EVALUATION OF BANANA (*Musa paradisiaca* L.) VARIETIES FOR FLOUR MAKING"

A

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ABSTRACT

"EVALUATION OF BANANA *(Musa paradisiaca* L.) VARIETIES FOR FLOUR MAKING"

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ABSTRACT

Investigation on "Evaluation of banana varieties for flour processing" was conducted at the Post Graduate and Post harvest technology laboratory of Department of Horticulture, N.M. college of Agriculture, Navsari Agricultural University, Navsari during the month of January to June 2010. Keeping the varieties V_1 (Rasthali), V_2 (Saba), V_3 (Bluggoe), V_4(Rajapuri) . V_5 (Chandraballi), V_6 (Udhyam) and V_7 (Grand Naine) as treatments in CRD with three repetitions. The nutritional value viz. titratable acidity (percent), ascorbic acid (mg/100gm), starch (percent), T.S.S. (°Brix), total sugar (percent) and organoleptic evaluation was carried out periodically during storage in respect of colour, texture, flavour, taste and overall acceptability. In respect of titratable acidity content, it was found maximum in Bluggoe variety and lowest in Grand Naine variety, it was decreasing in trend during the storage. While ascorbic acid

significantly maximum in Udhyam variety while lower in Chandrabali variety and it was decreasing in trend, during storage. In respect of starch content, it was found maximum in Grand Naine variety and lowest in Saba variety, it was decreasing in trend during the storage. However TSS significantly highest in Grand Naine whiles the lowest in Saba variety and increasing in trend during the storage. In other hand total sugar was found significantly maximum in Grand Naine variety while the lowest in Saba variety and it was increasing in trend during storage.

Considering the organoleptic evaluation of product, it can be elicited that colour acceptability was significantly highest in the flour of Rajapuri variety and lowest in Rasthali variety and it was decreasing acceptability score during storage. However texture acceptability was found significantly maximum in flour of Rajapuri variety and lowest in Rasthali variety and it was decreasing in trend during storage. In other hand the flavour found significantly highest in Rajapuri variety while lowest in Rasthali variety and decreasing in trend. While in case of taste acceptability score was significantly maximum in flour of Rajapuri variety and lowest in Rasthali variety, it decreasing in trend during storage. The overall acceptability was highest in flour of Rajapuri variety whereas lowest in Rasthali variety, it was decreased in trend of overall acceptability during the storage period.

Looking to nutritional point, Udhyam and Grand Naine varieties were found suitable for flour making, while in

organoleptic evaluation Rajapuri variety was found most acceptable for flour making. However, during storage nutritional as well as organoleptic quality decreases. Hence, farmers and starch processors are advised to grow and process Grand Naine, Udhyam and Rajapuri varieties of banana for flour making under South Gujarat condition.

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CERTIFICATE

This is to certify that the thesis entitled **"EVALUATION OF BANANA (*Musa paradisiaca* L.) VARIETIES FOR FLOUR MAKING''** submitted by Miss. **ISHA SWAMI** in partial fulfillment of the requirement for the award of degree of **MASTER OF SCIENCE (HORTICULTURE)** in **POST HARVEST TECHNOLOGY** of Navsari Agricultural University is a record of bonafide research work carried out by her under my guidance and supervision and the thesis has not previously formed on the basis for the award of any degree, diploma or other similar title.

Place : Navsari
Date : 26th April, 2011

(A. G. Naik)
Major Advisor

DECLARATION

This is to declare that the whole of the research work now submitted in this thesis for the partial fulfillment of the requirement for the degree of Masters of Science / ~~Doctor of philosophy in Agriculture~~ / Horticulture / ~~Forestry~~ / ~~Veterinary Sciences & Animal Husbandry~~ in the subject of **Post Harvest Technology** is the result of investigations done by me under direct guidance and supervision of **Dr. A. G. Naik**, Major Prof. (PHT) Professor and Head, Department of Horticulture, N. M. College of Agriculture, N.A.U., Navsari and that no part of the work has been submitted for any other degree so far.

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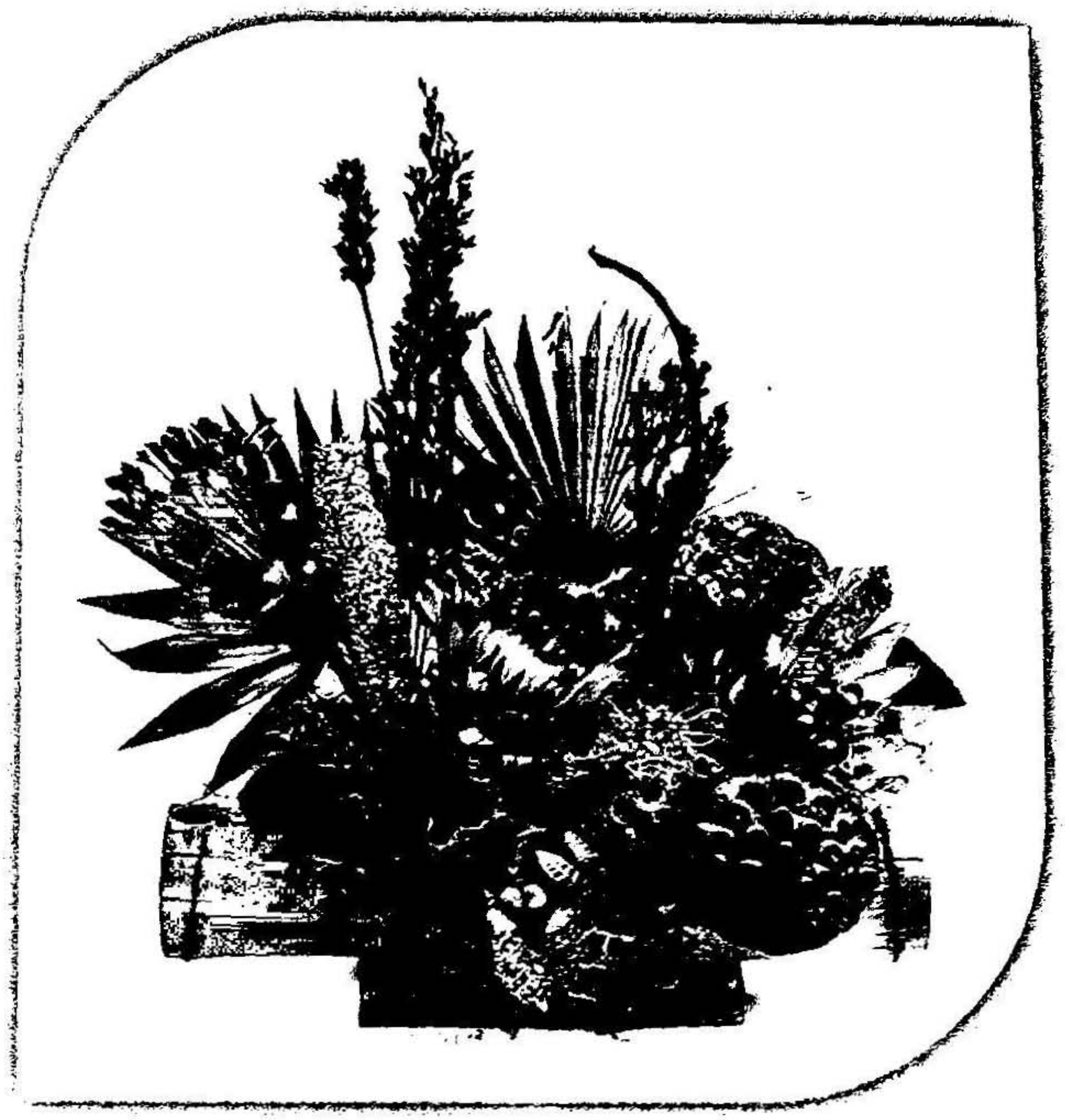
ABBREVIATIONS

Sr. No.	Abbreviation	Meaning
1	AA	Ascorbic acid
2	℃	Degree centigrade (Unit of heat)
3	C.D.	Critical difference
4	cv.	Cultivar
5	C.V.	Co-efficient of variance
6	*et al.*	*Et allii*, and others
7	Fig.	Figure
8	G	Gram (Unit of weight)
9	ha	Hectare (Unit of area)
10	hr	Hour (Unit of time)
11	hrs	Hours (Unit of time)
12	kg	Kilogram (Unit of weight)
13	L	Liter (Unit of volume)
14	mg	Milligram (Unit of weight)
15	mm	Millimeter (Unit of length)
16	ppm	Parts per million
17	C.R.D.	Completely Randomized Design
18	RS	Reducing sugar
19	S.Em.	Standard error of mean
20	Temp.	Temperature
21	TS	Total sugar
22	T.S.S.	Total soluble solids
23	var.	Variety
24	viz.	Namely
25	max.	Maximum
26	min.	Minimum



INTRODUCTION

I. INTRODUCTION

Banana (*Musa paradisica* L.) is a large herbaceous perennial monocotyledonous and monocarpic plant. Banana belongs to family Musaceae in order Scitamineae. Banana is known as "Apple of Paradise" and "poor man's apple".Its origin is in the tropical region of South–East Asia from *Musa accuminata* and *Musa balbisiana*. India is considered to be one of the centers of origin of banana *Musa balbisiana*. Indeed, many consider banana as one of the man's first food.

India is the largest banana consumer and producer country in the world followed by Brazil, contributing about 15 percent of the total world production. Among all the fruits, banana holds first position in production and productivity in India. It ranks third in area after mango. In India, annual production of banana 262.17 lakh tones from an area of 7.09 lakh hectares spread all over the country (Anon., 2010).

Banana covers 12 percent of the total area under fruits, contributing nearly one third of total fruit production in the country. In India, Tamil Nadu, Maharashtra, Kerala, Gujarat and Karnataka are the leading banana producing state. The highest productivity was noted 62.0 t/ha in Maharashtra followed by Gujarat (58.7 t/ha) in the year 2008-2009 (Anon., 2010).

In Gujarat state area under total fruit crops is 3.168 lakh ha. and production is 58.223 lakh MT out of this the banana crop occupies 60900 ha area with annual production of 35, 71,600 MT (Anon., 2010).

Banana is cultivated in the districts of Anand, Kheda, Vadodara, Bharuch, Surat, Navsari and Valsad because of favourable agro-climatic condition and abundant supply of well, pond, canal, check dam water for irrigation. It is one of the most important Tropical fruit crops of South Gujarat region. Hence, considering this importance ICAR had given AICRP on Sapota and Banana at Fruit Research Station, Gandevi, N.A.U, Navsari. Moreover ICAR had also given special project on Banana waste management at Navsari Agricultural University.

India is one of the horticultural rich countries of the world, produce large varieties of fruits and banana is one of them. Since last 50 years, a considerable research work has been done in the country on various aspects viz., improvement of varieties, production technology, spacing, organic farming, irrigation, weed control, desuckering of side suckers, growth regulators, bio-fertilizers and ratton crop etc. In India, post harvest losses in banana are estimated to be 20-30 percent and majority of losses occur after ripening of fruits during their retailing. Banana is perishable fruit having short shelf life so in these circumstances the fruit needs to be processed into variety of products.

In India, less than 2 percent of fruits and vegetables are being processed as against 65, 70, 78, 80 and 83 percent in US, Brazil, Philippines, South Africa and Malaysia respectively (Nayak, 2003).Therefore it is absolutely necessary that this fruit should be preserved so that wastage can be avoided or stopped and increased production can be properly managed and utilized. We

can reduce losses and increase the income of farmers producing banana, through proper postharvest technology.

The utilization of banana production as well as profitable farming in our country needs proper infrastructure like pre cooling chamber, hot water treatment plant, irradiation unit, packaging house and storage house. Also it is necessary to earn foreign exchange through export of banana. Total processed fruits and vegetables export is 797481.35 MT and 2502.27 crores out of which dried and preserved vegetable export is 1187.46 MT and 424.06 crores value from India during the year 2006-2007 (Anon., 2007). Most of the fruit is consumed as fresh and a very small amount has been processed into products viz. Banana puree, powder, wafers, flour, wine, figs, jam, canned slices, dehydrated banana slices, flakes, beverages, vinegar and fruit bar etc. but banana flour has been thrust area of post harvest technology.

Banana flour contains high percent of starch hence it is used for the formulation of nutritious weaning mixes and supplementary foods. (Ogazi *et al.*, 2000) Most important use in the baby food, "Soyamusa" a plantain baby food which is a mixture of 60% plantain flour, 32% soyabean grit, 8% sugar, vitamin and mineral added to improve the taste. (Akubor, 1998) has shown that plantain flour has a good potential for use as a functional agent in bakery products on account of its high water absorption capacity, the banana flour contains low gluten, so it could not be used as main material. Therefore to produce high quality cakes and biscuits could be formulated from wheat-plantain composite using up to 80:20 (w/w) % 60:40(w/w) ratios of wheat

plantain flour substitution for bread and biscuits, respectively (Horsfall *et al.*, 2007). Banana flour can also be used for one of the main components in various food items like puris, parathas, cakes, toffees, etc.

The information on the nutritional status of banana flour of different varieties is limited, in India more than 300 cultivars (AAA, AAB, ABB, AB and hybrids) of banana are grown. Out of this Dwarf Cavendish, Lacatan, Harichhal (Lokhandi), Grand Naine and Gandevi Selection are the major cultivars grown in Gujarat. Hence, this investigation is undertaken to evaluate banana varieties for banana flour making with following objectives for encouragement to banana growers as well as to processors.

1. To evaluate the suitability of banana varieties for flour making
2. To study the nutritional and organoleptic status of Banana flour made from different varieties during storage period.

Table-1.1 : Chemical composition of dried banana flour

Sr. No.	Name of nutrient	Level
1	Moisture (%)	4.50±0.5
2	Crude protein (%)	4.99±0.12
3	Crude fat (%)	2.16±0.13
4	Crude fiber (%)	2.60±0.10
5	Total ash (%)	2.26±0.11
6	Carbohydrate (%)	83.49±0.29
7	Energy (Kcal/100g)	373±0.33
8	Calcium (mg/100 g)	40.40±2.00
9	Iron (mg/100 g)	23.41±0.53
10	Phosphorus (mg/100 g)	113.10±1.00
11	B-Carotene (µg/100g)	114.00±1.00

Singh *et al.* (2004)

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

The aim of drying food is to withdraw enough water to inhibit the chemical and enzymatic reactions but more especially to prevent the microorganisms from developing further. Microorganisms need their nutrients in dissolved (diffused) form in order to grow and therefore foods have to be sufficiently moist for the microorganisms to grow. The microorganisms are by no means always killed by drying, some remain alive, but in an inactivate state (spores). When water is taken up, new growth will occur.

The withdrawal of water by natural and artificial drying is therefore an effective means of protecting food from microbial decay; however reaction of a particular kind may take place during drying and later in dried food with low water content when it is stored. These take place at a slower rate but limit the keepability of foods which are to be stored for a long time. The sorption of water, which contains dissolved salts (ions) carbohydrates, protein, acids and so on, is important in the structure of foods because the during the drying process, the increase in concentration of these dissolved materials, depending on the direction and speed, may lead to various chemical or enzymatic changes: hydrolysis, browning and other chemical rearrangements, protein denaturation or even enzymatic conversion. The characteristic changes which take place in dried foods may have the following reason: Influence of microbes: microbes need sufficient water to absorb nutrients from the foodstuffs which they attack. For most microbes the

relative humidity of air (R.H.) for optimum growth lies between 90 and 100%.

Enzymatic reaction: enzymatic reaction, caused by the native enzyme in the food or enzymes from microbes (which have died) occur- much more slowly when the water content below the limits for growth of moulds. In dried fruit and dried vegetable, native oxidase can regenerate during storage and produce a hay-like aroma and flavour substances if these enzymes are not completely inactivated by adequate blanching before processing. Chemical changes: purely chemical changes play a decisive part in the process of decay in dry (low moisture content) foods. Non-enzymatic browning reactions can occure in almost all foods when the necessary conditions are fulfilled; the presence of compounds containing reducing sugar and NH_2 groups (such as amino acids, proteins, cephalins), for dried potatoes, tomato powder and dried fruit. Drying processes. Vacuum drying, roller (contact) and spray drying, spray or atomization drying, foam mat drying, freeze drying etc. (Heimann, 1980).

Banana is abundantly grown in India, since fresh banana are available throughout the year in most part of the country, processed banana product intended to substitute fresh banana have not been widley used in our country. The need for such product arises, when handling is problematic and at a times and there is a glut in the market and also to regulate market and value addition for export to the countries where banana does not grow.

