"DEVELOPMENT OF PROCESS TECHNOLOGY FOR PREPARATION OF BANANA BEVERAGES"

MASTER OF TECHNOLOGY
(AGRICULTURAL ENGINEERING)

THESIS

BY

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DEPARTMENT OF AGRICULTURAL PROCESSING AND FOOD ENGINEERING

FACULTY OF AGRICULTURAL ENGINEERING

INDIRA GANDHI **KRISHI VISHWAVIDYALAYA RAIPUR** (C.G.)

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Moneshkumar Mahadeo Pethe

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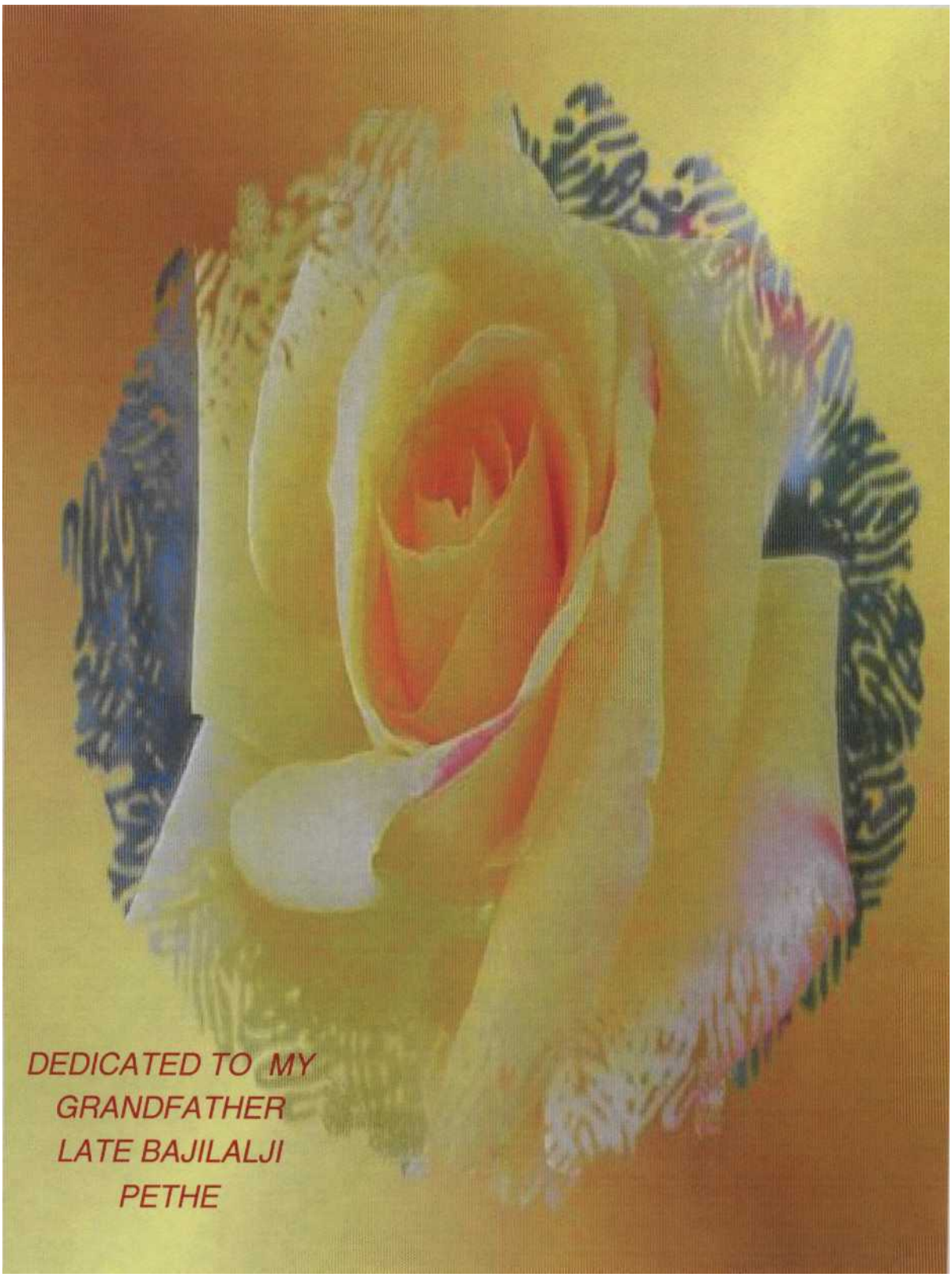
DEDICATED TO MY
GRANDFATHER
LATE BAJILALJI
PETHE

Vita

Moneshkumar Mahadeo Pethe was born on 28th October 1978 at Amravati, Dist. Amravati (Maharshtra). He completed his High School Education from *Govt. Higher Secondary School, Bhainsdehi, T. Bhainsdehi Dist. Betul (M.P.)* in 1993. He passed the Higher Secondary School Certificate Examination from *Shri Shivaji Mutipurpose Junior College, Amravati* in the year 1995, with first division. Thereafter, he joined College of Agricultural Engineering and Technology, *Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.)* and completed **B.Tech.** (Agril. Engg.) with second division in 1999.

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He has worked as a Junior Plant Engineer in *Khetan International Food Products, Akola* for six months. He played inter-university volleyball as a captain. He has presented a paper entitled *Design and Development of Juice Concentrator* in XXXV Annual Convention of ISAE, 2001.

Certificate - I

This is to certify that the thesis entitled **"DEVELOPMENT OF PROCESS TECHNOLOGY FOR PREPARATION OF BANANA BEVERAGES"** submitted in partial fulfilment of the requirements for the degree of **"Master of Technology in Agricultural Engineering"** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Shri Moneshkumar Mahadeo Pethe** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma (certificate awarded etc.) or has been published / Published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Dr S. Patel
Chairman Advisory Committee

DATE:17/9/2001

THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE

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Certificate -II

This is to certify that the thesis entitled **"DEVELOPMENT OF PROCESS TECHNOLOGY FOR PRAPARATION OF BANANA BEVERAGES"** submitted by **Shri Moneshkumar Mahadeo Pethe** to the Indira Gandhi Krishi Vishwavidyalaya, Raipur in partial fulfilment of the requirements for the degree of M. Tech. (Agricultural Engineering) in the Department of Agricultural Processing and Food Engineering has been approved by the Student's Advisory Committee after oral examination in collaboration with the external examiner.

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MONESHKUMAR M. PGTHG

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ABBREVIATIONS

Agri		Agriculture
Agril.	:	Agricultural
B.Tech.		Bachelor of Technology
cc		cubic centimeter
CD	:	Critical Difference
CFTRI	:	Central Food Technology Research Institue
C.G.		Chhattisgarh
CIAE		Central Institute of Agricultural Engineering
cm	:	centimeter
cm^2		square centimeter
cfu		colony forming unit
Conc.	:	concentration
db	:	dry basis
Dept.	:	Department
Dist.		District
Engg.		Engineering
et al.	:	etalibi (and other)
etc.	:	excetra
FAO		Food and Agriculture Organization
Fig.		Figure
g		gram
g/ml		gram per liter

Govt.	:	Government
h	:	hour
ha	:	hectare
Hg	:	mercury
ICAR	:	Indian Council of Agriculture Research Institute
IGKVV	:	Indira Gandhi Krishi Vishwavidhalaya
J	:	Journal
kg	:	kilogram
KMS	:	Potassium meta-bisulphite
m/s	:	meter per second
mg	:	milligram
min	:	minute
M.P.	:	Madhya Pradesh
MT	:	Metric Tonne
MMT	;	Million Metric Tonne
M.S.		Maharshtra
M.Tech.	:	Master of Technology
N	:	Newton
nm	:	Nanometer
No.	:	Number
Pa	:	Pascal
ppm		parts per million
PHT	:	Post Harvest Technology

Poce.	Proceeding
rpm	revolution per minute
s	second
Sci.	Science
SEm	Standard Error of mean
TSS	Total soluble solids
t	tonne
Tech.	Technology
Temp.	Temperature
TPA	Texture Profile Analyser
Trop.	Tropical
vs	versus
v/w	volume per weight
wb	Wet basis
w/w	weight per weight

CHAPTER - 1

INTRODUCTION

CHAPTER – I

INTRODUCTION

Banana (*Musaparadisica*) is an important fruit in world trade. Banana contributes 12 per cent of the total fruit production in India (FAO, 1998). With a growing appreciation in nutrition and medicinal properties banana gives high economic returns per unit area and sustainable income even to marginal farmers.

