCTS FROM BANANA *MUSA* (AAA GROUP) 'GRAND NAINE'

By

SRUTHY P. M.

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ABSTRACT OF THE THESIS

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ABSTRACT

Grand Naine banana is a popular high yielding cultivar of the well known Cavendish variety. It is well preferred as a table fruit, but is highly perishable. Hence, the present study was carried out to standardise value added products, to evaluate the quality attributes and shelf life of the products.

Fully matured unripe Grand Naine banana was collected from the Banana Research station, Kannara and demonstration farm of CPBMB, Kerala Agricultural University.

Grand Naine banana chips were prepared by adding salt (T_1) and salt along with pepper (T_2). The frying time of chips was found to be 3.2 minutes. A moisture content of 2.43 and 2.28 g/100g and oil content of 38.67 and 39.74 per cent was observed among treatments. The prepared chips were organoleptically acceptable and attained a mean score of more than 7.0 for all quality attributes.

The prepared chips were subjected to shelf life studies by storing in polyethylene bags (250 gauge) and laminated pouches. Peroxide value, moisture content and organoleptic evaluation of chips were carried out at an interval of 10 days for one month. Low peroxide value and moisture content was observed in chips prepared by adding salt and pepper, packed in laminated pouches. Chips packed in laminated pouches attained higher total score for organoleptic attributes compared to chips packed in polyethylene bags.

Preparation of mature Grand Naine banana flour was standardised using ascorbic acid and citric acid at varying proportions. Porridge was prepared using these flours and subjected to organoleptic evaluation. Based on organoleptic evaluation, the treatment T_5 (banana slices dipped in one per cent ascorbic acid and 0.5 per cent citric acid, dried at 50^0C for 48 hours) attained a higher total score and was selected for further studies.

The pH of freshly prepared Grand Naine banana flour was 4.0 which increased during storage upto 5.03. Moisture content increased from 3.17 g 100 g^{-1} to 5.13 g 100 g^{-1}. During storage, a gradual increase was observed in water holding capacity (3 to 4.29 g water/ g flour) and oil absorption capacity (0.86 g to 1.16 oil /g flour). A decrease in bulk density (g/ml) of the flour, from an initial value of 1.87 to 1.40 was observed.

The nutritional properties of Grand Naine banana flour was evaluated initially and at the end of storage. The TSS of freshly prepared Grand Naine banana flour was 4.03^0 brix and it increased during storage upto 5.1^0 brix. Total sugars (1.73 to 2.02 %) and reducing sugar content (1.26 to 1.43 %) of flour increased during storage. A gradual decrease in starch (70 to 66.8 g $100g^{-1}$), protein (3.6 g 100 g^{-1} to 3.4 g 100 g^{-1}), fibre (2.62 to 2.55 g 100 g^{-1}) and *in vitro* digestibility of starch (76.1 to 73 %) was observed during storage. A non significant difference in mineral content and *in vitro* availability of minerals during storage was observed in the study.

Ada was prepared by incorporating Grand Naine banana flour at different levels with rice flour and was dried at three different temperatures (60^0C, 65^0C and 70^0C). *Payasams* (milk based *payasam* and jaggery based *payasam*) were prepared using these treatments and both *ada* and *payasam* were subjected to organoleptic evaluation. *Ada* (T_{17}) prepared by blending rice flour and banana flour at a proportion of 50:50 and dried at 70^0c for 2 hours attained a maximum score for all organoleptic attributes. The same treatment T_{17} attained higher organoleptic scores for both milk based *payasam* and jaggery based *payasam*. The treatment T_{17} was stored in polyethylene bags for a duration of three months and was subjected to further studies. The organoleptic scores of *payasam* increased during the storage period. The initial moisture content of *payasam ada* was 10.21 g $100g^{-1}$ which increased to 11.63 g $100g^{-1}$during storage.

The presence of bacteria and fungi were detected during the storage period, but was found to be within the permissible limit in flour and *ada.*

From the study, it can be concluded that Grand Naine banana is suitable for the preparation of chips, flour and *Payasam ada*. Hence, the study reveals an immense scope for the development of value added products from Grand Naine banana.