Processing of banana in to products have so far been confined to canned slices, puree, dehydrated product such as figs,

wafers, sheets (fruit leather) and osmotically dried slices (Ramanuja and Jayraman,1980). At the same time they have not been commercialized due to various reasons like instability of product and lose of flavour. There for more stable and viable product are required to be developed from banana

2.1 STUDIES ON VARIETAL EVALUATION OF DEHYDRATED PRODUCTS

Banana

Pruthi *et al.* (1977) conducted varietal trials of banana grown in Kerala for processing. 24 banana varieties from Kerala (India) were tested for canning as chunks in syrup, pulp and puree and for dehydration. They studied physical properties (wt., circumference, length and pulp-peel ratio) and the chemical composition (soluble solids, Brix, sugar, starch, acidity, protein, crude fiber, ash and ascorbic acid). Eight varieties were found suitable for canning as chunks in syrup and pulp; four var. required addition of ascorbic acid (50 mg/100 g). In low acid var. citric acid addition improved the colour of pulp and prevented pink discoloration. They suggested that banana puree can be prepared from a good pulpy var. by adding water, raising the degrees Brix and adjusting pH to 4.0-4.2. Canned banana puree packed in plain tin cans and processed for 10 min in boiling water kept well for 1 year and possessed better acceptability than pulp. Eleven var. were suitable for dehydration.

Awasthi (1984) studied the screening of green banana varieties for dehydration. He studied the Physicochemical and dehydration characteristics of nine green banana varieties, viz.

Bankale, Benkumaiya, Campierganj, Hazara, Malbhog, Monthon, Nagbale, Raja Bajai, Thenkundali. Benkumaiya was rated to be the best variety for dehydration as it retained most of its original characteristics at the end of six months storage.

Jesus *et al.* (2005) evaluated dehydrated banana obtained from fruits of different genotypes . The genotypes used were: Caipira; Nanica; Pacovan and its hybrids PV03-44 and PV03-76; Prata Ana and its hybrids FHIA-18, Pioneira and Prata Grauda. Products obtained were appraised for physical, physicochemical, chemical and sensory aspects. The highest yield was obtained with Pacovan. Dehydrated bananas produced by the genotypes studied had good sensory acceptance, with means higher than 6 for the following attributes: appearance, colour, aroma, flavour and texture. Pioneira was the genotype with highest sensory acceptance.

Daramola and Osanyinlusi (2006) studied production, characterization and application of banana (Musa spp) Flour in whole maize. They observed that highest protein (3.25%), ash (3.60%) and fat (0.85%) in banana flour of Poyo variety where as crude fiber (0.70%) and moisture (12.1%) found highest in Cavendish than in lactacan, Red skin and Dwarf Cavendish varieties.

Karthiyani and Devdas (2007) studied the textural properties of canned banana slices.they studied canning of three different banana varieties viz. Poovan, Rasthali, Red Banana with sugar and jiggery syrup each of 20,25,30° Brix.They showed that texturally Rasthali variety was most suited for canning followed by

Poovan while the overall acceptability was best for Red Banana in sugar syrup.

Mandalik *et al.* (2009) studied the evaluation of banana (*Musa paradisiaca*) varieties, viz. Basrai, Shreemanti, Robusta, and Grand Naine for Flour processing. He observed that acidity, ascorbic acid and starch showed decreasing trend during storage, whereas TSS,total sugar and moisture increased in the flour during storage.

Idun *et al.* (2009) studied consumer preference, quality and shelf life of three popular varieties of banana (*Musa spp.*AAA) viz. Cavendish, Mysore (Alata Kwadu, local variety), and Gros Michel in Ghana. Mysore had the least moisture levels for all colour stages and lasted longer than both Cavendish and Gros Michel varieties. Mysore recorded the highest TSS of 25% which was significantly different from Cavendish (23.6%) and Gros Michel (24.2%) at colour stage 5 when it is usually consumed. All three varieties recorded similar pH values at colour stage 5. Mysore had the highest vitamin C content (31.0. mg/100 g) while Cavendish recorded the highest Vitamins B_6 and B_{12} contents. Mysore had the highest scoring for overall acceptability (1.02) significantly different from Cavendish and Gros Michel. There was however, no significant difference in overall acceptability between Cavendish and Gros Michel.

Molla *et al.* (2009) conducted study on the Suitability of Banana varieties viz. Sabri, BARI Kola-1 and BARI Kola-2 in Relation to Preparation of Chips. Based on taste testing panel, freshly prepared chips from Sabri kola scored first for its colour.

For crispiness, BARI Kola-2 obtained the lowest score while Sabri and BARI Kola-1 showed the same score. There was no statistically difference for taste, flavour and overall acceptability of the products.

Sapota

Arbat (2009) studied the evaluation of Sapota (*Manilkara achras* (Mill) Fosberg) varieties for dehydrated sapota slices. She found that slices prepared from Kalipatti, Kirtibarthi and DHS-1 variety and impregnated in orange juice by using KMS(0.1%) as preservative produce excellent quality of product in respect of nutritional status and long shelf life upto six months storage

Guava

Harsimart and Dhawan, (2002) studied the evaluation of guava varieties for preparation of intermediate moisture guava slices. They assessed the suitability of newly developed guava hybrids H 25-25, H 3-22, H 11-7 and commercial cultivars Lucknow-49 and Allahabad Safeda for preparation of intermediate moisture guava slices. Intermediate moisture (IM) guava slices were prepared by immersion equilibration method in glycerol and sugar solution and in sugar syrup alone using a soaking solution containing potassium sorbate, potassium metabisulphite and water. The quality of the products was evaluated during storage. Intermediate moisture slices prepared using glycerol and sugar were soft and attractive in colour. Among the cultivars/hybrids, Allahabad Safeda was superior in quality followed by hybrids H 3-22 and H 11-7 based on organoleptic rating. During storage, a

significant increase in total sugars, moisture and pectin, and decrease in acidity, ascorbic acid, tannins and organoleptic rating was observed.

Date palm

Godara *et al.* (1995) studied the thawing effect on the recovery and quality of soft dates from different cultivars of date palm. They prepared soft dates from four different varieties 'Khadarwy', 'Shamran', 'Zahidi and 'Zaglour' by thawing and dehydrated for 24 and 40 hours at 40^0C and 50^0C respectively. The best quality of soft dates were obtained from 'Shamran' with organoleptic rating 8.3/10 but the maximum recovery was obtained from 'Shamran' with organoleptic rating from 'Zagloul' due to higher TSS of fresh fruits and maximum water retention after dehydration.

Aonla

Patel *et al.* (2006) observed the organoleptic test of mukhwas of two varieties of aonla viz., Gujarat aonla-1 and NA-7 under sun drying condition under the different treatments in organoleptic taste, ginger and sugar of different preparations recorded higher scores and variety NA-7 registered higher scores for organoleptic taste that of Gujarat aonla-1.

Pawar (2010) studied the evaluation of Aonla (*Emblica officinalis* G.) varieties for osmodehydrated candy product processing. She found that the acidity of candy was lower in NA-7 while higher in Krishna variety. While ascorbic acid significantly maximum in NA-7 and Krishna while lower in Kanchan variety. In respect of total and reducing sugar content, it was found maximum

in NA-7 and lowest in Kanchan and Krishna variety. However TSS significantly highest in NA-7 whiles the lowest in Chakaiya and Kanchan was equivalent. In other hand moisture was found significantly maximum in Gujarat aonla-1 while the lowest in Na-7.

2.2 STUDIES ON METHOD OF PROCESSING AND NUTRITIONAL STATUS OF THE DEHYDRATED PRODUCTS

Banana

Rodriguez-Sosa *et al.* (1977) studied the preparation of green banana flour. AB Green bananas were steam-peeled in a retort using a pressure of 80 lb/in2, to loosen the peel from the pulp for easier removal by hand. After peeling the bananas were diced to cube size approx. 1.27 x 0.95 x 0.64 cm, and soaked for 4 min in 1000 ppm potassium metabisulphite solution acidified to pH 3.3 using citric acid. The cubes were dehydrated for either 1 hr at 160 degrees F and 5 hrs at 200 degrees F or for 6 hrs at 200 degrees F. Metal-mesh trays were filled at different levels. At lower filling levels the dehydration rate was faster. Initial moisture content of cube was more determinant of the dehydrating rate than were levels of temp used. Flour yields were between 23.69 and 29.34%.

Nagalani (1989) studied the plantain flour. blanching the plantain pulp at 80^{0}C for 5 minutes and cutting them into round pieces (or by soaking the round pieces for about 3 minutes in a sodium metabisulfite solution (41g/1) containing 3 g citric acid, followed by draining and drying in a drying oven at 65^{0}C for 48

hours or in the sun for some days resulted in the production of a more or less whitish flour

Firmin (1994) prepared banana flour by traditional method and observed the nutritional content. Firstly removed pulp then washed and dried, dried pulp was ground in to flour. They observed the highest loss of moisture 84 % for the flour. The changes observed in the amount of starch and sugars are variable. Sugar levels were high in ripe plantains and their derivatives but starch content was low. The energy content was higher in a fried ripe bananas, and flour. The proximate composition in banana flour moisture 9.1%, starch 74.5 % and sugar 2.45 %. They also observed the cooking of fruits before peeling, it appears to be most nutritionally advantages.

Suntharalingam and Ravindran (1999) selected 90-95 days old bunches which were free of injury and bruises, after that they were pressure–cooked at 15l/in^2 for 5 min. The fruits were cooled, peeled and cut in to transverse slices of about 0.5 cm thickness. Slices are then dipped in 1 % sodium metabisulphite solution at a fruit: solution ratio of 1:3 for 5 min. and drained the dried sample were ground in a wiley laboratory mill to pass through 60 mesh screen.

Da-Mota *et al.* (2000) examined the composition and functional properties of banana flour from different varieties. The flour was prepared by freeze-drying a homogenate of green banana pulp. Chemical composition of the flour was also varied according to the variety. the range obtained were 61-76.5 % starch, 19-23 %

amylase, 23-33 % protein, 4-6 % moisture, 0.3-0.8 % lipids, 2.6-3.5 % ashes, and 6-15.5 % total fiber.

Bello-Perez *et al.* (2006) studied the composition and application of banana flour. The chemical composition of banana flour showed that total starch 73.36 % and dietary fiber 14.52% are the highest constituents. Of the total starch, available starch (56.29 %) and resistant starch 17.50%.

Daramola and Osanyinlusi (2006) studied the production, characterization and application of banana flour. Fresh mature green bananas were peeled under water treated with 0.05% sodium metabisulphite and then sliced at average thickness of 1 cm using sharp knife. The slices were dried at 50^0C for 48 hours in air oven. Then dried chips were milled in Christy hunt model hammer mill to obtain flour from mature green banana fruits. The low (10.8-12.1%) moisture content of the flour signifies good storability of the product.

Horsfall *et al.* (2007) prepared plantain flour by cutting their heads into separate bunches which were subsequently defingered. The fingers were washed, peeled, cut into thin slices of 2 cm thick and blanched in 1.25% $NaHS0_3$ solution at 80°C for 5 min Blanched plantain slices sere drained and dehydrated in a Thelco air-recirculating oven at 60°C for 24 hours. Dried plantain slices were milled into flour in a Retch Muhle 2880 Hammer mill. Flour obtained were sifted through a 250 µm aperture sieve and packed in a two-ply medium density (0.926 – 0.949 g/cc) polythene bag.

Mango

Dabhade and Khedkar (1980 a) studied the drying and dehydration of raw mangoes for preparation of mango powder they selected full grown fruits of uniform size and maturity fruits were washed clean, peeled and pieces of uniform size were made. Raw mango slices were taken in muslin cloth and were dipped in boiling water for 120 second and sulphitation done by steeping the pieces in 1 per cent solution of potassium metabisulphite (KMS), twice the weight of the pieces, for 30 min. and they observed that greater leaching losses in sugars, acids and ascorbic acid were observed in steeping the raw mango pieces in KMS solution for 30 minutes. Though the pretreatment like blanching and sulphitation these are essential steps for processing of mangoes for amchur.

Ejilearassane *et al.* (2001) studied the quality evaluation of instant dehydrated mango chutney during storage in different containers. Raw fruits were washed, peeled and cut in to shreds (6.5X 1cm) lengthwise. After the pretreatment drying was carried out at a temperature of $60^0C \pm 5^0C$. The cross flow cabinet drier was used for dehydration purpose. The slices were turned over after every hour for uniform drying up to 6% moisture level. The pretreated and dehydrated raw mango slice was powdered with the help of grinding machine.

Sapota

Ganjyal *et al.* (1999) revealed the dehydration characteristics of the fruits which were determined by drying fruit pieces of different sizes. The powder retained the natural colour

and aroma of the ripe fruit. Chemical analysis showed that the total soluble solids (TSS) and ascorbic acid values increased after dehydration and were highest in the product obtained at the 65°C drying temperature.

Ghodke *et al.*, (2006) developed dehydrated products such as sapota powder and sapota slices by convective hot air drying. Sapota slices were successfully obtained by osmotic.

Guava

Harsimart and Dhawan (2001) prepared guava powder by osmo-air drying technique and cabinet drying. Fruits were cut in to quarters and their seed core was removed. The slices were blanched in boiling water (98±2^{0}C) for 2 min. after blanching were dried in a cabinet drier at 60-65^{0}C. Then product was ground to powder and packed in polythene bags.

2.3 STUDIES OF SLICESS

Banana

Unde *et al.* (2001) studied the effect of pretreatments on drying characteristics and quality of banana slices. Drying was carried out in a tray drier at 60°C for 5 hr. Moisture content of the banana slices during the drying period decreased exponentially.

Muyonga (2000) studied the production and evaluation of precooked dehydrated unripe banana slices. Mature unripe Cavendish bananas three quarter to full quarter levels, the bananas were washed and steamed in a steam kettle at 1 kg/cm^2 (100-115^{0}C) for 7 minutes. This time was adequate to eliminate discoloration it was also adequate to loosen the banana peel, allowing hand stripping-off by hand .the slices were dried in a

cross flow hot air drier (Armstrong Smith, PVT Ltd., India), with air flow rate 1.5 m/s for 4 hours. The drying temperature was maintained between 60-65^{0}C. The dry slices were packaged in polyethylene bags (250) and stored for 90 days.

Demirel and Turhan (2003) revealed that air-drying behavior of Dwarf Cavendish and Gros Michel. Air drying behavior of untreated, and sodium bisulphate and ascorbic/citric acid treated Dwarf Cavendish and Gros Michel banana slices was investigated between 40 and 70^{0}C. Pretreatments and increasing temperature decreased the browning and the colour change in the untreated samples was acceptable. The effective moisture diffusivity (D) increased with increasing temperature Between 40 and 60^{0}C, and decreased at 70^{0}C in the pretreated samples.

Awasthi (1984) conducted study on screening of green banana varieties for dehydration. Nine varieties of green banana, fully developed fruit were selected, washed, peeled, cut into 1.25 cm. thick slices, sulphited for 30 minutes in 0.2 per cent potassium metabisulphite solution, drained, spread on trays, dehydrated at 60-65^{0}C *till the 6.5 moisture per cent*, packed and stored at room temperature. Awasthi also observed the chemical composition of green banana. He found the value of starch content ranged between 17.8 to 25.4 per cent, the lowest being in the Monthon and the highest in Malbhog. The highest percentage of acidity (0.200%) was obtained in Bankale while Thenkundali it was only (0.096%). The total soluble solids and total sugars were almost similar in all the varieties ranging from 2.00 to 3.50 Brix and 0.18 to 0.24 per

cent. The concentration of ascorbic acid varied from 2.0 to 4.4mg/100gm. of fresh slices.

Mango

Dabhade and Khedkar (1980 b) studied the dehydration of raw mango pieces by using a cross flow cabinet drier. Prepared raw mango pieces were spread on aluminium trays (16"X32"X11/2") and kept in the drier. The drying was carried out at 55±5^{0}C temperature. Air flow of the drier was 4-6 ft/sec. the pieces were turned over every hour for uniform drying and dried to 2-3 per cent.

Sapota

Ambadan (1985) dehydrated the sapota slices using tray dryer at 70°C for 30 hr & packed them in 400 mm polythene bags at ambient, the acceptability was maintained up till 6 months. while storing at 5°C improved the acceptability for a period of one year.

Singaravelu and Arumugum (1993) described another technique of solar drying of sapota, where dipping of sapota slices initially in 600 ppm KMS for minute before solar drying in solar drier has been suggested. Drying was proceeded up to 11 per cent moisture. The product showed acceptability up to 4 months.

Ber

Khurdiya (1980) made comparative evaluation of methods of drying and found that sun dried ber comparatively lost ascorbic acid, retained less SO_2 and had darker colour compared to tray dried ber. He along with Roy in 1986 developed various types of solar driers and compared their performance in drying of 'katha'

ber after blenching and sulphuring and found that product from solar drier with plain glass had better quality, exhibited lower non-enzymatic browning and retained higher SO_2 level compared to sun drying.

Guava

Mehta and Tomar (1980 a) conducted a study with guava fruits slices after treatment they were placed in trays and dehydrated in an electric cabinet cross flow drier, for 6 to 10 hr at 60°C depending on treatment. They noted that in final dried product, the level of reducing sugar increased by five times and total sugar by about ten times over the initial guava slices while the level of vitamin C and total SO_2 ppm declined during tray drying and at 12 months of storage, it was also found that reconstituted guava slices in water in 1:3 = product: water ratio obtained significantly higher marks than other samples.