India is the largest banana producing country with the production of 9.935 MT (FAO, 1998) and 2,77,919 ha area under cultivation. The major banana producing states in the countries are Maharashtra (3455.6, MT), Kerala (415.1, MT), Tamil Nadu (4405.5, MT), Gujarat (1097.3, MT), Bihar (566.4, MT), Andhra Pradesh (922.1, MT), and Karnataka (2010.4, MT), (NHB, 2000). Karnataka, Tamil Nadu and Maharashtra occupy 49.35 per cent of total area under the crop contributing about 55.18 per cent of total production. In Chhattisgarh, total area under banana production was 354 ha. The total production of banana was 6300 MT per year and productivity was about 17.79 MT/ha (Anonymous, 2000).

Bananas are cultivated in over 100 countries in the tropical and subtropical regions of the world. It is a major staple food crop for millions of the people, as well as provides a valuable source of income through local and international trade. It is grown over a harvested area of appropriately 10 million ha with an annual production of around 88 MT (FAO, 1998) of which 40 per cent is in Asia.

Banana is relatively cheapest and nutritionally rich in all the fruits. Banana rich in carbohydrate and low fat content and making them particularly full in low fat diet. As a staple food crop, the protein level is low as compared to the major cereal crops. Also, it is a good source of many vitamins and minerals.

Banana is consumed world over either raw, in the ripe state, or as a cooled vegetable. Indeed, an important constraint on the large scale development of banana processing is the lack of demand for banana products since the fresh fruit is available throughout the year in most parts of the tropical world. Post harvest losses are in the range of 12-14 per cent (FAO, 1998) due to lack of proper transportation and storage facilities leading to damage and over-ripening of fruits. It is estimated that in India alone 3 MT (NHB, 2000) of banana is wasted, therefore, processing and product development using ripe/over ripe banana is of utmost importance for value addition and improved returns. Banana can be processed for banana fig, chips, flour, powder, starch, juice, wine, brandy, *etc.* Therefore, bananas grown in the tropics are excellent for processing because fruit is available throughout the year.

Very few processed banana products are marketed, primarily due to the characteristics of banana during processing. In recent years, there is an increased trend to develop a variety of new preservable products by introducing new and improved methods of processing. One such product is liquid banana named as banana beverage. Ripe and over-ripe banana can be converted into beverage by simple pressing or centrifugation, whereas some tropical fruits, including banana are usually too pulpy and pretinaceous to yield juices by these methods without

involving excessive amount of energy and also liquefaction of pulp can be achieved by fermentation and enzyme treatments (Floribeth *et al*., 1981).

There is no systematic studies have been reported on processing, storage and acceptability of the cereal based low cost fermented beverages. Looking to the present demand of food process industry this study have been contemplated with the following objectives:

Objectives:

1. To standardize the process for the preparation of banana beverage.
2. To evaluate the physico-chemical properties of fresh and stored products.
3. To work out the techno economic feasibility for one tonne per day banana processing unit.

CHAPTER - II

REVIEW OF LITERATURE

CHAPTER - II

REVIEW OF LITERATURE

This chapter covers information on background information status in world trade, post harvest handling, bio-chemical composition; recent work done on various types of banana beverages prepared from raw and ripened banana and similar kinds of other fruits, by product / waste utilization and details of designing and engineering of the processing plant.

2.1 Background:

4000 years B.C. the earliest cultural and agricultural links between South East Asia and Oceania are speculated. The earliest records of the banana indicate cultivation in India about 500 B.C. Their cultivation is best described as a form of “proto - agriculture" (Simmonds, 1960).

The Center of greatest diversifies of wild Musa species and the presumed center of origin of the group, is in Indo-China and South East. All banana produce fruits that are to some degree consumed by animals, presumably as a part of seed disposal (Simmonds, 1960).

Banana belongs to the family Musaceae in the order Scitaminae, besides Musa, another genus in this family is 'Ensete'. The genus Musa contains four species, Eumusa, Rhodochlamys, Astralimusa, and Callimusa Rhodochlamys. Callimusa are of ornamental interest only. Australimusa species are utilized across a large area of the Pacific as a cooked vegetable. However, Eumusa is the largest, most wide spread geographically and contains all major edible species of

banana. Most edible banana varieties are delivered from two members of the Eumusa *i.e.* Musa acuminata and Musa balbisiana (Hulme, 1971).

In India the banana is sacred to one of the forms of the Goddess Kali and is worshiped on the third day of the month *Sravana*. In Southern India a dessert banana is offered as both the actual and symbolic end of a meal. A crop of such fundamental importance to so many people has frequently acquired major significance in the societies in which it is used (Nagy and Shaw, 1980).

2.2 Statistics and world trade:

The vast majority of bananas are produced for local consumption and sale in the world trade.

Table 2.1 Major banana producing countries

S. No.	Country	Production, (MT)	Rank
1	India	9935	1st
2	Brazil	5779	2
3	Indonesia	4768	3rd
4	Phillipines	3500	4th
5	China	3141	5th
6	Costa Rica	2400	6th
7	Colombia	2200	7th
8	Mexico	2064	8th
9	Thailand	1700	9th
10	Burundi	1507	10th
11	Vietnam	1282	11th
	Total world production	58975	

Source: FAO, Production Year Book, 1998.

In Chattisgarh, total area under banana production was 354 ha. The total production of banana was 6300 MT per year and productivity was about 17.79 MT/ha

Table 2.2 Major banana producing districts in Chhattisgarh state

S. No.	Districts	Area, (ha)	Production, (MT)
1	Raipur	17	540
2	Mahasamund	-	-
3	Dhamtari	10	225
4	Durg	34	-
5	Rajnadgaon	-	-
6	Kawardha	2	77
7	Bastar	79	1310
8	Kanker	34	635
9	Dantewada	61	1073
10	Bilaspur	18	623
11	Janjgir	14	477
12	Korba	4	146
13	Raigarh	26	459
14	JashpurNagar	25	211
15	Surguja	28	524
16	Korea	2	-
	Total	354	6300

Source: Anonymous, 2000

2.3 **Harvesting and post harvest handling:**

The fruit is harvested when the ridges on the surface of the skin change from angular to round, *i.e.* after the attainment of three-fourths full stage. Dwarf bananas are ready for harvest in 11-14 months after planting, while tall varieties take about 14-16 months to harvest (Kotecha and Desai, 1995).

Marchal (1997) studied on overview on post-harvest aspects of banana and showed that banana is living organs subject to continuous changes after harvesting. The major problems of festooning banana quality are physical damage, browning and which leads to unpredictable ripening.

2.4 Bio-chemical composition:

Banana contains nearly all the essential nutrients, including minerals and vitamins, and has several medicinal properties. Banana is a rich source of energy and gives about 1 cal/g. The bio-chemical composition of the fruit is given below:

Table 2.3 Bio-chemical composition of ripe banana fruit

Constituent	Content
Moisture, per cent	70
Carbohydrates, per cent	27
Crude Fibre, per cent	0.5
Proteins, per cent	1.2
Lipids, per cent	0.3
Minerals, per cent	0.9
Phosphorous (mg/100g)	29
Calcium (mg/100g)	–
Iron (mg/100g)	0.6
β-Carotene (mg/100g)	0.05
Riboflavin (mg/100g)	0.05

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15	Surguja	28	524
16	Korea	2	-
	Total	354	6300

Source: Anonymous, 2000

Niacin (mg/100g)	0.7
Ascorbic acid (mg/100g)	12
Energy, cal/100g	104

Source: Kotecha and Desai, 1995

2.5 **Banana beverages and wine:**

Mumyanganizi and Coppens (1974) process used banana ripe fruit cut into pieces, blanched for 2 min in steam, pulped and pectolytic enzyme added at a concentration of 2 g enzyme per 1 kg pulp, then held at 60 to 65° C and 2.7 to 5.5 pH for 30 min lime is used to eliminate the pectin. Calcium oxide (0.5 %) is added to the pulp and after standing for 15 min and neutralized which yielded up to 88 per cent clear, attractive banana juice.