Papaya

Mehta and Tomar (1980 b) studied the dehydration of papaya. After the treatment the slices were placed in trays and dehydrated in an electric cabinet cross-flow drier for 6 to 10 hours at 60^0C depending on the treatment. Dehydrated slices were placed in 250 gauge polythene bags, heat sealed, placed inside friction top in tin container and stored at room temperature.

Apple

Sharma *et al.* (2006) studied the dehydration of apple cultivars. Fruits were washed, sorted peeled, cored and trimmed. Peeled fruits were immersed in 0.2% NaCl +0.05% citric acid solution during slicing. Slices were steam blanched for 3 min

followed by sulphitation (potassium metabisulphite at 2500 ppm) for 1 hour dehydration was carried out in cabinet drier temperature of 60±2^{0}C to a moisture content of 11-14 %.

Bael

Sani and Singh (2005) studied the storage of dehydrated bael fruits. The fruits were washed and, cut, peeled and divided in to small pieces of 2.0-2.5 cm. the fruits were dipped in 1% potassium metabisulphite solution for 30 min. the treated fruit was dried in sun and other in tray drier at 50±5, 60±5 and 70±5^{0}C till the moisture content was less than 10 %.

They also observed that there were no appreciable changes in the biochemical composition up to 4 month of storage. There was gradual decline in all the biochemical constituents with increasing storage period. The ascorbic acid content of the dehydrated product recorded a much quicker and highest decline with the advancement of storage, irrespective of pre-treatment. Crude fibre, pectin and total sugar registered comparatively much slower decline than rest of the chemical constituent up to 22-24 months.

2.4 STUDIES ON COMPOSITIONAL CHANGES DURING STORAGE PERIOD

Banana

Amin and Bhatia (1962) reported increase in sugar during drying of banana slices under sun due to activity of invertase or amylase which are known to found in large quantities in banana.

Awasthi (1984) observed the Benkumaiya banana slice rated best in respect of colour, texture, taste and flavour and scored the highest marks in comparison to other varieties during storage. Next in order of preference were Thenkundali, Monthon and Bankale. Remaining varieties found unfit for dehydration. All the varieties the colour, flavour and taste of the dehydrated product deteriorated gradually with the increase in storage period. In this respect the storage capacity of Benkumaiya, Thenkundali, Monthon and Bankale was good as they retained most of their original qualities at the end of six month.

Suntharalingam and Ravindran (1999) Alukehel and Monthan studied Meal yield from green banana fruits viz. 31.3 % and 25.5 % respectively. The pH of the meal varied from 5.4 to 5.7. The chemical composition of meal constitutes 3.2 % gross protein, 1.3 % gross fats, 3.7 % ash, 12.6 % fibres, 3.0 % cellulose, 1.0 % lignin and 5.0 % hemicelluloses, 12.0 % polysaccharide other than starch. They also observed the total sugar content of banana flour averaged 2.9 % and 2.7 % for variety Alukehel and Monthan, respectively the total sugar varied significantly among the samples collected from different locations indicating that the starch-sugar transformation is influenced by environmental condition. Light and temperature are probably the major contributing factors. However they also found starch is the predominant component of carbohydrates in banana flour the starch of variety Alukehel (70.5 %) was higher than that of variety Monthan (68.8 %) the interaction between variety and location was significant indicating that the starch content of the two variety

differes in different location. In case of the vitamin C heavy losses occur during the preparation of banana flour were also found to be high. The losses were 80.5 % and 80.6 % for varieties Alukehel and Monthan respectively. The content of vitamin C (mg/100 gm) on dry basis was 9.2±3.1, 10.2±1.8 respectively in Alukehel and Monthan.

Muyonga *et al.* (2001) studied effect of predehydration steaming on physicochemical properties of unripe banana flour. Flour produced from steamed and unsteamed unripe bananas was analyzed to determine the effect of steaming on physicochemical properties. Steaming of bananas prior to dehydration slowed dehydration of banana slices, increased water uptake, density and solubility of flour and decreased viscosity, setback, breakdown, discoloration and vitamin C content. Banana flour produced with predehydration steaming gives pastes of low paste bulk density, which is desirable for weaning and supplementary foods.

Evelin *et al.* (2007) carried out the packaging and storage studies on spray dried ripe banana powder under ambient condition. They observed the moisture, NEB, reducing and total sugars of the banana powder progressively increased throughout the storage period whereas the acidity decreased.

Mandalik *et al.* (2009) studied the evaluation of banana (*Musa paradisiaca*) varieties, viz. Basrai, Shreemanti, Robusta, and Grand Naine for Flour processing. He observed that acidity, ascorbic acid and starch showed decreasing trend during storage, whereas TSS, total sugar and moisture increased in the flour during storage.

Savvashe (2010) investigated the effect of drying and chemical preservative on storage life and quality of banana figs (*Musa paradisiaca* L.) cv. Grand Naine. Looking to the organoleptic quality during storage it was found in decreasing trend and these product remains acceptable at initial as well as during the 3 and 6 months of storage period.

Guava

Harsimart and Dhawan (2001) reported that powder prepared by osmo-air drying technique had significantly higher content of total sugars (77.40 %) than the powder prepared by cabinet drying .In general, no significant significantly increase in total sugar content was observed during storage. However, slight increase in total sugars was noticed in osmo-air dried product. Powder prepared by cabinet drying method significantly higher (2.0 %) acidity than the powder prepared by osmo-air drying (0.44 %). no significant change was noticed during storage.

Higher ascorbic acid retention was observed in powder prepared by cabinet drying (26.42 mg), than in osmo-air drying (19.24 mg). A significant reduction in ascorbic acid content was also noticed with increase in storage period.

Aonla

Naik and Chundawat (1996) studied on storage behaviour of various aonla products made from Gujarat Aonla-1 and reported that during storage dried flakes retain higher quality values in terms of vitamin C, acidity, tannin and lower moisture level than pickle, preserve, chyavanprash, and brine preserve.

Singh *et al.*, (2006) studied the effect of pre drying treatments and drying methods on quality of dehydrated aonla shreds. Two types of pre treatments (blanching and blanching with sulphitation), three drying methods (sun, solar and oven) and their combinations were used. Among the drying methods, the highest colour value at initial and after four month storage was obtained at solar drying followed by oven drying due to the effect of direct sun light. Both the blanching treatment of solar drying recorded significantly higher ascorbic acid content during the entire period of storage over control.

Mango

Khedkar and Roy (1989) examined the storage studies in dried and dehydrated raw mango slices. During storage, the cabinet dried and sulphited slices had better retention of SO_2 and ascorbic acid, and less browning as compared to sun-dried and control lots. A progressive decrease in SO_2, vitamin C and acidity, and increase in both reducing and total sugars were noticed.

Sagar *et al.*, (2000) observed the quality of ripe mango powder as affected by storage temperature and period. A slight decrease in acidity at room temperature was noticed during storage. The increases in sugars were slightly higher at room temperature as compared to low temperature. They also found ascorbic acid content decreased during the storage.

Sapota

Rajput (2007) conducted studies on Development of sapota product: Dehydrated slices in cv. Kalipatti by applying

seven treatments of different fruit juice and sugar. She had observed that the chemical parameter like reducing sugar, total sugar and ascorbic acid are in decreasing trend whereas moisture and acidity were in increasing trend during the 6 month storage. The TSS was found non-significant and increased d0uring 6 month storage. She observed that the highest overall acceptability score value in treatments of dipping orange juice than rest of treatments., however this was also equivalent with treatment 50% sugar, acid lime juice, sweet orange juice.

MATERIALS AND METHODS

III. MATERIALS AND METHODS

The present investigation on "Evaluation of Banana varieties for flour making" was conducted with the objectives to evaluate the suitable variety for flour processing and to study the nutritional and organoleptic status of Banana flour made from different varieties during storage period. Full three quarter level Fruits were used for drying.

3.1 Location

The experiment was conducted at the Department of Horticulture, N. M. College of Agriculture, N.A.U., Navsari. Navsari Agricultural University is located three kilometers away in the south-west direction from Navsari station (22°-57' North latitude and 72°-54' East longitude at an altitude of ten meters above the mean sea level) and twelve kilometers away in the east from the Arabian sea-shore and the historic place 'Dandi'.

3.2 Climate

The climate of this area is typically tropical, characterized by fairly hot and humid summer, warm monsoon with more humidity and moderately cold winter.

The summer season commence from February end and reaches the maximum by May with temperature range varying from 29.6° to 37.8°C. Relative humidity during summer varies from 80 to 89 per cent. By the second week of June, monsoon starts with heavy rainfall during July-August and ends by October. Annual

precipitation varies from 1117.3 to 2207.3 mm. Relative humidity during monsoon varies from 85 to 90 per cent being highly humid. The winter season sets in the end of October and continues till February, with December-January being the coldest months. Temperature range during winter varies from 10° to 23.8°C.

3.3 Site of experiment

Experiment was carried out in Post Graduate and Post Harvest Technology Laboratory and Central Instrumentation Laboratory of N. M. College of Agriculture, Navsari Agricultural University, Navsari.

3.4 Experimental material

Full three quarter level banana fruits were collected from Fruit Research Station, N.A.U., Gandevi, Navsari.

3.5 Preparation of fruits

The Full three quarter level (Thompson and Burden, 1995) healthy fruits were selected and washed with water to remove any surface dust and dirt.

3.6 Methodology for flour processing:

Cleaned and washed fruits were steamed at 1kg /cm^2 (100-115^{0}C) in Steam Autoclave for 7 min., then fruits were removed immediately from steam. This time was adequate to eliminate discolouration. It was also adequate to loosen the banana peel then the fruits were taken and peeled by stainless steel knife, further fruits were sliced to 1.0 cm thickness by steal knife.

Immediately it was treated with 0.05% sodium metabisulphite (Daramola and Osanyinlusi, 2006.)

3.7 Tray loading

Treated banana slices were drained and spreaded over stainless steel trays. The inner bottom of the tray was covered with white paper to avoid metal contact and covered with white muslin cloth to keep off dust, dirt and insects and birds.

3.8 Drying

Treated banana slices were drained and spreaded over stainless steel trays and kept in oven drying at 60-65 °C temperature, during drying Slices were shaken at every 45 min. Slices were dried to the level of 4.50±0.5 percent moisture.

3.9 Grinding

After drying, these slices were ground in grinding machine, to obtain fine flour and sieved through 40 mesh sizes to get uniform flour.

3.10 Weighing, filling and heat sealing polyethylene bags

The treatment wise weight of flour was recorded and then filled in 200 gauge polyethylene bags, the bags were heat sealed, labeled appropriately with details of treatment and repetition and kept for observations.

3.11 Storage of flour

The packed bags were stored at room temperature which range from 20° to 35°C. These were then subsequently used for

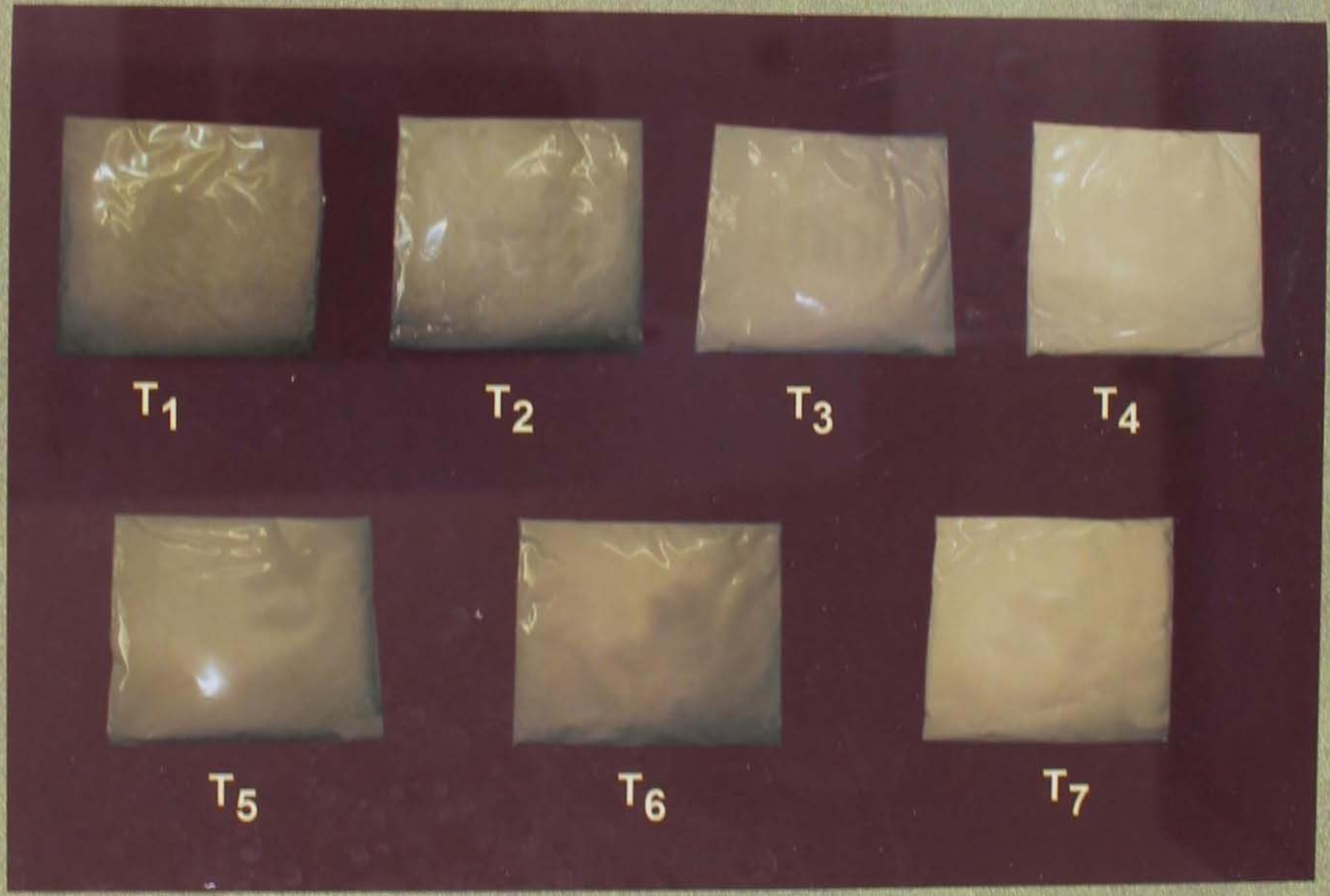


Plate-I : comparative value added flour products of banana varieties

periodical observations for a period of initial, 3 and 6 months storage studies.

3.12 Observations to be recorded:

Banana flour was subjected to following periodical observations.

3.12.1 Physical parameters of fruits

i. Average weight of Fruit (g)

ii. Average weight of Pulp (g)

iii. Average weight of Peel (g)

iv. Pulp to peel ratio.

3.12.2 Biochemical parameters of banana flour at initial, 3 and 6 months of storage. (Ranganna, 1986)

1. T.S.S.(°Brix)

2. Sugar (%)

3. Titratable acidity (%)

4. Ascorbic acid (mg/100 g)

5. Moisture (%)

6. Starch (%)

3.12.3 Organoleptic evaluation of banana flour at initial, 3 and 6 months of storage.

1. Colour (25 Score)

2. Texture (25 Score)

3. Taste (25 Score)

4. Flavour (25 Score)

5. Overall acceptability (100 Score)

3.13 Methodology adopted for recording the observations

3.13.2 Fruit weight (g)

The banana fruits were weighed on weighing balance and the reading was noted.

3.13.2 Pulp weight (g)

The fruits, which were used for steaming, were used for calculating pulp weight. Peel of the fruits was removed and then Peeled fruits were weighed on weighing balance and the reading was noted.

3.13.3 Peel weight (g)

The fruits used for calculating pulp weight, were used for calculating peel weight. Removed Peel of the fruits was weighed on weighing balance and the reading was noted.

3.13.4 Pulp to peel ratio

The fruits, which were used for steaming, were used for to calculating pulp to skin ratio. Pulp to skin ratio was calculated by dividing respective pulp weight by respective peel weight.

3.13.5 Total sugar (TS; percent)

For the estimation of total sugars, the filtrate obtained in the estimation of reducing sugars was used. An aliquot from the

filtrate was taken. 10 ml of dilute HCl was added and the inversion was carried out at room temperature for 24 hours. Subsequently, contents were cooled and neutralized with 40 per cent Sodium hydroxide solution using phenolphelin as indicator and the final volume was made. The solution was filtrated through Whatman No. 1 filter paper and titration was carried out using filtrate as detailed for reducing sugars. The total sugar content was expressed as percentage in terms of invert sugar according to the following formula (Ranganna, 1986).

$$\text{1. Total sugar (\%)} = \frac{\text{Glucose equivalent } (0.052) \times \text{Total volume } \textit{made up} \times \text{Volume made up after } \textit{inversion}}{\text{Titre Value} \times \text{Weight of sample} \times \text{Aliquot taken for inversion}} \times 10$$

2. % Sucrose = (% Total invert sugars – Reducing sugar ordinally present) x 0.95

3. % Total sugar = (% Non-reducing sugar + % Sucrose)

3.13.6 Moisture (Percent)

A five g sample product was taken in a flat dish and kept in an oven at 70°C for 48 hours and thereafter, the sample was weighted. The moisture loss was calculated as per the following formula and expressed on per cent basis.

$$\text{\% Moisture (wt/wt)} = \frac{\text{Fresh weight of sample (g) - Dry weight of sample (g)}}{\text{Dry weight of sample (g)}} \times 100$$

Plate-II : View of chemical analysis

3.13.7 Titratable acidity (Percent)

The method described by Ranganna (1986) was adopted. 10 grams of homogenized sample was taken and transferred to 100 ml of volumetric flask and volume was made up with distilled water. The solution was well mixed and centrifuged and the clear supernatant aliquot was taken in a 100 ml conical flask. From this, 10 ml aliquot was taken into a 50 ml of beaker and titrated against standard solution of sodium hydroxide (0.05 N NaOH), using phenolthalein as an indicator. The titrable acidity was expressed in terms of percent citric acid equivalent adopting following formula.

$$\text{Titratable acidity (\%)} = \frac{\text{Titre value} \times \text{Normality of alkali} \times \text{Total volume made up} \times \text{Equivalent weight of citric acid}}{\text{Aliquot taken for estimation} \times \text{Weight of sample} \times 1000} \times 100$$

3.13.8 Ascorbic acid (AA; mg per 100 g of pulp)

The titrimetric method described by Ranganna (1986) was adopted. Ten grams of the pulp before processing, and ten grams flour after processing was transferred to a 100 ml volumetric flask and volume made up with 3 per cent metaphosphoric acid solution. After 30 min., the suspension was filtered through Whatman No. 1 filter paper. Before actual titration, the 2,6-dichlorophenol indophenol dye solution was standardized by titrating against standard ascorbic acid was taken from the filtrate and titrated against standardized dye solution was calculated. Five ml of the aliquot was taken from the filtrate and

titrated against standardized dye solution through for 15 seconds. AA content was calculated adopting the following formula.

$$\text{Ascorbic acid (mg / 100 g)} = \frac{\text{Titre x Dye factor x Total volume made up X 100}}{\text{Aliquot of extract taken for estimation x Weight of sample}}$$

3.13.9 Starch (percent)

For estimation of starch the acid hydrolysis method described by Ranganna (1986) was employed. After the sugars present in the sample were leached out starch was hydrolyzed to reducing sugar by adding HCl. Reducing sugar released were estimated and converted in to starch percentage. Starch content was calculated as under.

Starch (%) = Reducing sugar (%) X 0.9.

3.13.10 Total soluble solids (T.S.S. ; °Brix)

The total soluble solids in sample were recorded by using Erma made hand refractometer. In case if fresh fruit, the pulp were crushed and extract was extracted through cheese cloth on refractometer prism and three reading were taken and averaged out to express the T.S.S. percentage. While, in case of flour, 10 g of product was dissolved in distilled water in 1:4 (Product: water) ratio for four hours and crushed. Pulp was extracted though cheese cloth on refractometer prism and observations were recorded. These values were multiplied by 5 to represent T.S.S. percentage of flour product (Ranganna, 1986).

3.14 Organoleptic parameters

Flour prepared under varied treatments was evaluated for sensory characteristics viz., colour, texture, flavour, taste and overall acceptability (Total score/ 100 points). Each attribute was given a separate score of 25 points. Higher product scoring was treated as more acceptable from the quality point of view. Sensory evaluation was carried out by panel consisted of 5 trained panelist .They evaluated the sample as per the procedure described by Ranganna (1986) in format detailed as below.

Treatments	Colour (25)	Texture (25)	Flavour (25)	Taste (25)	Overall acceptability (100)
T_1					
T_2					
T_3					
T_4					
T_5					
T_6					
T_7					

3.15.1 Statistical analysis

Experiment was conducted in simple C.R.D. The data were collected on physical parameters of fresh banana have been represented as mean of three readings. While, data collected on quality aspects of fresh product and during storage including sensory analysis were statistically analyzed by the adopting analysis of variance techniques as described by Panse and

General view of organoleptic test

Organoleptic test by panel

Plate-III : View of organoleptic evaluation

Shukhatme (1967). The treatment difference was tested by 'F' test of significance on the basis of null hypothesis. The appropriate standard error (S.Em. ±) was calculated in each case. The critical difference (C.D.) at 5 percent level of probability was worked out.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

Banana is second most important fruit crop in India. It is chiefly utilized as fresh fruit. In recent past and presently its area is increased due to high economic return per unit area and ease of cultivation. If it is cultivation continues to grow at present rate, its utilization may pose problem. There for it is required to be utilized in processing industry to support the growth of banana industry and to utilize under quality fruit. This fruit is available throughout the year; it is most favored raw materials for processing industries. With these points in view, the present experimentation was conducted for evaluating banana varieties for flour making.

The results obtained in the experiment are being described in this chapter

4.1 Physical compositional status of fresh unripe fruits of banana varieties, viz. Rasthali, Saba, Bluggoe, Rajapuri, Chandrabali, Udyan, Grand Naine

For physical composition, fresh 75 percent mature banana fruits were used in this experiment.

4.1.1 Physical parameters

The observation recorded for the physical parameters was taken average of 5 determinations and have been presented in Table 4.1

Table 4.1: Physical status of fresh banana varieties

Treatments		Avg fruit wt(g)	Avg pulp wt(g)	Avg peel wt(g)	Pulp:Pe
V_1	Rasthali	293.25	169.56	123.69	1.37
V_2	Saba	377.38	205.39	171.99	1.19
V_3	Bluggoe	354.61	194.16	160.45	1.21
V_4	Rajapuri	223.28	125.08	98.20	1.27
V_5	Chandrabali	320.51	172.41	148.10	1.16
V_6	Udhyam	334.45	189.69	144.76	1.31
V_7	Grand Naine	265.25	142.11	123.14	1.15

*Average of five determinations

4.1.2 Average fruit weight

Looking to the average fruit weight V_2 (Saba) variety gave maximum (377.38), while lowest (223.28) was found in V_4 (Rajapuri) variety.

4.1.3 Average pulp weight

Looking to the average pulp weight V_2 (Saba) variety gave maximum (205.39), while lowest (189.69) was found in V_4 (Rajapuri) variety.

4.1.4 Average peel weight

Looking to the average peel weight V_2 (Saba) variety gave maximum (171.99), while lowest (98.20) was found in V_4 (Rajapuri) variety.

4.1.5 Pulp: peel

Looking to the average pulp to peel ratio V_1 (Rasthali) variety gave maximum (1.37), while lowest (1.15) was found in V_7 (Grand Naine) variety.

4.2.1 Biochemical parameters during storage of Banana flour

Immediately after the preparation of a product from varieties, they were analyzed for a qualitative status in respect of Titratable acidity (percent), Ascorbic acid (mg/100g), Starch (percent), T.S.S. (°Brix), Total sugar (percent), which is described constituent wise as below.

4.2.2 Titratable Acidity (percent)

The value of titratable acidity in Banana flour recorded during initial, 3 and 6 months of storage have been presented in Table 4.2 and depicted in Fig.4.1 with below description.

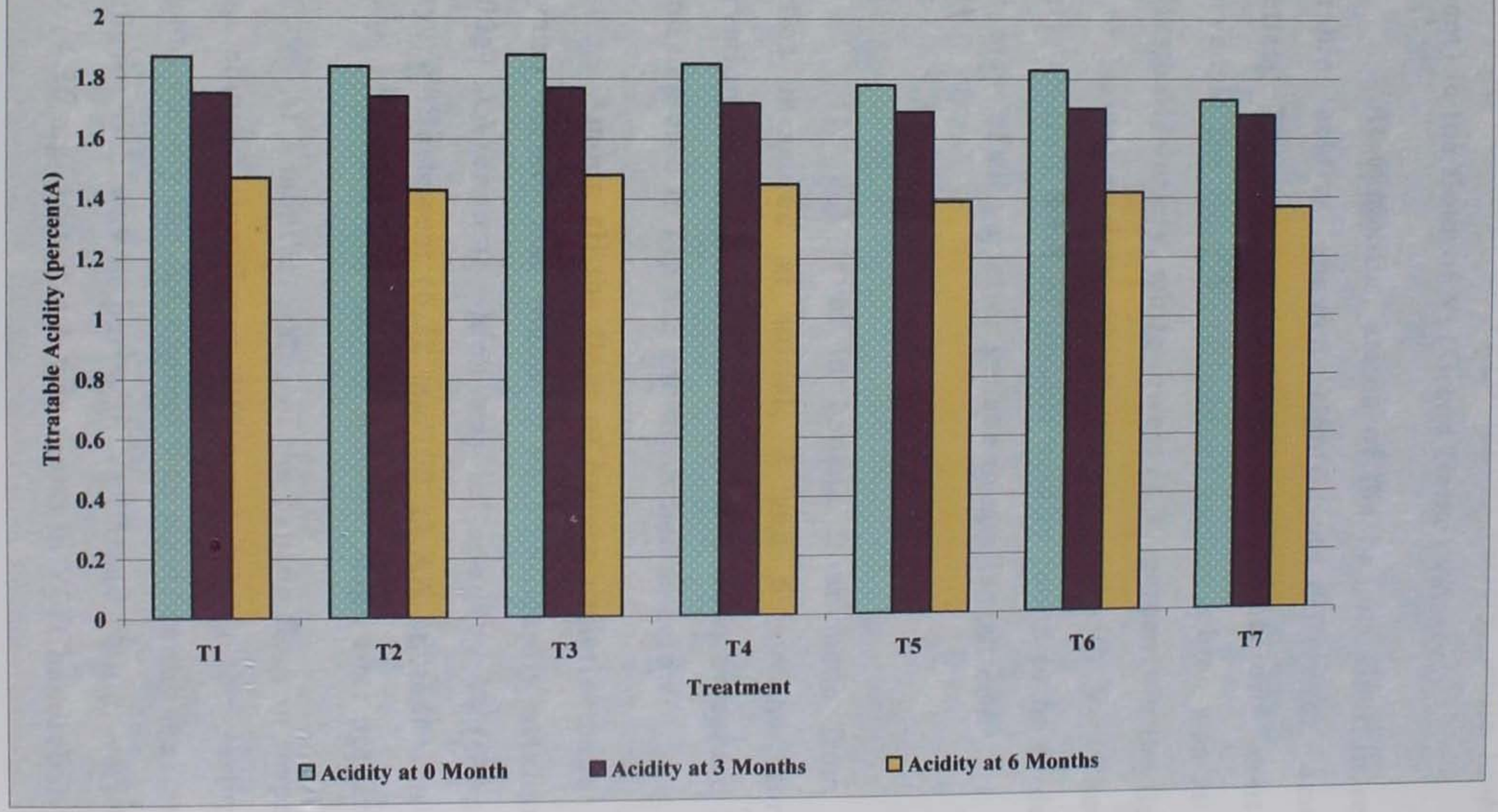
It was manifested from the presentation of statistically analyzed data in respect of titratable acidity content in the banana flour made from different varieties (during the storage at initial,3 and 6 months) that initially the variation in titrable acidity in a banana flour of different varieties was found statistically significant. However, at initial stage maximum (1.88 percent) acidity was found in the flour of V_3 (Bluggoe) variety which is at par with V_1(Rasthali) and V_4 (Rajapuri) varieties. While lowest (1.73 percent) acidity was found in flour of V_7 (Grand Naine) variety.

At 3 month of storage acidity the variation in titrable acidity in banana flour of different varieties was found statistically non significant. However the titrable acidity was maximum (1.77

Table 4.2: Changes in Titratable Acidity (percent) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	1.87	1.75	1.47	1.70
V_2	Saba	1.84	1.74	1.43	1.67
V_3	Bluggoe	1.88	1.77	1.48	1.71
V_4	Rajapuri	1.85	1.72	1.45	1.67
V_5	Chandrabali	1.78	1.69	1.39	1.62
V_6	Udhyam	1.83	1.70	1.42	1.65
V_7	Grand naine	1.73	1.68	1.37	1.59
	S.Em. ±	0.010	0.023	0.007	
	C.D. at 5 %	0.03	N S	0.02	
	CV %	0.484	1.126	0.378	

Fig- 4.1 : Difference in Titratable Acidity (percent) of various banana flour during the storage period



percent) in the flour of V_3 (Bluggoe) variety, while lowest (1.68 percent) in the flour of V_7 (Grand Naine) variety.

At 6 months, status of the banana flour in respect of titratable acidity showed significant difference among the varieties. The maximum (1.48 percent) acidity content was observed in the flour V_3 (Bluggoe) variety which was at par with V_1 (Rasthali) variety, while lowest (1.37 percent) in the flour of V_7 (Grand Naine) variety which was at par with V_5 (Chandrabali) variety. Overall level of titrable acidity found to be in decreasing trend, most of all varieties behave in similar pattern.

4.2.3 Ascorbic acid (AA;mg/100g)

The AA level in banana flour made from different varieties measured at initial, 3 and 6 months storage and observations were recorded thereof have been presented in Table. 4.3 and depicted in Fig 4.2 and described as below.

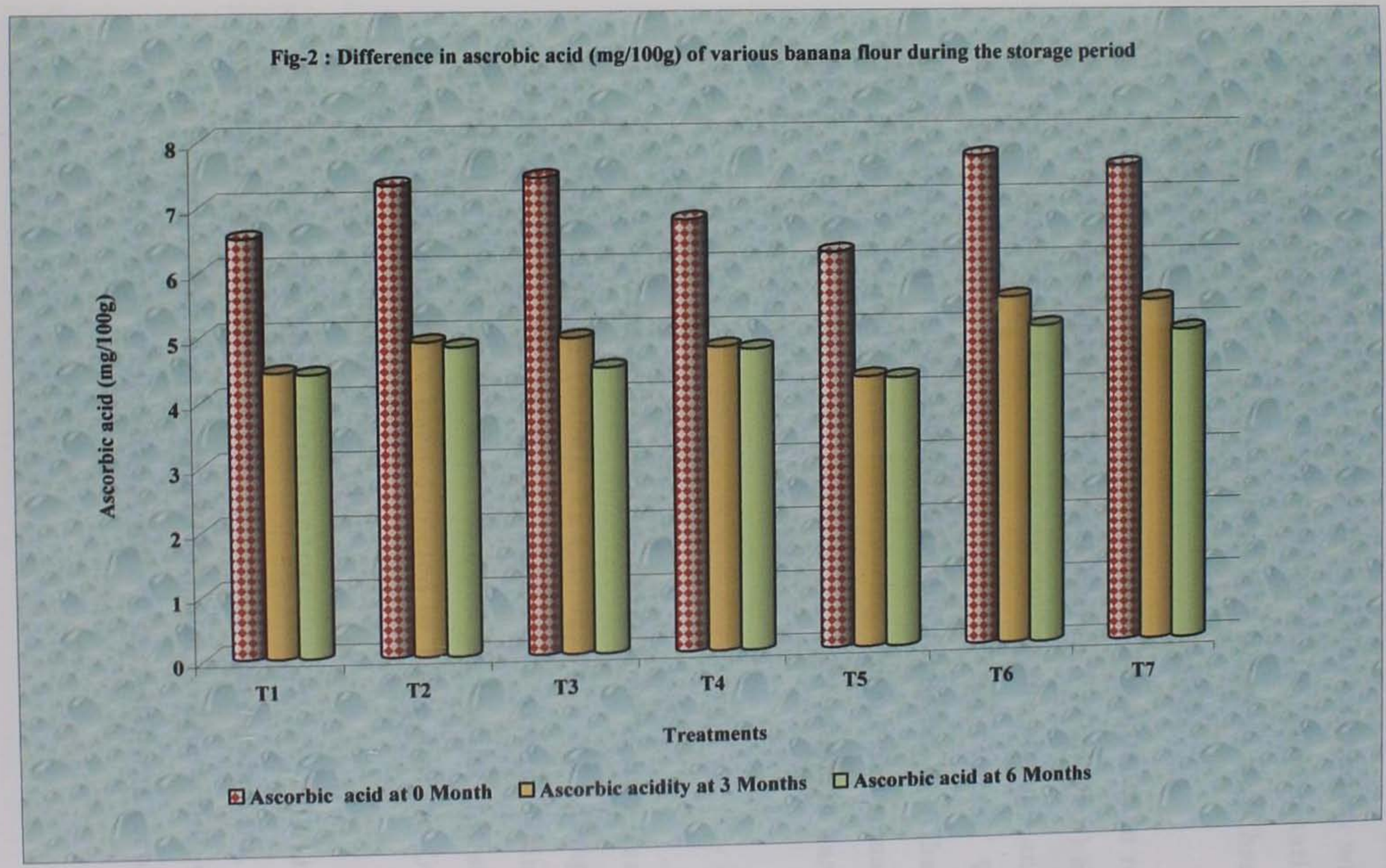
Among all the flour of banana varieties under study V_6 (Udhyam) variety was found to be significantly maximum (7.69 mg/100g) AA content which was followed by V_7 (Grand Naine) variety. While lowest (6.22 mg/100 g) AA content was observed under V_5 (Chandrabali) variety at initial stage after preparation.