Bardiya and Kundu (1974) studied on guava wine and standardized procedure and concluded that the fermentation of guava pulp in presence of *pectinase*, yields a wine of high tannin content, dark colour and astringent taste.

Banana juice can be extracted from banana pulp by pressing or centrifugation once the pulp has been depectinized. Although banana beverages are not generally produced on a commercial scale, several processes have been described (Dupaigne *et al.*, 1974).

Satyanarayana (1976) concluded that is barely malt use in brewing is an expensive process. With the enzyme and improved techniques brewers are employing the microbial enzymes to mash barely and other cheaper starchy materials and obtain wart similar in character to all malt wort.

Jaleel *et al.*, (1978) reported that the clear and sparkling juice from banana pulp having the taste and flavour of original fruit was prepared by

enzymatic method. It could also be concentrated into an amber coloured product with honey consistency and used in the preparation of banana juice drink

Ghildyal and Ramakrishna (1981) showed that on large scale production of *pectolytic* enzyme by solid state fermentation related that the production of enzyme by *Aspergillus carbanerious* CFTRI 1048 on wheat bran medium was highest at 21 h of fermentation. Control of temperature of the solid-state fermentor at 30° C is necessary. Steaming of wheat bran medium at 15 pa for 45 min is needed to get good result.

Pectinolytic enzyme treatments to increase the yield, reduce the viscosity and clarify the juice obtained from ripe banana pulp were studied. Clear juice yields of between 55 and 60 per cent (based on pulp weight used) was obtained from pulp incubated at 45° C for 1h with 0.01 per cent (w/w) of enzyme by subsequent centrifugation at 2900-rpm maximal relative centrifugal force for 20 min (Floribeth *et al,* 1981).

Sandhu and Bhatia (1985) studits on physico - chemical changes during preparation of fruit juice concentrate and reported that orange, pineapple, banana, guava and mango juices were concentrated under vacuum at 55-55° C in a glass evaporator. Cloudy juice of orange can be concentrated upto40-42^{o} Brix while clear juice of pineapple, banana, guava and mango can be concentrated upto 45-48° Brix successfully.

Mabesa, *et al.* (1985) reported that efficiency of*pectic* enzymes to extract juices from banana and papaya was evaluated. Banana pulp treated with 0.5 to 0.75 per cent (v/w) enzyme at 18 to 24 h room temperatures obtained 60 to 80 per

cent juice yield. Addition of 0.1 per cent potassium meta-bisulphite to the pulp before enzyme treatment retarded browning of juice.

The muskmelon juice recovered from fruits unfit for table purpose was fermented *(S. Cerevisiae)* for 96 h at 30 ± 5° C. the fermented juice contained 6.50 per cent (w/v) ethanol and exhibited a very good sensory quality when adjusted to 10 and 12° Brix level with total soluble solids:acid ratio of 34.5 and 41.4 respectively (Teotia *et al*., 1991).

Juices from over-ripe mango and banana were fermented into wine using *S. Cerevisiae.* The effect of pasteurization and packaging in polythene bags on the chemical and sensory properties of the wines during storage were also investigated. Total fermentable sugar content depended on the degree of ripeness, varying between 18 and 20 per cent on weight basis for both fruits. Sweet smelling wines with aroma characteristics of grape wine, and alcoholic contents of 13-14 per cent (v/v) were produced. Total acidity, natural ester, total solids and ethanol contents increased with storage time, while pH decreased. Pasteurized bottled banana wines had greater ester and alcohol contents than unpasteurized but pasteurization did not significantly alter the composition of bottled mango wine. Wines packaged in polythene bags had greater acidity than bottled wines. However, neither pasteurization nor packaging material significantly affected the sensory properties of the wines. (Akingbala *et al*., 1994).

Study on effect of enzymes, lye peeling and condition of fruits on the quality of guava juice, concluded that lye peeling improved the sensory quality of guava juice and nectar prepared from yellow with green tinge fruit. Enzymes had

variable effects on the physico-chemical composition of liquefied guava juice (Khurdiya *et al*., 1994).

Ahmed (1996) studies that the enzymatic juice extraction quality of four varieties of bananas namely Singapuri, Kathali, Chapa and Mortamanwere revealed. Singapuri give maximum juice yield (63 %) compared to other three varieties.

Beverages prepared using Muskmelon clarified juice (10 %) were excellent in colour, flavour and taste and its fortification with ascorbic acid @ 35mg/100g improved the quality of the beverage (Teotia and Kaur, 1997).

Gautam (1997) reported that incorporation of *pectolytic* enzyme to the pulp of sapota @ 3.0 per cent, incubation for 4 h at room temperature and cold pressing of treated pulp improved the juice yield, clarity, physico-chemical and sensory qualities of the juice over hot pressing method of juice extraction.

Non-alcoholic beverages were developed from sorghum malt and breadfruit, plantain, potato or sweet cassava using the endogenous enzymes of the malt and a little quality of external enzyme for sachrication and conducted that all the samples were acceptable in terms of the overall quality (Ilori and Irefin, 1997). The optimal fermentation of known juice for production of wine was recorded at 30° C temperature, pH 4.5 and TSS of 24° Brix with an inoculum level of 19 per cent (v/v) and within 4-5 days. A maximum ethanol content of 11.3 per cent (v/v) was detected under optimized conditions (Singh, 1998).

A *pectinolytic* enzyme was developed in the laboratory and used to express juice from guava fruits. The enzyme showed maximum activity. When

used at 0.5 per cent level and incubated at 40° C for 18-h original flavour and other constituents are preserved in the liquid fruit (Sreekantiah and Jaleel, 1998).

Kyamuhugire and Peterson (1998) studied that the juice extraction process is dependent on controlled ripening of the banana by either the rack or the pH methods. The process of juice extraction involves pressing, folding and turning the pulp mash mixed with grass, over and over again until the juice starts to appear. The role of the added gram is probably to modify the rhelogical properties of the pulp so that the applied forces, through mixing, have maximum shear effect on the pulp.

Jawahar *et al.*, (2001) prepared a wine from guava juice and found that the strain *S. Cerevisiae* 3287, 22 per cent of sugar, pH 4.0 and 0.05 per cent of DAHP were the optimum conditions obtained for the preparation of good quality wine from guava juice.

2.6 Utilization of by product / waste:

The animal feed stuff is one of the most important potential by products of the banana and plantain industries, the whole fruit, peelings, and pseudostem all being usable in this way. Fresh whole ripe bananas, dried green banana peel, and ensiled bananas have been used successfully as pig feed (Clavaija and Maner, 1975).

Dried peel from banana contain 9.16 per cent protein and to be nontoxic when fed at a 20 per cent concentration to rats, chicks, chickens, and pigs, growth rates being almost as high as in the controls (Rios *et al.*, 1975). Jarman *et al.*, (1977) concluded that fibre could be extracted from the stem of edible bananas.

The yield, however, is low, about 1 to 1.5 per cent per stem, 100 tonnes of stems being required for 1 tonne of fibre.

The process for commercial production of starch from bananas includes cutting the green fruit into pieces and grinding into a paste, which is mixed with sodium hydroxide to raise the pH to neutral. It is then washed through a series of screens to remove fibre, cell wall materials, sugar, *etc.;* and then centrifuged. The starch has been used for producing glue used in the manufacture of cartons for exporting the fresh bananas (Stover and Simmonds 1987).

Caraphin News (1995) reported that an 'ecopaper' was developed in Costa Rica. It is made of a waste by product of banana cultivation, *i.e.* the stem of the banana bunches. Ecopaper, which shows some likeness to papgrus, can be used for a variety of purpose, such as silk screening, painting, printing, screens and lamp shades, sculptures, art books & book binding, as well as a number of other art and craft purposes.

Green banana fruit, pseudostems, and foliage are suitable as animal feed and mainly serve as a source of energy and require supplementation with a protein source. Banana are economical as a source of animal feed only where the livestock are nearby, because of the high cost of transport, corns, shoots, and male buds find wide spread use as an animal food in Asia and Africa (Kotecha and Desai, 1995).

Ripe banana peels, which constitute about 22-30 per cent, are found littered all around streets causing pollution and sliding risks. Dried banana leaves can be used for making dispensible beautiful cups and trays. A banana plant

contains 20-25 green leaves, which find expensive use to serve meals in Indian homes (Maini and Anand , 1997).

Saikia *et al*., (1997) found that pulp was used for paper making. Fibers were extracted for making ropes and twines from banana plants. Paperr and sheets formed from bleached pulp exhibited physical strength properties of burst indices, tear indices and tensile indices, indicating high strength properties for writing and printing paper. From this study, it may be conducted that the banana plants would be a good source of raw material for cordage industry and a supplementary source for pulp and paper industry.

Silva *et al*., (1998) studied on use of banana pseudostem for cellulose and paper production. The production of kraft cellulose to be whitened for the manufacture of special paper used in the restoration of documents. Chemical analysis shows that if consist of 57.3 per cent cellulose, 17.8 per cent lignin, 15.5 per cent ash, 9.4 per cent compounds extracted by alcohol/toluene, 22.6 per cent compounds extracted by hot water and 40.9 per cent extracted by NaOH I per cent. Vargas *et al*., (1998) studied on composting of reject banana rachis, and conducted that it is comparatively simple to make compost from reject banana and ractis using soil as the source of inoculum of decomposition micro-organisms.

2.7 **Designing of plant - considerations and technology:**

Hoffman and Berg (1967) found that vacuum filtration has a place in the winery and particularly in a dry wine operation, by increasing the wine yield per tonne from high priced grapes. There is a very strong possibility that this process would be useful in producing better concentrates and preservation of fresh juice.

Jaleel (1979) studied on developmental studied on enzymatic processing of banana. II Pilot scale investigations with a view to compile data for processing banana on an industrial scale and evaluated the performance of certain equipment investigations relating the pilot plant scale processing of banana using pectinolytic enzyme concentrate.

Cleland *et al*., (1981) studied on application of multiple linear regression to analysis of data from factory energy surveys. Methods described for estimation of energy use for each product is obtained by the use of multiple linear regression to relate total energy consumption data from existing meters to production of the various products.

Kumbhar and Singh (1991) concluded that the final cost of the processed food could be reduced considerably by proper monitoring of post harvest operations. Increase profit margin through reduction of post harvest losses, efficient and judicious use of utilities, full capacity utilization and better management.

Blaschek (1993) Studied on approaches to making the food processing industry more environmentally friendly and suggested that microbial and cell-free enzyme systems that bio convert food processing wastes into value added products after the promise into value added products after the promise of both cost savings and a more environmentally friendly food industry.

A Belgian Company in 1989 designed a line, which produced 1600 lit of juice per day from 2500 kg of bananas (Gowen, 1995). Schottler *et al*., (1995) suggested that the use of decanters for processing of tropical fruits. Use of 2-gear price decanter for manufacture of juices and purees from tropical fruit.

Application examples for various process techniques are presented for pineapple, guava, mango, bananas and cashew apples.

2.8 **Epilogue:**

It appears from the literature that no systematic and detailed studies have been carried out for the development of different types of banana beverages using sorghum flour and crude enzyme extract and compared with the pure *pectinolytic* enzymes alongwith the evaluation of status physico-chemical properties during products manufacture and storage.

CHAPTER - III

MATERIALS AND METHODS

CHAPTER - III

MATERIALS AND METHODS

This study was undertaken in the Food processing laboratory of Central Institute of Agricultural Engineering (CIAE), Bhopal. For systematic study the research work was carried out to develop the process technology for preparation and evaluation of physico-chemical properties of fresh and stored banana beverages of the main concern. On the basis of experimental results to propose a one tonne per day banana processing unit. This chapter deals with the information of experimental procedures adopted and material used during the study.

3.1 Development of products:

Three types of banana beverages were prepared using bananas of variety *Dwarf Cavendish* from local market in the month of March - May. The detailed method of preparation of the different types of banana beverages is given below:

3.1.1 Banana beverages:

Bananas were washed with flowing water and peeled out by hand. Peeled fruits were cut into small pieces and blended in a mixer. Grinded pulp was treated with three different proportions by addition of water *i.e.* 1:2, 1:4, 1:6 ratios. This diluted pulp was clarified by centrifuge at 9000 rpm for 30 min at 15° C. Filtered juice was pasteurized at 65° C for 15 min in thermostatically controlled water bath and preservative potassium meta-bisulphite @ 1g/lit was added for obtaining a good quality of clarified beverage. Pasteurized beverage was kept in refrigerator at 5-7° C for 15 days storage period. Physico-chemical properties were estimated using standard methods as prescribed by Ranganna (1977) and details of the

methods for different attributes was described in section-3.3. Sensory evaluation was done for fresh and stored beverage using nine-point standard hedonic scale by appointing six trained panel judges. The process flow chart for banana beverage is shown in Fig. 3.1.

3.1.2 Banana fermented beverages:

Banana fruit peeled out by hand and cut into small pieces. Pulping was done in the mixer. Grinded pulp is treated with three different proportions by addition of potable water (w/v). By adding the water TSS, (°Brix) is lowered and therefore again adjusted the TSS upto 15^{o} Brix by adding sugar. Now sorghum flour (w/w) was added in dilute pulp by dividing the weight of dilute pulp with 6 and 12 proportions. Thereafter, add *Saccharomyces cerevisiae* (10^{5} - 10 cfu/ml) culture @ 5ml/200 ml was added in each treatment and kept for fermentation for 24 h. Clarification of beverage was achieved by centrifuging at 9000 rpm for 30 min at 15^{o} C after fermentation. Filtrate beverage was pasteurized at 65° C for 15 min and potassium meta-bisulphite (@ 1g/lit) added as preservative. Pasteurized beverage was kept in refrigerator at 5-7° C for 15 days storage period. Physico-chemical properties were estimated using standard methods as described by Ranganna (1977) and detailed procedures are presented in section-3.3. Sensory evaluation was done for fresh and stored beverage using nine-point standard hedonic scale by appointing six trained panel judges. The process flow chart for fermented banana beverage is shown in Fig.3.2.

3.1.3 Banana fermented enzyme treated beverages:

Ripe bananas were selected for preparation of banana beverages. Bananas were peeled out by hand and pulped in a grinder. In grinded pulp water was added