At 3 months, status of the banana flour in respect of AA content showed significant difference among the variety. In V_6 (Udhyam) variety the AA content was significantly maximum (5.47 mg/100g) which was at par with V_7 (Grand Naine) variety, while lowest (4.26 mg/ 100 g) AA was found in V_5 (Chandrabali) variety.

Table 4.3 : Changes in Ascorbic acid (mg/100g) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	6.52	4.45	4.42	5.13
V_2	Saba	7.32	4.9	4.82	5.68
V_3	Bluggoe	7.42	4.94	4.47	5.61
V_4	Rajapuri	6.75	4.77	4.73	5.42
V_5	Chandrabali	6.22	4.26	4.24	4.91
V_6	Udhyam	7.69	5.47	5.01	6.06
V_7	Grand naine	7.51	5.39	4.91	5.94
	S.Em. ±	0.019	0.056	0.014	
	C.D. at 5 %	0.06	0.17	0.04	
	CV %	0.475	1.779	0.424	

Fig-2 : Difference in ascrobic acid (mg/100g) of various banana flour during the storage period



At 6 month 0f storage, the significantly maximum (5.01 mg/100g) AA content was found in V_6 (Udhyam) variety which was followed by V_7 (Grand Naine) variety. While, significantly lowest (4.24 mg/100g) level of AA content was found in V_5 (Chandrabali) variety.

Looking to the initial status of the product in respect of AA content was highest (7.69 mg/100g) in V_6 (Udhyam) among all varieties and trend was decreasing during the storage and remain higher (6.06 mg/100g) in mean value of AA content. While the lowest AA content (6.22 mg/100g) was found in V_5 (Chandrabali) and found to be decreasing trend during storage and remain lowest (4.91 mg/100g). Hence the comparative AA content in banana flour product was acceptable up to 6 month.

4.2.4. Starch (percent)

The data on starch (per cent) content in a Banana flour of V_1 (Rasthali), V_2 (Saba), V_3 (Bluggoe) , V_4 (Rajapuri) , V_5 (Chandrabali) , V_6 (Udhyam) and V_7 (Grand Naine) was chemically analyzed and data recorded during the initial, 3 and 6 months and value have been depicted in Table 4.4 and Graphically in Fig 4.3 with description.

At 0 hour initially, the variety V_7 (Grand Naine) recorded the highest (65.85 percent) starch content, and was significantly superior to rest of the banana variety followed by V_6 (Udhyam) variety, while lowest (60.79 percent) was recorded in V_2 (Saba) variety.

Table 4.4 : Changes in Starch (percent) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	64.12	62.26	61.93	62.77
V_2	Saba	60.79	58.84	57.37	59.00
V_3	Bluggoe	62.34	60.69	59.43	60.82
V_4	Rajapuri	63.78	61.65	60.72	62.05
V_5	Chandrabali	63.08	61.38	60.12	61.53
V_6	Udhyam	64.38	62.95	61.54	62.96
V_7	Grand naine	65.85	63.79	62.74	64.13
	S.Em. ±	0.008	0.009	0.006	
	C.D. at 5 %	0.02	0.03	0.02	
	CV %	0.065	0.073	0.049	

Fig-4.3 : Difference in starch (percent) of various banana flour during the storage period

At 3 month storage, again V_7 (Grand Naine) recorded the highest (63.79 percent) starch content, and was significantly superior to the rest of the banana variety followed by V_6 (Udhyam) variety, while lowest (58.84 percent) level of starch was found in V_2 (Saba) Variety.

At 6 month storage, significantly the maximum (62.74 percent) value of starch was observed in V_7 (Grand Naine).This was followed by V_1 (Rasthali) variety, while lowest (57.37 percent) starch was found in V_2 (Saba) variety.

Looking at the initial status of banana flour in respect to starch percent V_4 (Grand Naine) contained maximum (65.85 per cent) starch percent, which decreased during the storage and remains maximum (64.13 percent) in mean value. The lowest (60.79 percent) starch content was found in V_2 (Saba) and it decreased during the storage and remain lowest (59.00 percent) in mean value.

4.2.5. Total soluble solids (T.S.S.; °Brix)

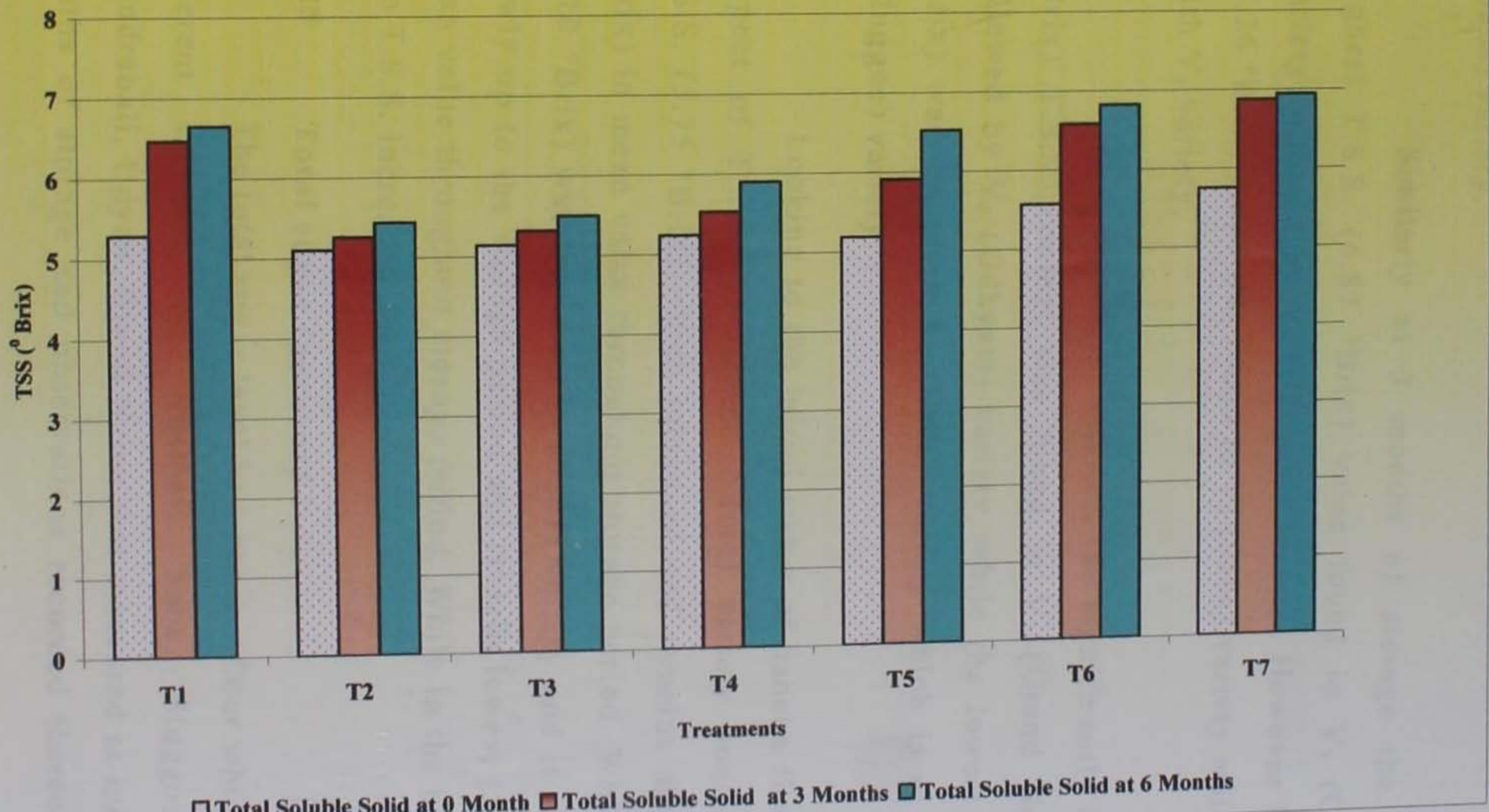
The T.S.S. values in the product were measured at initial, 3 and 6 months storage have been presented in Table 4.5 and depicted in Fig. 4.4 and described as below.

Observation revealed that variation in initial status of flour product in terms of T.S.S. content initially was found significant. The V_7 (Grand Naine) variety significantly gave highest (5.75 °Brix) value of T.S.S. content followed by V_6

Table 4.5 : Changes in Total Soluble Solids (°Brix) of banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	5.29	6.47	6.65	6.14
V_2	Saba	5.10	5.26	5.44	5.27
V_3	Bluggoe	5.14	5.32	5.50	5.32
V_4	Rajapuri	5.24	5.53	5.90	5.56
V_5	Chandrabali	5.19	5.91	6.52	5.87
V_6	Udhyam	5.57	6.58	6.82	6.32
V_7	Grand naine	5.75	6.87	6.94	6.52
S.Em. ±		0.008	0.026	0.037	
C.D. at 5 %		0.02	0.08	0.11	
CV %		0.22	0.71	0.96	

Fig-4.4 : Difference in Total Soluble solids (^{0}Brix) of various banana flour during the storage period



(Udhyam) variety. While the lowest (5.10 °Brix) was found in V_2 (Saba) variety.

Similarly at 3 months of storage the significantly highest T.S.S. (6.87 °Brix) value found in V_7 (Grand Naine) variety followed by V_6 (Udhyam) variety. However lowest T.S.S. (5.26 °Brix) value was found in V_2 (Saba) variety which was at par with V_3 variety.

At 6 months of storage, the significantly highest (6.94 °Brix) T.S.S. content was found in V_7 (Grand Naine) variety followed by V_6 (Udhyam) variety, while the lowest T.S.S. (5.44 °Brix) was found in V_2 (Saba) variety which is at par with V_3 (Bluggoe) variety.

Looking to the initial status of banana flour product in respect of T.S.S. V_7 (Grand Naine) variety content maximum T.S.S. (5.75 °Brix) which increased and remains maximum (6.52 °Brix) in mean value throughout storage period. While the lowest (5.10 °Brix) was found in V_2 (Saba) variety and it also increased slowly up to the storage period and remain lowest (5.27 °Brix) in mean value throughout storage period. While in the other varieties also T.S.S. increased during storage.

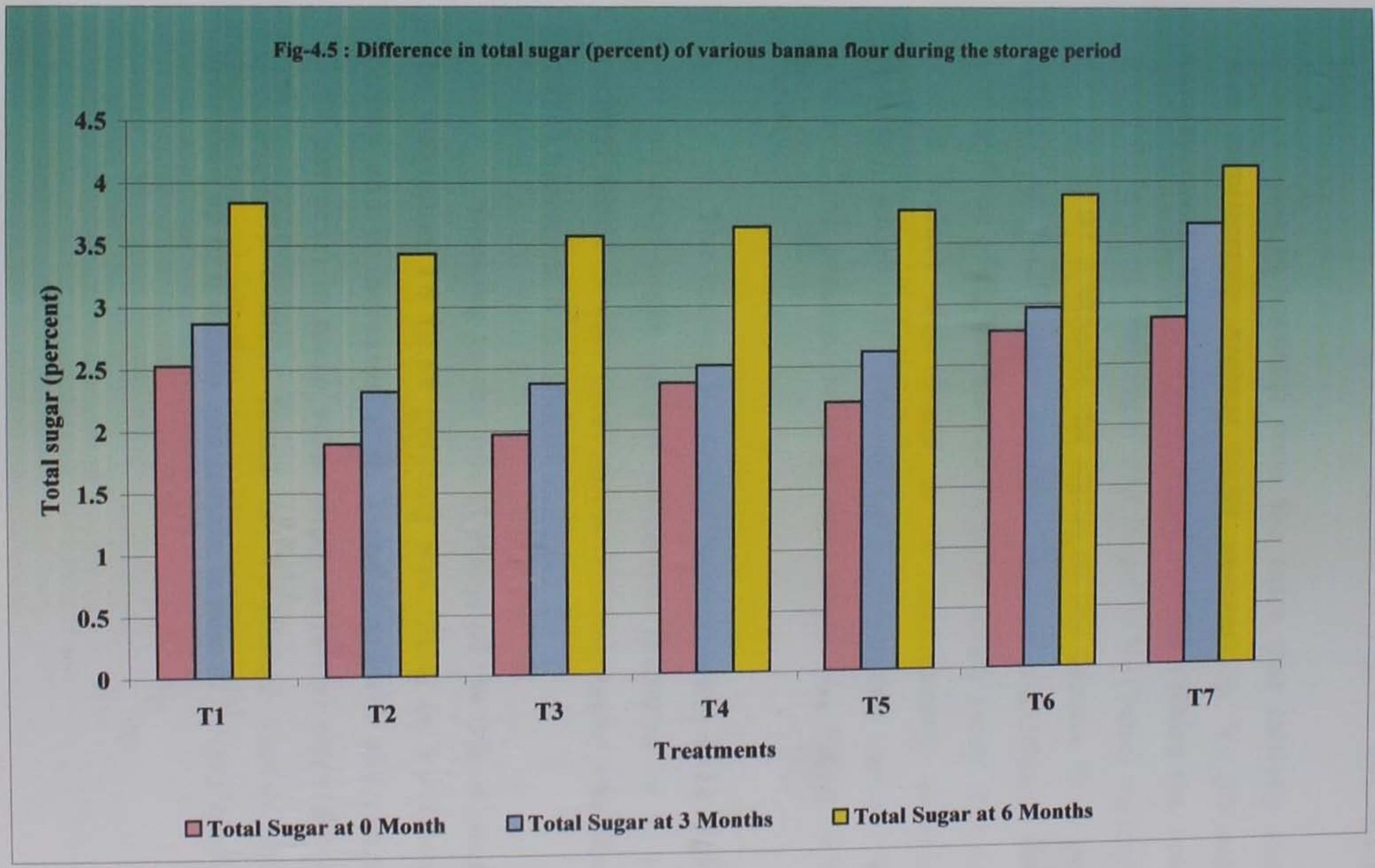
4.2.5 Total sugar (percent)

The total sugar level in a banana flour which made from different varieties viz. Rasthali, Saba, Bluggoe, Rajapuri, Chandrabali, Udyan, Grand Naine was measured at initial, 3 and 6 months of storage and observations recorded thereof have been

Table 4.6 : Changes in Total Sugar (percent) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	2.53	2.87	3.84	3.08
V_2	Saba	1.9	2.32	3.43	2.55
V_3	Bluggoe	1.97	2.38	3.57	2.64
V_4	Rajapuri	2.38	2.52	3.64	2.85
V_5	Chandrabali	2.21	2.62	3.77	2.87
V_6	Udhyam	2.78	2.97	3.89	3.21
V_7	Grand naine	2.88	3.65	4.12	3.55
	S.Em. ±	0.010	0.007	0.008	
	C.D. at 5 %	0.03	0.02	0.02	
	CV %	0.43	0.27	0.27	

Fig-4.5 : Difference in total sugar (percent) of various banana flour during the storage period



presented in Table 4.6 and depicted in Fig.4.5 and described as below.

It is apparent from the table that initially total sugar was significantly highest (2.88 percent) in V_7 (Grand Naine) variety, while V_6 (Udhyam) stood second. While the lowest (1.9 percent) level of total sugar was found in V_2 (Saba) variety.

At 3 months the status of the banana flour product in respect of total sugar content, showed significant differences among flour of all the banana varieties under study. The variety V_7 (Grand Naine) was found to be significantly superior (3.65 percent), which was followed by V_6 (Udhyam) variety. While the lowest (2.32 percent) level of total sugar was found in V_2 (Saba) variety.

The variety V_7 (Grand Naine) revealed the highest (4.12 percent) total sugar content which was followed by V_6 (Udhyam) variety, while lowest (3.43 percent) total sugar was found in V_2 (Saba) variety at 6 months of storage.

Looking to the initial status of the TS of banana flour, the maximum TS (2.88 percent) was found in V_7 (Grand Naine) variety and it increased at 0, 3 and 6 months and remain higher (3.55 per cent) in mean value while at initial stage the lowest TS (1.9 percent) content found in V_2 (Saba) variety and slowly increased up to 6 month and remain lowest (2.55 per cent).

4.2.6 Moisture (percent)

Data on moisture content in the flour of different banana varieties recorded during the initial, 3 and 6 months storage have been presented in Table 4.7 and depicted in Fig.4.6.

Observations revealed that there was variation in initial status of product in terms of moisture content at 0 month. The maximum moisture (9.73 percent) was found in V_7 (Grand Naine) variety which was followed by V_3 (Bluggoe) variety. While the lowest moisture content was (8.28 percent) found in V_5 (Chandrabali) variety.

At 3 month, the maximum value (10.26 percent) was observed in V_7 (Grand Naine) variety which was followed by V_3 (Bluggoe) variety. Lowest moisture content was (8.72 percent) found in V_5 (Chandrabali) variety.