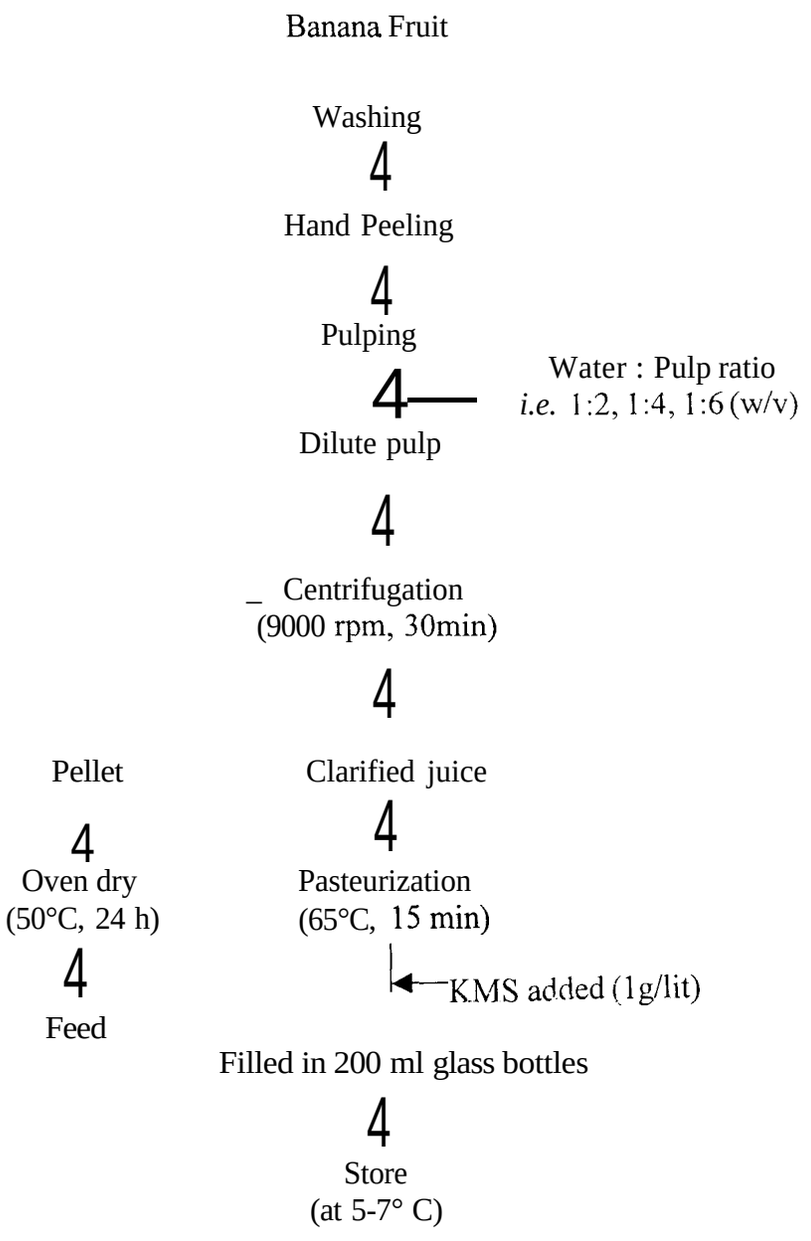

Fig. 3.1 Flow chart for preparation of banana beverage

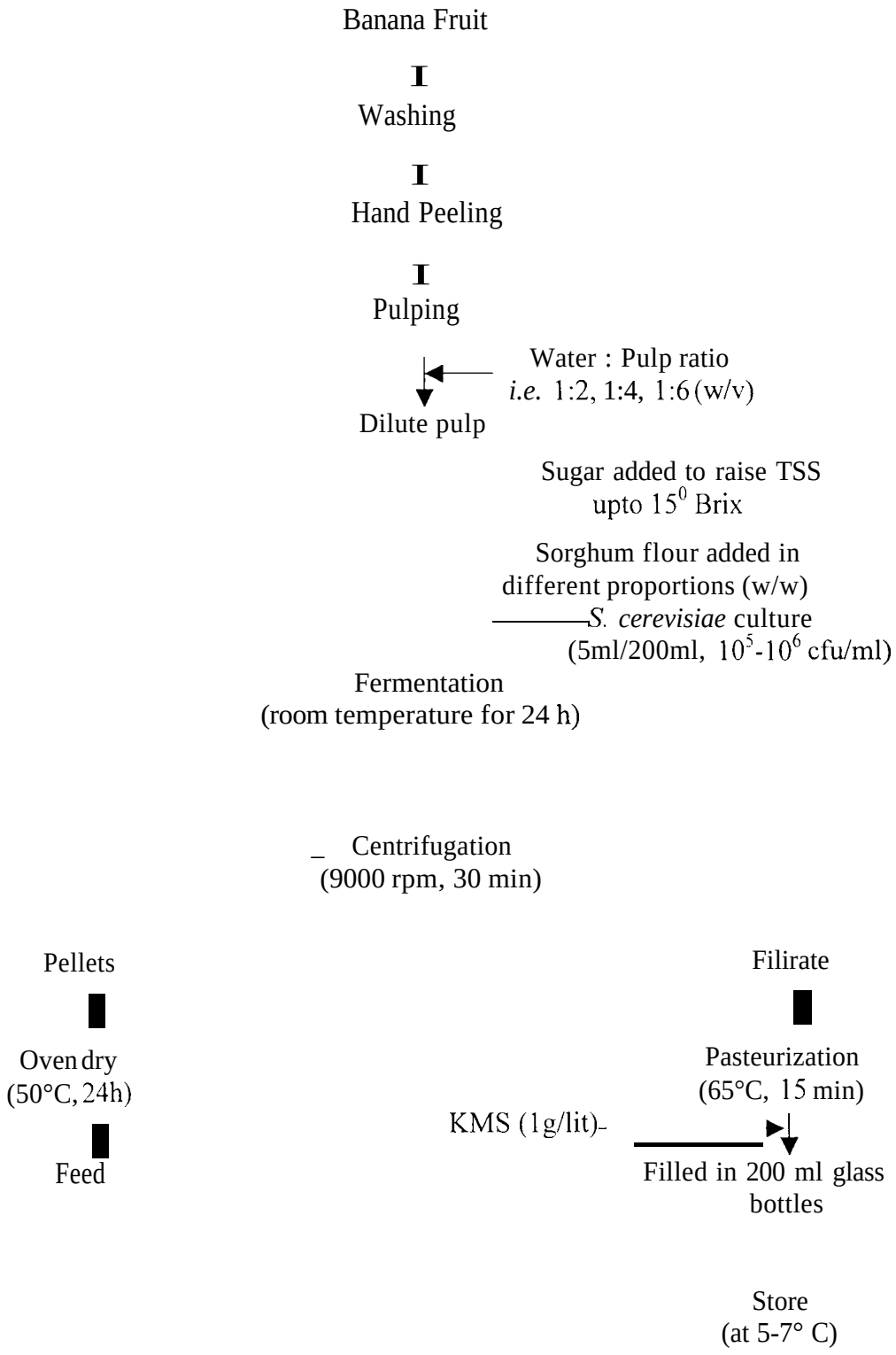

Fig. 3.2 Flow chart for preparation of fermented banana beverage

by weight of pulp in three different proportions. By addition of water TSS, (° Brix) is lowered down, so that TSS was raised upto 15^{o} Brix by adding sugar. Sorghum flour was mixed in dilute pulp by dividing the dilute pulp with 6 and 12 (w/w) proportions. After this, *Saccharomyces cerevisiae* culture @ 5ml/200 ml, (10^{5}-10^{6} cfu/ml) was added in each treatments, and kept for fermentation at room temperature for 24h. Clarification was done by centrifugation at 9000 rpm for 30 min at 15° C. Filtrate was treated with α-amylase @ 0.2% (V/W) and amylase enzyme extracted @ 0.2 per cent (V/V) as described in section-3.2. The samples were kept in incubator for 30 min at 35° C. Enzyme treated beverage was pasteurized at 65° C for 15 min in thermostatically controlled water bath and potassium metabisulphite as a preservative was added @ 1g/lit. Pasteurized beverage was kept in refrigerator at 5-7° C for 15 days storage period. Physico-chemical properties were estimated using standard methods as described by Ranganna (1977) and details of the methods for different attributes was described in section-3.3. Sensory evaluation was done for fresh and stored beverage using nine-point standard hedonic scale by appointing six trained panel judges. The process flow chart for fermented enzyme treated banana beverage is shown in Fig. 3.3.

3.2 **Culture and growth conditions:**

It is essential to improve the efficiency of fermentative product, by means of altering the reaction environment to encourage the growth of desirable organisms. The culture growth conditions are discussed below:

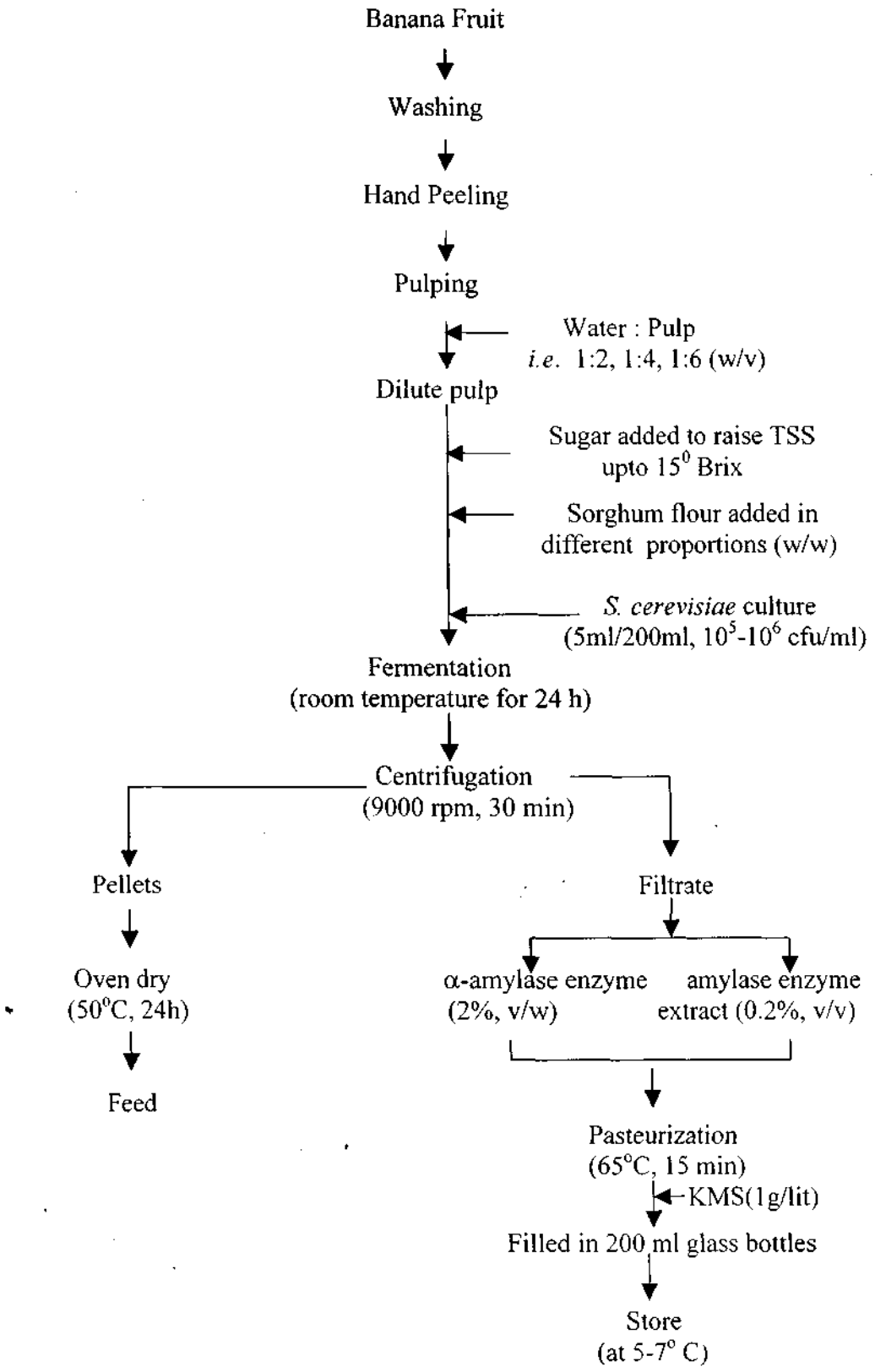

Fig. 3.3 Flow chart for preparation of fermented enzyme treated banana beverage

3.2.1 ***Saccharomyces cerevisiae:***

The yeast *Saccharomyces cerevisiae* (strain Y11587) was procured from Agricultural Research Service Culture Collection (National Utilization Research US- Department of Agricultural Peoria, Ollirois). The culture was grown at (35° C. 48h) on potato dextrose agar by subculturing whenever required, it was maintained in refrigerated temperature.

The banana beverage was inoculated with *Saccharomyces cerevisiae* culture (10^5-10^6 cfu/ml) @ 5ml/200 ml and fermentation was carried out at room temperature. The plate count of *Saccharomyces cerevisiae* in fermented banana juice was done as per the operating procedure given in Appendix-A.

3.2.2 ***Aspergillus niger:***

Enzyme extract was prepared for clarification of pulp strain *Aspergillus niger* was used. *Aspergillus niger* (strain-1054) strain was procured from National Chemical Laboratory, Pune. This strain was grown on Czapek dox agar by subculturing (35° C, 7 days) in slants. The whole slant culture scratched out and distilled water was added and mixed. This mixture was directly added to wheat bran for α-amylase production as per the procedure suggested by Ray Lalitagauri, (1991).

Enzyme extract dosage employed throughout the fermentation process was 0.2 per cent of the volume of the beverage. Activity of enzyme extract was evaluated by reducing sugar method given in Appendix-B.

3.3 Physico - chemical properties:

For determination of physico-chemical properties of banana beverages, different standard methods were used during the investigation given below:

3.3.1 Total soluble solids:

For measuring the TSS, (°Brix) of the sample a hand refractometer-having range of 0-50° Brix was used. One drop of sample was added on the prism and closed slowly. The refractometer was directed towards the light and observed through an eyepiece. While observing through an eyepiece, the scale calibrating screw was rotated so the boundary line separating the light and dark areas of the image was aligned with the zero line on the scale. A correct measurement in percentage of sugar was read at the point where boundary line crossed the scale.

3.3.2 **pH:**

pH, was measured by using pH paper ranges from 2-6, 4-8 and 6-10.

3.3.3 Titrable acidity:

Titrable acidity was estimated by titration method as suggested by Ranganna (1977).

Taking known weight of sample and dissolve in water. The content was filtered through whatman filter paper. 5 ml of the filtrate was taken in a conical flask and tiltrate the content with 0.01 N NaOH, using phenolphthalein as indicator till pink colour was achieved which is the end point of titration.

$$\text{Titrable acidity, } (\%) = \frac{\text{Titre} \times \text{Noramality of alkali x Eq. weight of acid}}{\text{Weight of sapmle}} \times 100$$

Equivalent weight of citric acid= 64

3.3.4 Reducing sugar:

The reducing sugar was estimated by Lane and Eynon's method as given by Ranganna (1977). Neutralized the sample solution with 1N NaOH using phenolphthalein as indicator. Taking 10 ml of Fehling's solution (5 ml of

Fehling's A + 5 ml of Fehling's B) in a conical flask and burette was filled with the neutral sample solution. Fehling's solution was boiled for few seconds. Methylene blue was added as an indicator. Adding sample solution drop wise till end point brick red colour was observed to complete the titration.

Calculation:

10ml Fehling's solution = P mg standard reducing sugar
(From standard table values)

let the filtration reading be Q

Q ml of sample = 10 ml Fehling's solution

or Q ml of sample = P mg of standard reducing sugar

or 100 ml of sample = P/Q X 100 mg of reducing sugar

But 100ml of sample is made up from 10 g

10g sample contains [P/Q X 100] mg of reducing sugar

100gm sample contains [P/Q] gm reducing sugar

or [P/Q] % reducing sugar.

3.3.5 Total sugar:

Total sugar of the sample was measured by Lane and Eynon's method as given by Ranganna (1977).

Taking 50 ml of the filtrate solution and 10 ml HC1 (54%) was added. Heat at boiling temperature for 10 min. to complete the inversion of sucrose, and then cool to room temperature. Thereafter neutralized with 1N NaOH solution using phenolphthalein as indicator. Made up the volume with water to 250 ml. Proceed as method described in section-3.3.4 for reducing sugars.

Calculation:

10ml Fehling's solution = P mg of total sugar as invert sugar
(From standard table values)

let the filtration reading be Q

Q ml of sample contains = Q 150 g sample in 100ml of sample taken.

Q ml of sample = P mg of TS as invert sugar

50 ml of sample = P/Q X 50 mg of TS as invert sugar

But 50 ml sample has 1 g of sample

Thus 1 g sample will contain P/Q X 50 mg of TS as Invert sugar

or 100 g sample will contain P/Q X 5g of TS as invert sugar.