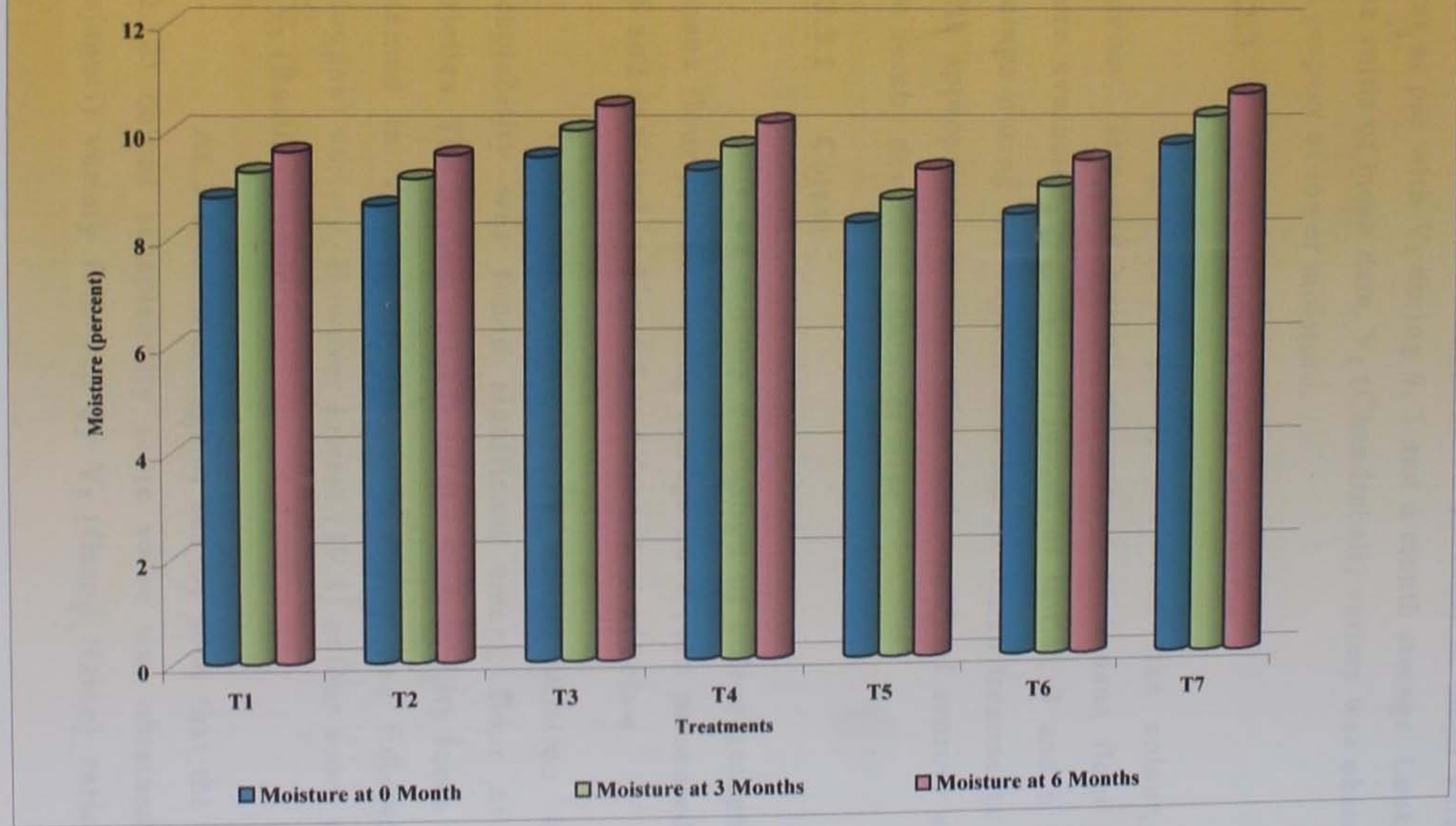
Similarly at 6 month storage, among the different varieties the moisture content was observed maximum (10.69 percent) in V_7 (Grand Naine) variety which was followed by V_3 (Bluggoe) variety. The lowest moisture content was (9.28 percent) found in V_5 (Chandrabali) variety.

Looking into the initial status of the moisture content of product the maximum moisture (9.73 percent) was found in V_7 (Grand Naine) variety and it was in increasing trend during the storage period and remained higher (10.23 percent) in mean value. While, the lowest moisture content was (8.28percent) initially found in V_5 (Chandrabali) variety and it slowly increased up to 6

Table 4.7 : Changes in Moisture (percent) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	8.77	9.24	9.62	9.21
V_2	Saba	8.62	9.12	9.56	9.10
V_3	Bluggoe	9.52	10.02	10.48	10.01
V_4	Rajapuri	9.27	9.72	10.16	9.72
V_5	Chandrabali	8.28	8.72	9.28	8.76
V_6	Udhyam	8.42	8.95	9.44	8.94
V_7	Grand naine	9.73	10.26	10.69	10.23
	S.Em. ±	0.010	0.008	0.011	
	C.D. at 5 %	0.03	0.02	0.03	
	CV %	0.21	0.17	0.23	

Fig-4.6 : Differences in moisture (percent) of various banana flour during the storage period



month and remained lowest (8.76 percent) in mean value and it was at par with V_5 during 0, 3 and 6 month storage. Looking in to the value of mean data, V_5 (Chandrabali) variety was observed best in respect of lower moisture.

4.2.3 Organoleptic quality attributes

Organoleptic quality attributes like colour, texture, flavour, taste and overall acceptance of banana flour products, were evaluated by panel of judges at initial, 3 and 6 month of storage during the experimentation in which treatments were put with appropriate randomization and results of sensory evaluation are hereby described character wise.

4.2.3.1 Colour

Data on sensory evaluation of colour acceptability of banana flour product during storage have been presented in Table 4.8 and depicted in Fig. 4.7 and described as below.

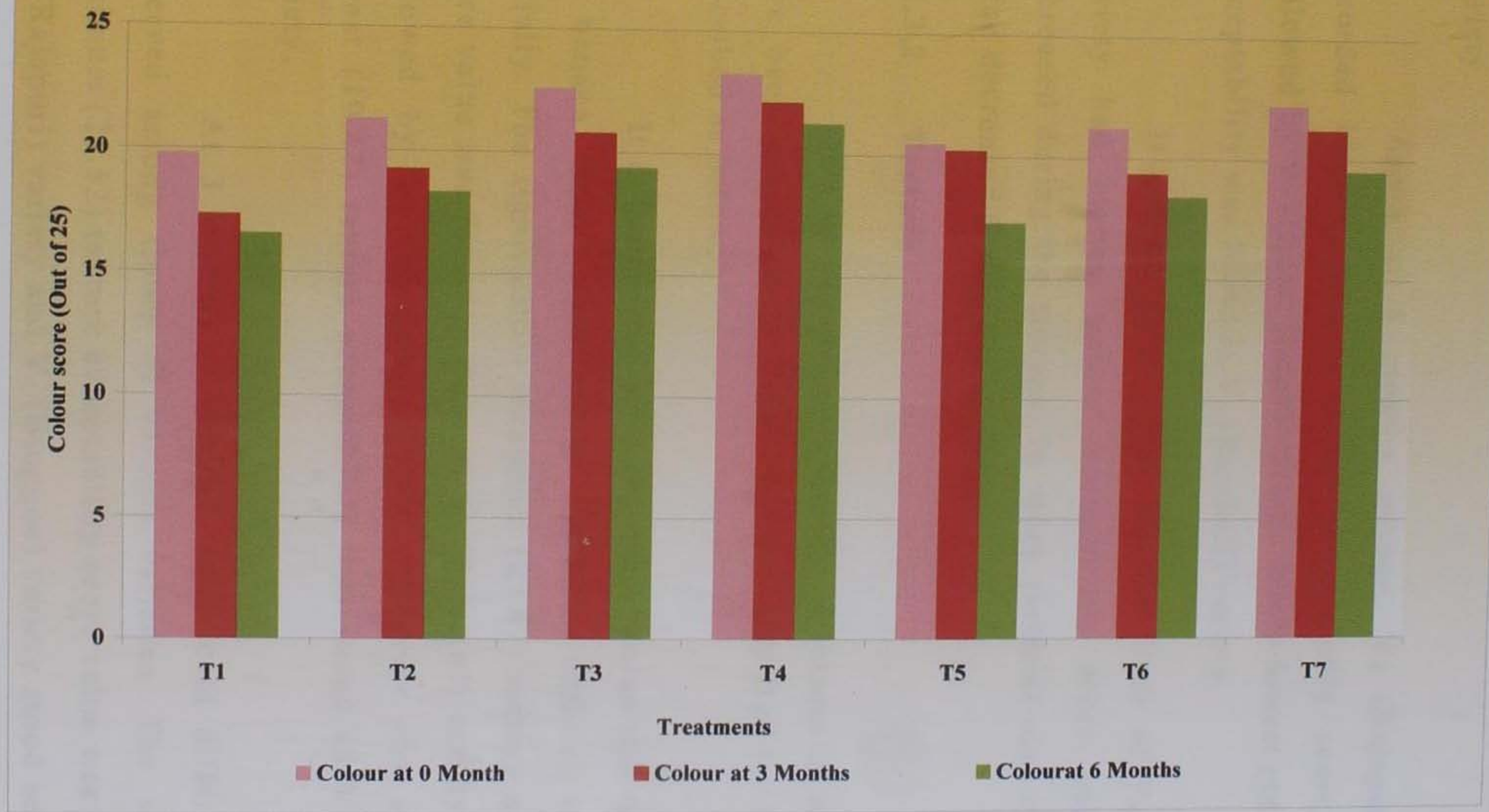
It is revealed that initially variation in colour acceptability was found significant among flour of different varieties. The highest (23.27) colour acceptability score value was obtained in V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety. However lowest (19.8) colour score was found in V_1 (Rasthali) variety.

At 3 months storage it can be seen that the maximum (22.12) colour acceptability score value was obtained in a V_4 (Rajapuri) variety followed by V_7 (Grand Naine) variety. While

Table 4.8: Changes in colour (score out of 25) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	19.8	17.32	16.57	17.90
V_2	Saba	21.29	19.25	18.33	19.62
V_3	Bluggoe	22.58	20.78	19.38	20.91
V_4	Rajapuri	23.27	22.12	21.27	22.22
V_5	Chandrabali	20.52	20.25	17.29	19.35
V_6	Udhyam	21.24	19.37	18.43	19.68
V_7	Grand naine	22.24	21.23	19.52	21.00
	S.Em. ±	0.021	0.046	0.027	
	C.D. at 5 %	0.07	0.14	0.08	
	CV %	0.30	0.68	0.41	

Fig-4.7 : Difference in colour score (out of 25) of various banana flour during the storage period



lowest (17.31) colour acceptability was observed in V_1 (Rasthali) variety.

Again at 6 months storage, V_4 (Rajapuri) variety recorded highest (21.27) colour acceptability score, similarly followed by V_7 (Grand Naine) variety. While lowest (16.57) colour acceptability was found in V_1 (Rasthali) variety.

It can be summarized that the flour of V_4 (Rajapuri) variety had highest colour acceptability score value and it decreased during the storage. In other varieties also colour score value decreased during the storage.

4.2.3.2 Texture

Data on organoleptic quality of texture of banana flour have been presented in Table 4.9 and depicted in Fig.4.8 and described as below.

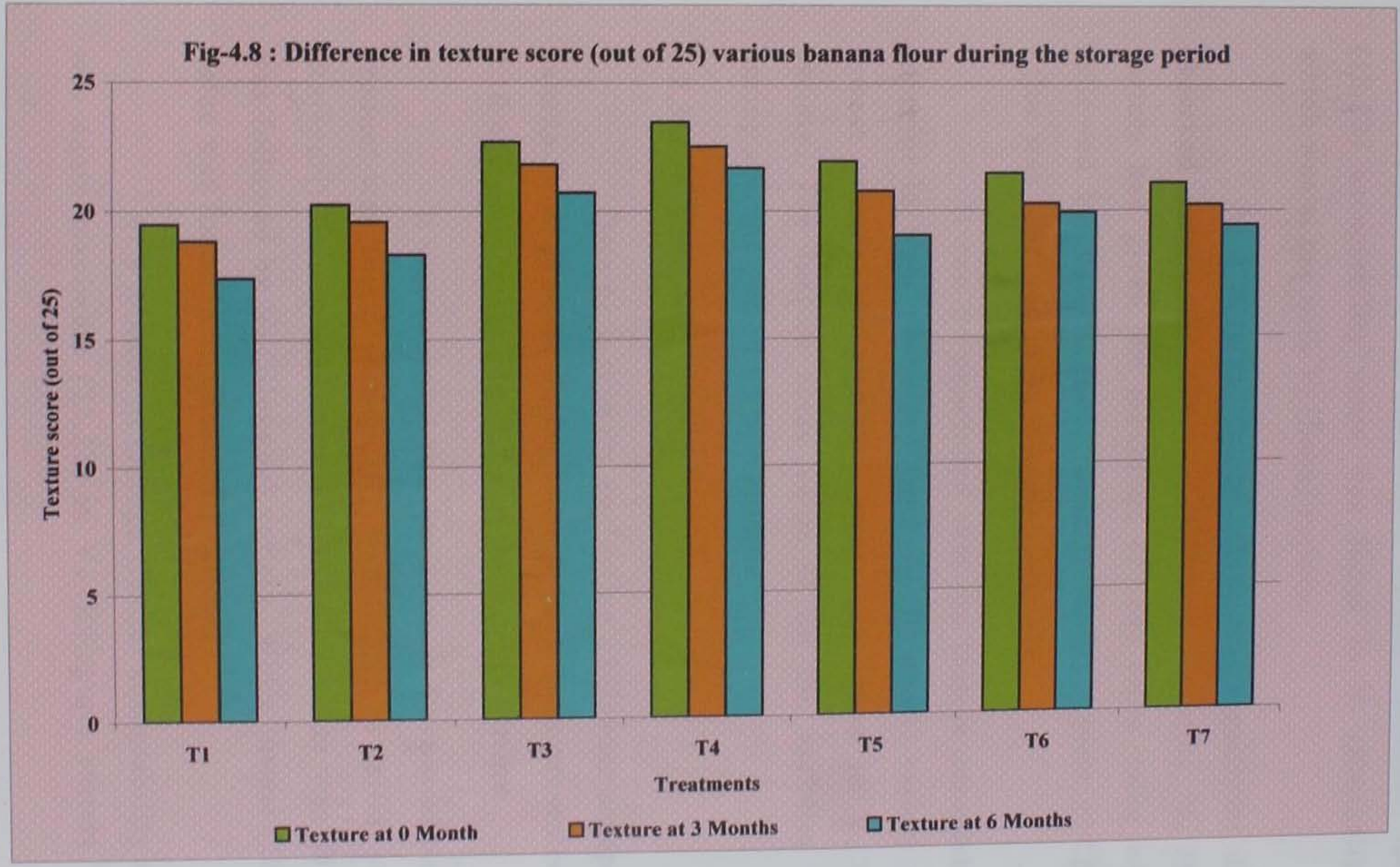
It is manifested from the presentation that the variation of banana flour significantly affected texture acceptability initially. The significantly maximum (23.47) texture acceptability score value was found in flour of V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety. However the significantly lowest (19.47) texture acceptability was found in V_1 (Rasthali) variety.

At 3 months of storage, significant differences were observed among flours of various varieties. The significantly maximum (22.52) texture acceptability score value was observed in V_4 (Rajapuri) variety and V_3 (Bluggoe) variety stood second which

Table 4.9 : Changes in texture (score out of 25) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	19.47	18.82	17.38	18.56
V_2	Saba	20.26	19.59	18.31	19.39
V_3	Bluggoe	22.69	21.82	20.72	21.74
V_4	Rajapuri	23.47	22.52	21.68	22.56
V_5	Chandrabali	21.93	20.77	19.03	20.58
V_6	Udhyam	21.47	20.28	19.93	20.56
V_7	Grand naine	21.09	20.22	19.41	20.24
	S.Em. ±	0.033	0.030	0.035	
	C.D. at 5 %	0.10	0.09	0.11	
	CV %	0.46	0.43	0.52	

Fig-4.8 : Difference in texture score (out of 25) various banana flour during the storage period



was at par with V_5 (Chandrabali) variety. However, the lowest (18.82) acceptability score was found in V_1 (Rasthali) variety which was at par with V_2 (Saba) variety.

At 6 months storage, there was significant difference observed among the flour of different varieties. V_4 (Rajapuri) variety had given the maximum (21.68) score value which was followed by V_3 (Bluggoe) variety. While, lowest (17.38) score value was observed in V_1 (Rasthali) variety.

It can be concluded that the texture acceptability was superior in flour processed from V_4 (Rajapuri) variety while the lowest texture acceptability score was found in V_1 (Rasthali) variety. The texture score value of all the varieties decreased during storage period up to 6 months.