Non-reducing sugar, % = Total sugar - Reducing sugar.

3.3.6 Moisture content:

Known weights of sample were kept in oven for drying at 60° C till constant weight for 24 h and moisture content (%) was calculated using following equation.

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

3.3.7 **Optical density:**

For measuring optical density, UV- VIS DigiSpec - 200GL Spectro-photometer was used at visible wavelength 520 nm. The mixture of all colours of different wavelength in the visible region is known as white light. The visual colour sensation produced at the desired wavelength was direct by measured on digital display.

3.3.8 Alcohol:

Alcohol percentage was determined by using method as suggested by Caputi *et al*., (1965). The detailed procedure for estimation of alcohol per cent in the all banana beverages prepared during the investigation is given below.

One ml filtrate sample added in 30 ml distilled water and place in the distillation flask. On the receiving side, 25 ml potassium dichromate solution was taken in the conical flask and the distillate was collected in this upto 45 ml. The distillation was done at 74-75° C. Care was taken that the tip of the dropper dipped in potassium dichromate. After, distillation the sample was heated to 60° C for 2 min and then volume made upto 50 ml. The absorbance of the solution was read at 620 nm wavelength on Spectrophotometer and the alcohol content estimated from standard curve as given in Appendix-C.

3.3.9 Viscosity:

U-tube viscometer (B size-215 viscosity range) was used for determination of viscosity as per the method given by Ranganna, (1977). The extracted juice was braught up to room temperature and drawn up through the capillary into the bulb above the constriction marked A. The time noted in sec for the liquid to flow back, from mark A to mark B. The apparatus was held upright at 136 cm from ground level. Precaution was taken to keep it at same height. The pipette washed thoroughly. Viscometer was standardized by using normal water to flow between the same marks at same temperature.

$$\text{Viscosity, (sec)} = \frac{\text{Time in sec for the extract to flow through}}{\text{Time in sec for the water to flow through}}$$

3.4 Storage study:

Three types of banana beverages were prepared during course ot study was stored at 5-7° C for 15 days in refrigerated conditions, to evaluate the shelf life of the products. Simultaneously physico-chemical properties also, determine

for all the banana beverages using various methods as described for fresh and stored samples in section 3.3.

3.5 Sensory Evaluation:

Sensory evaluation of beverages was done by 6 panel judges on 9-point hedonic scale rating test for the attributes of appearance, colour, flavour, taste and over-all acceptability of the products. Proforma is given in Appendix-D.

3.6 By product / waste utilization:

By products and waste products are obtained during the preparation of beverages are dried at 60° C for 24 h. After drying of by product (Semi solid mass) and waste (Peels and pellets) were mixed and grinded in mixer and grinded material was packed in polyethylene bags and stored at room temperature. This dried and grind mixture can be used for cattle feeding and also this material taken into consideration for calculation of product cost during the course of investigation.

3.7 Cost analysis of banana beverages for one tonne per day unit:

Cost analysis of three types of banana beverages were prepared during study by taking variable cost and fixed cost. The total capital investment in the form of variable and fixed cost taken in to considerations. Under the variable cost; total manufacturing cost, cost of by products, ex-factory cost of product where as, for fixed cost included building cost, machinery cost and fixed cost capital investment. On this basis the techno economic feasibility of a one tonne banana beverage unit was calculated with sales revenue, gross profit, return on investment, pay back period, break even point for production kg/year and number of days production per year and sales revenue. Looking to the techno economic

feasibility of a small banana beverage project profile have been suggested for an entrepreneur as given in Appendix-I.

3.8 Statistical **analysis:**

The data of physico-chemical properties of different banana beverages *viz;* banana beverage, fermented banana beverage and fermented enzymes treated banana beverage were statistically analysed by completely randomized design.

CHAPTER - IV

RESULTS

CHAPTER - IV

RESULTS

The data recorded on various observations during the course of investigation revealed many interesting facts and the results are elucidated in this chapter under appropriate findings along with tables and suitable illustrations.

4.1 Product development:

Three types of banana beverages *i.e.* plane banana beverages, fermented banana beverages and enzyme treated banana beverages were prepared to evaluated the physico-chemical properties and over-all acceptability of the products. Among the developed products it is observed that banana beverages having 1:4:0.83 was highly acceptable looking to its physico-chemical properties, shelf life and sensory scores.

4.2 Physico-chemical properties of banana beverages:

The fresh and stored banana beverages prepared were analysed for viscosity, yield, titrable acidity, total soluble solids, pH, reducing sugar, total sugar, non-reducing sugar, optical density, and pellet per cent as well as sensory evaluation was carried out and separately discussed below:

4.2.1 Physico-chemical properties of fresh banana beverages:

The physico-chemical properties of banana beverage are presented in Table 4.1. «

Viscosity was recorded highest in 1:2 ratio (2.54 s) followed by 1:4 ratio (1.87 s) and 1:6 ratio (1.11 s). Yield of beverage was 79.53, 83.25 and 86.95 per cent in 1:2, 1:4 and 1:6 ratios, respectively where as titrable acidity decreased

Table: 4.1 Physico-chemical properties of fresh banana beverages

S. No.	Parameters	Pulp : Water Ratio			SEm (±)	CD*
		1:2	1:4	1:6		
1	Viscosity, (s)	2.54	1.87	1.11	0.02	0.10
2	Yield, (%)	79.53	83.25	86.95	0.45	2.71
3	Titrable acidity, (%)	0.88	0.40	0.21	0.04	0.23
4	TSS, (°Brix)	7.00	5.00	3.50	-	-
5	pH	4.50	4.30	4.10	0.28	-
6	Reducing sugar, (%)	1.33	1.28	1.20	0.12	-
7	Total sugar, (%)	39.57	36.84	35.64	1.27	-
8	Non-reducing sugar, (%)	38.24	35.56	34.44	1.25	-
9	Optical density, (520 nm)	0.32	0.16	0.10	0.00	0.01
10	Pellet, (%)	17.54	9.57	6.35	0.37	2.22

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

with the increase of pulp-water ratio was 0.88, 0.40 and 0.21 per cent in 1:2, 1:4 and 1:6 banana beverages, respectively (Table 4.1).

The content of total soluble solid was recorded to be 7.00° Brix, 5.00° Brix and 3.50° Brix in the pulp-water ratio of 1:2, 1:4 and 1:6, respectively. The pH of the fresh banana beverages was recorded highest (4.50) in 1:2 ratios as compared to 1:4 (4.30) and 1:6 (4.10) ratios (Table 4.1).

The reducing sugar was found to be 1.33, 1.28 and 1.20 per cent in 1:2, 1:4 and 1:6 ratios, respectively. Non-reducing sugar was found to be higher 38.24 per cent in the1:2 ratio where as it was lowest 34.44 per cent in the 1:6 ratio. The total sugar content (39.57 %) in 1:2 ratio was more than the other ratios, whereas the pellet per cent in 1:2, 1:4 and 1:6 banana beverages was 17.54, 9.57 and 6.35, respectively (Table 4.1).

The optical density of fresh banana beverage was found decreased significantly ($P < 0.05$) in 1:2 ratio (0.32) as compared to those of 1:4 (0.16) and 1:6 (0.10) ratio at 520 nm (Table 4.1).

The data revealed that there was significant ($P < 0.05$) effect of ratios on some of the physico-chemical properties *i.e.* viscosity, yield, titrable acidity, optical density and pellet per cent, on the other hand the test result indicated that a non significant effect of ratios exist on some of the physico-chemical properties namely, reducing sugar, total sugar, non-reducing sugar and pH (Table 4.1).

4.2.2 Physico-chemical properties of stored banana beverages:

The effects of 15 days storage period on physico-chemical properties are presented in Table 4.2. The prepared product stored in glass bottles in refrigerator at 5-7° C temperature.