4.2.3.3 Flavour

Data on a sensory evaluation of flavour acceptability of banana flour product during storage have been presented in Table 4.10 and depicted in Fig. 4.9 and described as below.

It was revealed that variation in flavour of banana flour product was found statistically significant. At initial stage in V_4 (Rajapuri) variety maximum (23.3) score value was found which was followed by V_3 (Bluggoe) variety. While lowest (18.19) score value was found in V_1 (Rasthali) variety.

At 3 months of storage flavour acceptability score value was again maximum (22.27) in V_4 (Rajapuri) variety which was

Table 4.10 : Changes in flavour (score out of 25) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	18.19	17.31	16.78	17.43
V_2	Saba	20.39	19.28	18.57	19.41
V_3	Bluggoe	21.83	20.79	19.28	20.63
V_4	Rajapuri	23.3	22.27	21.68	22.41
V_5	Chandrabali	21.43	20.31	19.18	20.31
V_6	Udhyam	20.67	19.43	18.92	19.67
V_7	Grand naine	21.34	21.27	19.33	20.65
	S.Em. ±	0.021	0.025	0.025	
	C.D. at 5 %	0.06	0.08	0.07	
	CV %	0.29	0.37	0.37	

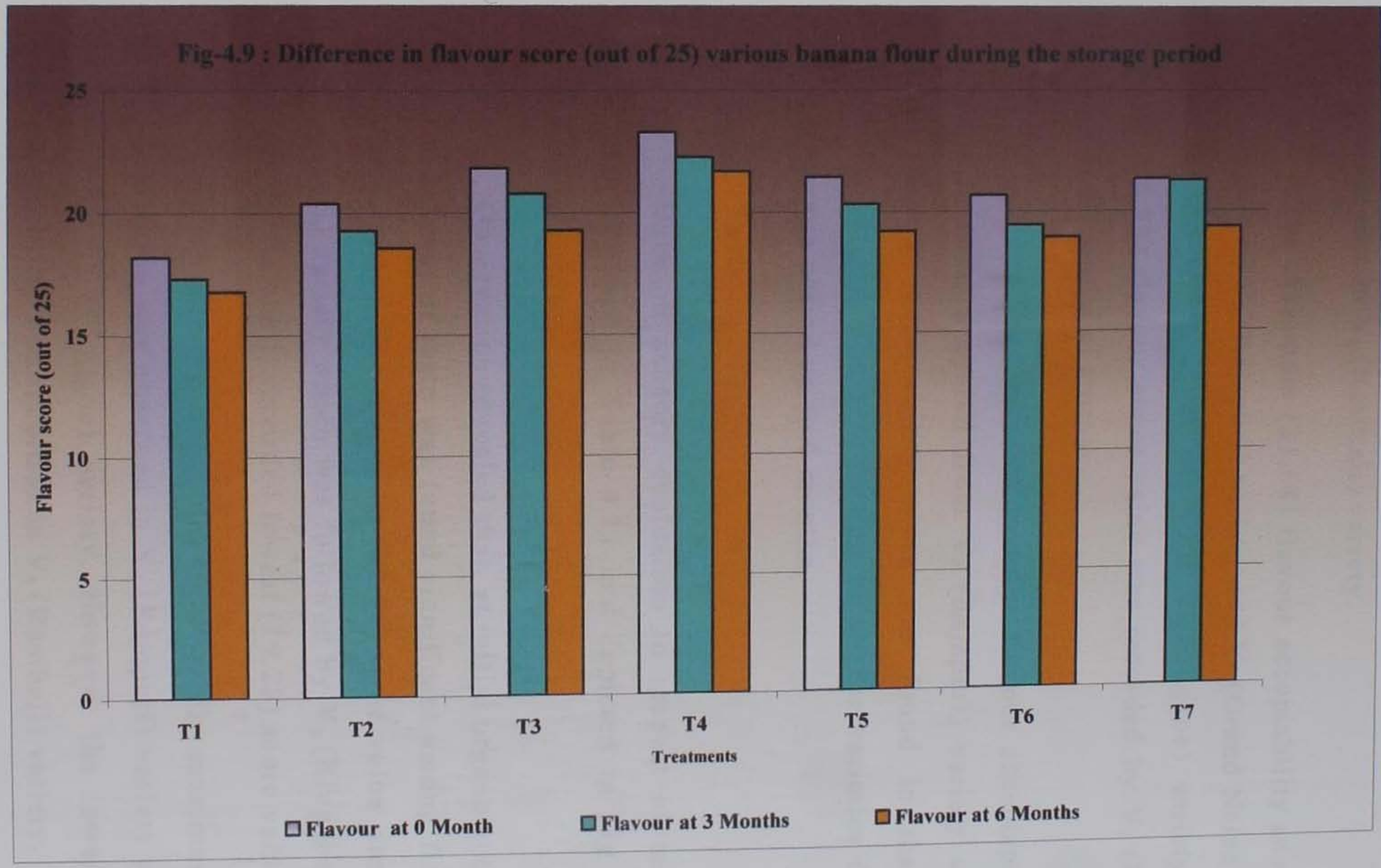


Fig-4.9 : Difference in flavour score (out of 25) various banana flour during the storage period
Flavour score (out of 25)
25
20
15
10
5
0
T1
T2
T3
T4
T5
T6
T7
Treatments
Flavour at 0 Month
Flavour at 3 Months
Flavour at 6 Months

followed by V_7 (Grand Naine) variety. While the lowest (17.31) score value was in V_1 (Rasthali) variety.

The maximum (21.68) flavour acceptability score value was obtained in V_4 (Rajapuri) variety and V_7 (Grand Naine) variety stood second which is at par with V_3(Bluggoe) variety. While lowest (16.78) flavour score value was recorded by V_1 (Rasthali) variety at 6 months of storage.

It can be concluded that the flavour acceptability was superior in flour prepared from V_4 (Rajapuri) variety while the lowest flavour acceptability score was found in that of V_1 (Rasthali) variety. The score value of all the varieties decreased during storage period up to 6 months.

4.2.3.4 Taste

Data on sensory evaluation in respect of taste value have been depicted in Table 4.11 and depicted in Fig 4.10 and described as below.

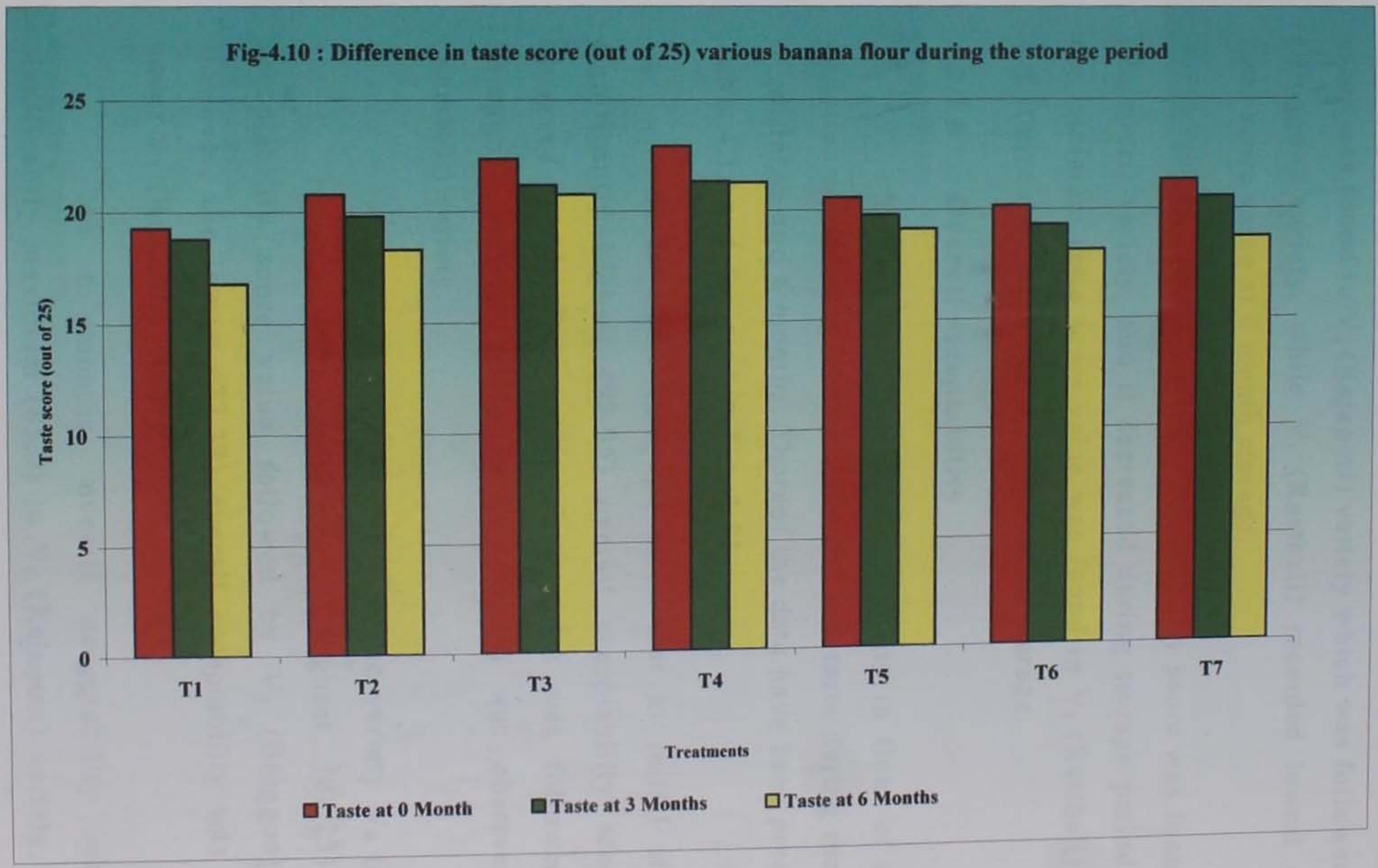
Observation revealed that, at initial organoleptic quality status in respect of taste was found significant among flour of the different varieties. The maximum (22.91) score value was found in V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety. However V_1 (Rasthali) recorded lowest (19.28) score value.

At 3 months stage, the significantly maximum (21.32) taste score value was observed in V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety. However the lowest (18.78) taste acceptability was recorded in V_1 (Rasthali) variety.

Table 4.11 :Changes in taste (score out of 25) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	19.28	18.78	16.79	18.28
V_2	Saba	20.79	19.81	18.3	19.63
V_3	Bluggoe	22.36	21.18	20.76	21.43
V_4	Rajapuri	22.91	21.32	21.27	21.83
V_5	Chandrabali	20.57	19.77	19.13	19.82
V_6	Udhyam	20.17	19.3	18.15	19.21
V_7	Grand naine	21.34	20.57	18.71	20.21
	S.Em. ±	0.016	0.022	0.021	
	C.D. at 5 %	0.05	0.07	0.06	
	CV %	0.22	0.33	0.31	

Fig-4.10 : Difference in taste score (out of 25) various banana flour during the storage period



At 6 month storage, again maximum (21.27) taste score value was found in V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety, while V_1 (Rasthali) recorded lowest (16.79) taste score value at 6 month storage.

The maximum taste acceptability score was found in V_4 (Rajapuri) variety, and it decreased during storage period. While the minimum taste score value was found in V_1 (Rasthali) variety and it also decreased during 6 months of storage.

4.2.3.5 Overall acceptability

The data on overall acceptability in flour of different varieties considering, texture, flavour and taste during the storage of initial, 3 and 6 months. Thereof the data have been presented in Table 4.12 and depicted in Fig. 4.11

It is clear from the table that at initial stage, the significantly highest (92.95) overall acceptability score value observed in V_4 (Rajapuri) variety which was followed by V_3 (Bluggoe) variety, while lowest (76.74) was observed in V_1 (Rasthali) variety.

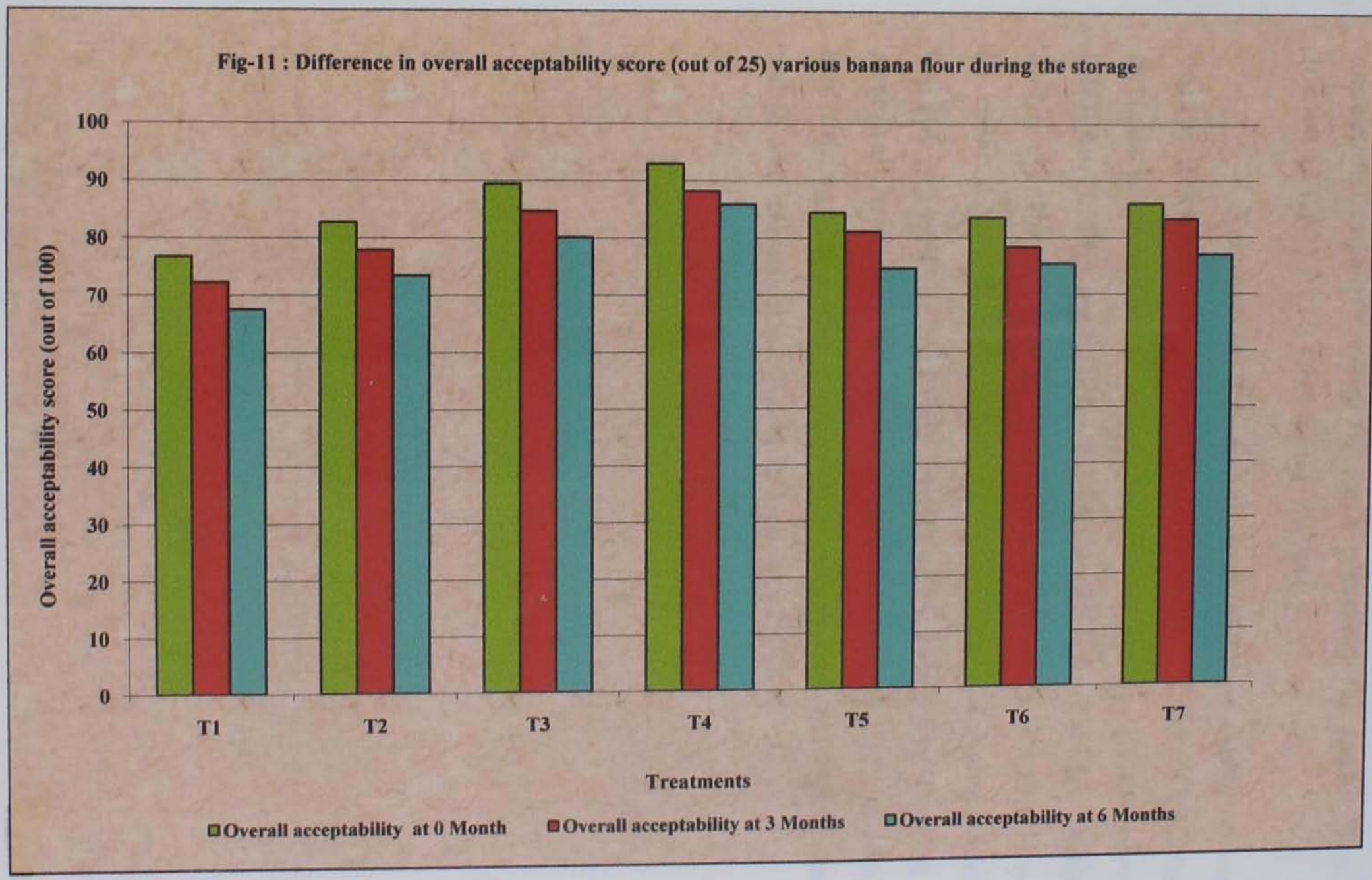
At 3 months of the storage, the variety V_4 (Rajapuri) variety recorded the significantly highest (88.23) overall acceptability score value followed by V_3 (Bluggoe) variety. However, the lowest (72.33) overall acceptability was observed under V_1 (Rasthali) variety.

At 6 months, overall acceptability was again significantly maximum (85.9) in V_4 (Rajapuri) variety. This was

Table 4.12 : Changes in overall acceptability (score out of 100) of various banana flour during the storage periods

Treatments		Storage Periods			
		0 Month	3 Months	6 Months	Mean
V_1	Rasthali	76.74	72.23	67.52	72.16
V_2	Saba	82.73	77.93	73.51	78.06
V_3	Bluggoe	89.46	84.71	80.14	84.77
V_4	Rajapuri	92.95	88.23	85.9	89.03
V_5	Chandrabali	84.45	81.1	74.63	80.06
V_6	Udhyam	83.55	78.38	75.43	79.12
V_7	Grand naine	86.01	83.29	76.97	82.09
S.Em. ±		0.059	0.077	0.055	
C.D. at 5 %		0.17	0.23	0.16	
CV %		0.42	0.56	0.41	

Fig-11 : Difference in overall acceptability score (out of 25) various banana flour during the storage



followed by V_3 (Bluggoe) variety. However, the overall acceptability score value of flour product was found significantly lowest (67.52) in V_1 (Rasthali) variety.

Perusal of the result presented in table in respect of colour, texture, flavour and taste at initial, 3 and 6 months storage periods showed that at 0 hrs the highest score value observed in V_4 (Rajapuri) .this was followed by V_3 at initial stage. During the 3 and 6 months of storage it decreased and remain (89.03) maximum in mean score value. Other varieties also decreased score value during 3 and 6 months storage. While, the lowest overall acceptability was recorded in V_1 (Rasthali) variety at initial stage and during the 3 and 6 months of storage steadily decreased score value and remain significantly lowest (72.16).

DISCUSSION

V. DISCUSSION

The results obtained from the present investigation on "Evaluation of banana varieties for flour making", has been discussed within this chapter with probable reasoning and the work reported by earlier workers.

5.1 Physical parameter

5.1.1 Fruit weight (g)

The maximum average fruit weight was found in V_2 (Saba) variety, while lowest was found in V_4 (Rajapuri) variety.

5.1.2 Pulp weight (g)

The maximum average pulp weight was found in in V_2 (Saba) variety, while lowest was found in Grand Naine (V_7) variety.

5.1.3 Peel weight (g)

The maximum average peel weight was found in in V_2 (Saba) variety, while lowest was found in V_4 (Rajapuri) variety.

5.1.4 Pulp: Peel

The maximum pulp to peel ratio was found maximum in V_1 (Rasthali) variety, while lowest was found in V_4 (Rajapuri) variety.

5.2 Biochemical parameters

The composite value of various chemical constituent in the flour product, prepared from different varieties of banana showed significant results. Data presented in this chapter

pertaining to the acidity (percent), ascorbic acid (mg/100 g), starch (percent), total soluble solid (°Brix), total sugar (percent), and moisture (percent) constituent were found significant and discussed as below.

5.2.1 Titratable acidity (percent)

At initial stage the content of titratable acidity in flour was significantly highest in Bluggoe (V_3) variety which was at par with Rasthali (V_1) and Rajapuri (V_4) varieties, while the lowest titratable acidity in Grand Naine (V_7) variety. Titratable acidity shows the decreasing trend and it also may be affected due to increase in moisture level during the storage. During the storage titratable acidity has been influenced by metabolic changes; loss of acids might be due to utilization of acids for conversion of non reducing sugar to reducing sugar and non enzymatic reaction. This observation is supported by Sagar *et al.* (2000) in study of ripe mango powder; Sharma *et al.* (2006) in study of dehydration of apple; Evelin *et al.* (2007) in study of spray dried ripe banana powder and Mandalik *et al.* (2009) in study of banana flour.

5.2.2 Ascorbic acid (AA; mg/100g)

The initial status of the product in respect of ascorbic acid content was highest in Udhyam (V_6) variety than rest of the varieties may be due to the highest content of AA in fruits and status of variety; trend was decreasing during the storage up to 3 and 6 months. While lowest ascorbic acid content was found in flour of Chandrabali (V_5) variety and decreasing during the storage and remain lowest, in mean value. The decreasing trend of ascorbic

acid was found mostly due to its oxidation and as substrate in non enzymatic browning during the storage period. This kind of observation also recorded by Harsimart and Dhawn (2001) in study on guava powder, Sani and Singh (2005) in study on dehydrated bael, Sharma *et al.* (2006) recorded in dehydrated apple; Rajput (2007) in study of dehydrated sapota slices; Mandalik *et al.*(2009) in study of banana flour.

5.2.3 Starch (per cent)

Initial stage flour starch (percent) content of Grand Naine (V_7) variety was found maximum which decreased during the storage and remained maximum at mean value, while lowest level of starch was found in flour of Saba (V_2) and it also decreasing trend and remains lowest among rest of the varieties viz. Rasthali (V_1), Bluggoe (V_3), Rajapuri (V_4), Chandrabali (V_5) and Udhyam (V_6). The status of varieties having higher content of starch remains higher and lower content remain lower in flour. The decreasing starch level can be mainly because of conversion of starch to sugar as evidenced by increase in total sugar content similarly changes were also seen by Sagar *et al.* (2000) in study of mango powder; Evelin *et al.* (2007) recorded in banana powder and Mandalik *et al.* (2009) in study of banana flour.

5.2.4 Total soluble solids (°Brix)

The initial TSS (°Brix) level of the flour of Grand Naine (V_7) variety was found maximum. This high TSS (°Brix) content is due to fruit pulp varietal character. While lowest in Saba (V_2) variety. Varieties having high content of TSS remain highest

and lower content of TSS remain lowest in flour. The TSS content increasing trend was observed it might be due to the hydrolysis of polysaccharides and their subsequent conversion to reducing sugar as evidenced by decreasing the starch content of the flour. This kind of observation were also recorded by Harsimart and Dhawn (2001) in study of guava powder; Evelin *et al.* (2007) in study on banana powder and Mandalik *et al.* (2009) in study banana flour

5.2.5 Total sugar (percent)

The content of TS in the banana flour was significantly highest in Grand Naine (V_7) variety at initial stage, while the lowest TS in Saba (V_2) variety, it might be due to the genetically character and status of the varieties. TS increasing trend was observed in banana flour during storage period it might be due to the break down and hydrolysis of starch to sugar as evidenced by decrease in starch content of the flour during the storage, this kind of observation also recorded by Sagar *et al.* (2000) in study of mango powder; Harsimart and Dhawn (2001) in study of guava powder and Mandalik *et al.* (2009) in study of banana flour.

5.2.6 Moisture (percent)

The level of moisture was significantly highest in Grand Naine (V_7) variety, while the lowest moisture was found in Chandrabali (V_5) variety. It may be due to genetical character and status of the status of the dry pulp of respective variety. Increasing trend in moisture level during storage can be seen mainly because of hygroscopic nature of dry powder of respective variety due to which it absorbs moisture from atmosphere and fluctuation in

temperature due to seasonal variation. Similar observation was recorded by Mehta and Tomar (1980 a&b) in study of dehydrated guava and papaya; Naik and Chundawat (1996); Singh *et al.* (2006) in study of aonla dehydrated product; Rajput (2007) in dehydrated Sapota slices and Mandalik *et al.*(2009) in banana flour

The result of biochemical component viz. acidity, ascorbic acid, starch, TSS and TS of the flour of various banana varieties was individually discussed at a glance with the appropriate reasons and supporting findings of other scientists. It can be elucidated that considering the acidity maximum in Bluggoe (V_3), ascorbic acid in Udhyam (V_4), starch maximum in Grand Naine (V_7), these component showed decreasing trend during the storage while TSS and TS was found maximum in Grand Naine (V_7) and increased during the storage, hence it can be seen that the banana flour product remains in most acceptable condition as well as value added up to 6 month.

5.3 Organoleptic quality attributes

The composite value of various organoleptic acceptability of the banana flour product made by different varieties showed significant result except flavour, discussed in this chapter pertaining to the colour, texture, flavour, taste and overall acceptability of the banana flour.

5.3.1 Colour

The organoleptic attributes evaluation of colour acceptability was maximum in Rajapuri (V_4) variety which contains higher level of carotenoid pigent, it might be due to the

genetical character evidenced by ivory pigent colour of fresh banana pulp. Colour score value of flour decreased during the storage and remains highest in mean value during storage. However lowest colour acceptability was observed in Rasthali (V_1) variety, it also decreased score value during storage and remain lowest in mean value. Colour score value of a flour decreasing during the storage, which may be due to absorption of atmospheric moisture and oxygen which effect the compositional status and browning reaction. This kind of observation also recorded by Awasthi (1984) in dehydration of banana; Sagar *et al.* (2000) study on mango powder; Evelin *et al.* (2007) study on banana powder ; Rajput (2007) in dehydrated sapota chips; Mandalik *et al.*(2010) in banana flour and Savvashe (2010) in banana fig.

5.3.2 Texture

The texture acceptability of banana flour product was the maximum in Rajapuri (V_4) variety at initial stage, While lower texture acceptability was observed in Rasthali (V_1) variety. These might be due to the varietals characteristics. During the storage higher acceptability score remain highest in mean value and lower acceptability score remain lowest in mean value. The texture score value decreased during storage it might be due to the absorption of moisture and hygroscopic nature of flour. This type of observation also recorded by Naik and Chundawat (1996) in aonla dehydrated product; Sagar *et al.* (2000) study on mango powder; Evelin *et al.* (2007) in banana powder; Rajput (2007) in dehydrated

sapota slices; Mandalik *et al.*(2010) in banana flour and Savvashe (2010) in banana fig.

5.3.3 Flavour

The flavour score value was found significantly maximum in Rajapuri (V_4) variety, while Rasthali (V_1) variety ranked lowest in flavor score value. It was observed that decreasing trend during the storage, might be due to loss of flavouring compound and variation in the pulp of the various varieties during storage.This type of result also observed by Avasthi (1984) study on dehydration of green banana; Sagar *et al.* (2000) in mango powder; Sharma *et al.* (2006) in dehydration of apple; Mandalik *et al.* (2010) in banana flour and Savvashe (2010) in banana fig.

5.3.4 Taste

Looking to the taste acceptability of banana flour product Rajapuri (V_4) variety was found significantly maximum at initial as well as 3 to 6 months of storage it might be due to varietal characteristics. However lower acceptability was found in Rasthali (V_1) variety.The taste value depend upon the chemical composition of pulp of respective varieties viz. TSS, TS, titratable acidity, ascorbic acid, starch and moisture content level. During the storage period taste acceptability score value was decreased, and higher acceptability score remain highest in mean value as well as lower acceptability score remain lowest in mean value. This observation also supported by Awasthi (1984) in dehydration

of green banana; Rajput (2007) in dehydrated Sapota slices and Mandalik *et al.* (2010) in banana flour.

5.3.5 Overall acceptability

Looking to the overall acceptability of banana flour considering the colour, texture, flavour and taste were found acceptable in Rajapuri (V_4) variety. This might be due to the calculated score of all four parameters viz. colour, texture, flavor and taste. Whereas Rasthali (V_1) variety ranked lowest among the rest of varieties. A general trend was observed in reduction of overall acceptability score during storage which may be attributed change in chemical composition of the product and loss of colour, flavor, texture and taste during the storage. This kind of observation also observed by Sharma *et al.* (2006) in study of apple dehydration; Avasthi (1984) in dehydration of banana; Mandalik *et al.*(2010) in banana flour and Savvashe (2010) in banana fig.

From above discussion in respect of organoleptic evaluation of new banana flour product it can be elucidated that the Rajapuri (V_4) variety found highest overall acceptability of the banana flour product than the rest of the varieties viz Rasthali (V_1), Saba (V_2), Bluggoe (V_3), Chandrabali (V_5), Udhyam (V_6) and Grand Naine (V_7).This banana flour product remains highest in organoleptic evaluation at initial status and remains acceptable during the 6 months of storage with similar status.

SUMMARY AND CONCLUSION

VI. SUMMARY AND CONCLUSION

The present investigation on "Evaluation of banana (Musa paradisiaca L.) varieties for flour making" viz. Rasthali, Saba, Bluggoe, Rajapuri, Chandrabali, Udhyam and Grand Naine for flour making was conducted at Post Graduate and Post Harvest Technology Laboratory, Department of Horticulture, N.M. College of Agriculture, Navsari Agricultural University, Navsari with following objectives

1. To evaluate the suitability of banana varieties for flour making
2. To study the nutritional and organoleptic status of Banana flour made from different varieties during storage period.

The brief summary of results were presented as under

The average fruit weight was found maximum in V_2 (Saba) variety, while lowest was found in V_4 (Rajapuri) variety.

In respect to average pulp weight of fresh fruit, maximum was found in V_2 (Saba) variety, while lowest was found in V_4 (Rajapuri) variety.

In respect to average peel weight of fresh fruit, maximum was found in V_2 (Saba) variety, while lowest was found in V_4 (Rajapuri) variety.

In respect to pulp : peel ratio of fresh fruit, maximum pulp: peel ratio was found maximum in V_1 (Rasthali) variety, while lowest was found in V_7 (Grand Naine) variety.

In respect to titratable acidity content in various products was significantly found maximum in flour of Bluggoe (V_3) variety and it was at par with Rathali (V_1) and Rajapuri (V_4) variety. While significantly lowest in Grand Naine (V_7) variety at initial stage and during storage, the status of banana flour was observed decreasing the value up to 6 months

In respect of AA content in various products was significantly found maximum in flour of Udhyam (V_6) variety which was followed by Grand Naine (V_7) variety. While significantly lowest in Chandrabali (V_5) variety at initial stage and during storage the status of banana flour was observed decreasing the value up to 6 months

The maximum starch was observed in flour of Grand Naine (V_7) variety which was followed by Udhyam (V_6) variety. The significantly lowest starch content was observed in flour of Saba (V_2) variety, at initial stage while during storage, the status of banana flour was observed decreasing the value up to 6 months.At 6 months storage Udhyam (V_1) variety stood second and Udhyam (V_6) variety third in starch content and the rest is similar to the initial stage.

The maximum TSS was observed in flour of Grand Naine (V_7) variety which was followed by Udhyam (V_6) variety. While the lowest TSS was observed in flour of V_2 (Saba) variety at initial stage while increasing during 3 and 6 months of storage.

In respect of TS, the maximum TS was observed in flour of Grand Naine (V_7) variety which was followed by Udhyam

(V_6) variety. While the lowest level of TS was found in flour of Robusta (V_3) at initial stage and during storage, the status of banana flour product was decreasing trend up to 6 months.

The organoleptic quality in respect of colour acceptability was significantly highest in the flour of Rajapuri (V_4) variety which was followed by Bluggoe (V_3) variety. However lowest colour acceptability was found in flour of Rasthali (V_1) variety at initial stage at initial stage, while during storage the status of banana flour product was decreasing trend up to 6 months.

In respect of texture acceptability, the maximum texture acceptability was observed in flour of Rajapuri (V_4) variety and it was followed by Bluggoe (V_3) variety. However the significantly lowest texture acceptability was found in flour of Rasthali (V_1) variety at initial stage at initial stage, while during storage the status of banana flour product was decreasing trend up to 6 months.

In respect of flavour acceptability, the maximum flavour acceptability was observed in flour of Rajapuri (V_4) variety and it was followed by Bluggoe (V_3) variety. However the significantly lowest texture acceptability was found in flour of Rasthali (V_1) variety at initial stage at initial stage, while during storage the status of banana flour product was decreasing trend up to 6 months.

Considering the taste acceptability, the maximum taste acceptability was observed in flour of Rajapuri (V_4) variety which

was followed by Bluggoe (V_3) variety. However the lowest taste acceptability was recorded in flour of Rasthali (V_1) variety at initial and during storage it remains similar.

The overall acceptability of product in respect of colour, flavour, texture and taste, the highest overall acceptability was observed in flour of Rajapuri (V_4) variety which was followed by Bluggoe (V_3) variety. However lowest acceptability was observed in flour of Rasthali (V_1) variety at initial stage, during the storage they remain similar pattern.

Conclusion

The above summary reflected that the banana flour made from Rajapuri (V_4) variety is best suitable for flour making in respect to organoleptic acceptability while Grand Naine (V_7) variety is most suitable for flour making in respect to the nutritional composition of flour among the seven varieties viz. Rasthali, Saba, Bluggoe, Rajapuri, Chandrabali, Udhyam and Grand Naine . Flour made from all the seven varieties remain acceptable at initial as well as during the storage.

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* Original not seen

** Thesis (Unpublished)

APPENDIX

Appendix-I Meteorological data during the year 2010

Months	Standard Week	Temperature		Rainfall (mm)	Rainy days	Relative humidity (%)	
		Max.	Min.			AM	PM
January	1	29.8	17	0	0	71	40
	2	29.9	15.6	0	0	68	42
	3	30.5	15.4	0	0	71	34
	4	31.9	15.4	0	0	69	26
	5	32	15	0	0	81	34
February	6	31.1	17.7	0	0	81	41
	7	30.7	13.2	0	0	73	29
	8	32.1	16.3	0	0	77	35
	9	34.6	17	0	0	77	34
March	10	33.7	19.5	0	0	79	32
	11	36.4	19.1	0	0	82	28
	12	36.6	19.6	0	0	82	30
	13	32.8	22.1	0	0	90	54
April	14	35.7	21.7	0	0	91	45
	15	36	23.9	0	0	89	60
	16	33.9	25.4	0	0	83	73
	17	38	24.1	0	0	90	53
	18	35.3	25.6	0	0	91	68
May	19	39	26.1	0	0	90	50
	20	37.1	26.3	0	0	90	54
	21	34.9	28.8	0	0	87	63
	22	33.4	28.3	0	0	84	68
June	23	33.4	26.6	68	2	87	66
	24	32.8	29.3	131	2	90	75
	25	33.5	26.8	37	1	94	75
	26	31.2	26.5	33	1	96	81

Source : Agricultural Meteorological observatory, N.M. College of Agriculture, Navsari

CERTIFICATE

This is to certify that I have no objection to supply one copy of any part of this thesis at a time to any scientist through reprographic process, if necessary for rendering reference service in a library or documentation centre.

Place : Navsari

Date : 26th April , 2011

(Isha Swami)