It was also found that decrease rate of viscosity significantly ($P < 0.05$) as water-pulp ratio was increased in 1:2 (2.61 s), 1:4 (1.98 s) and 1:6 (1.16 s) in banana beverages when stored for 15 days as presented in Fig. 4.1

Titrable acidity of stored banana beverages was significantly ($P < 0.05$) increased from 1.02 per cent, 0.82 per cent and 0.43 per cent in the pulp-water ratio of 1:2, 1:4 and 1:6, respectively during a storage period of 15 days as can be seen in Fig. 4.2.

The total soluble solids remained constant in 1:2 ratio (7.00° Brix), 1:4 ratio (5.00° Brix) and 1:6 ratio (3.50° Brix) during storage period of 15 days. The pH of the stored banana beverages was recorded higher (4.30) in 1:2 ratios as compared to 1:4 (4.00) and 1:6 (4.00) ratios (Table 4.2).

The optical density of stored banana beverages have been observed was 0.72, 0.40 and 0.26 at 520 nm in the beverages prepared with 1:2, 1:4 and 1:6 ratios, respectively over a 15 days period of storage (Fig. 4.3).

Figure 4.4 depicted the reducing sugar decreased significantly ($P < 0.05$) during storage period of 15 days in all the combinations of banana beverages was 1.74, 1.55 and 1.42 for 1:2, 1:4 and 1:6 ratios, respectively.

4.2.3 Sensory evaluation of fresh and stored banana beverages:

The banana beverages made out of pulp blended with water in three different ratios were used for sensory evaluation. Both, the fresh beverages and beverages after storage period of 15 days were used for the evaluation. Table 4.3 presents the total score of the panelists obtained for different beverages. It can be seen from the table that the highest ranking (195) has been given to the fresh

Table: 4.2 Physico-chemical properties of banana beverages after 15 days storage period

S. No.	Parameters	Pulp : Water Ratio			SEm (±)	CD*
		1:2	1:4	1:6		
1	Viscosity, (s)	2.61	1.93	1.16	0.02	0.10
2	Titrable acidity, (%)	1.02	0.82	0.43	0.01	0.07
3	TSS, (°Brix)	7.00	5.00	3.50	-	-
4	pH	4.30	4.00	4.00	0.10	-
5	Reducing sugar, (%)	1.74	1.55	1.42	0.03	0.20
6	Total sugar, (%)	28.87	27.96	26.69	1.16	-
7	Non- reducing sugar, (%)	27.13	26.41	25.27	0.75	-
8	Optical density, (520 nm)	0.72	0.40	0.26	0.03	0.16

at 5 level
SEm - Standard Error of mean
CD - Critical Difference

Table: 4.3 Total sensory score of banana beverages

S. NO.	Pulp:Water Ratio	Fresh	15 days stored
1	1:2	172	156
2	, 1:4	195	179
3	1:6	155	130

* - The values are the average of two replications given by six judges panel

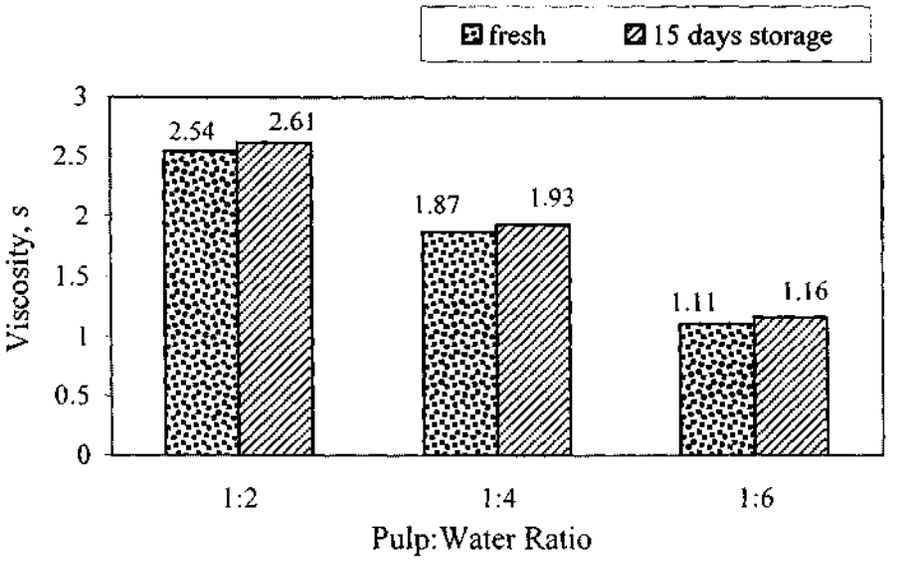

Fig. 4.1 Effect of different ratios on viscosity of banana beverages

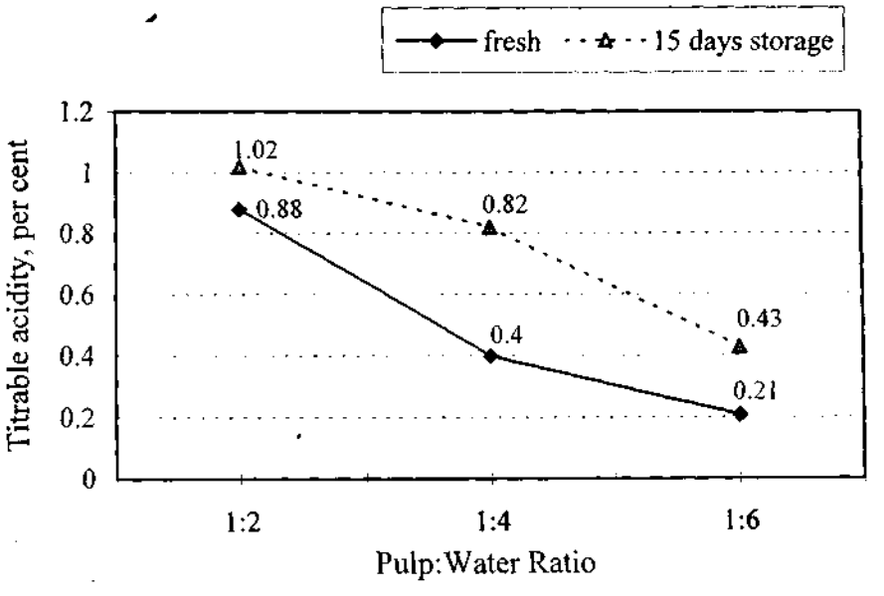

Fig. 4.2 Effect of different ratios on titrable acidity of banana beverages

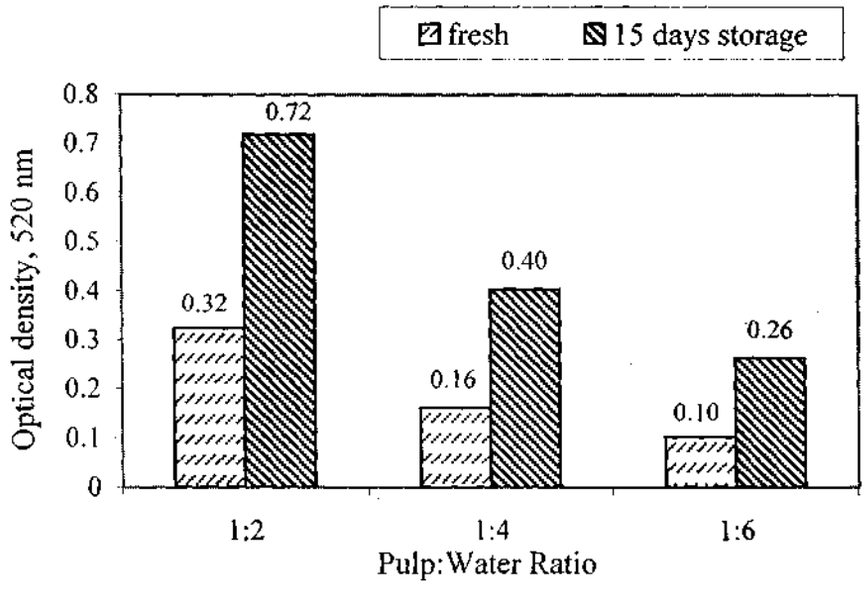

Fig. 4.3 Effect of different ratios on optical density of banana beverages

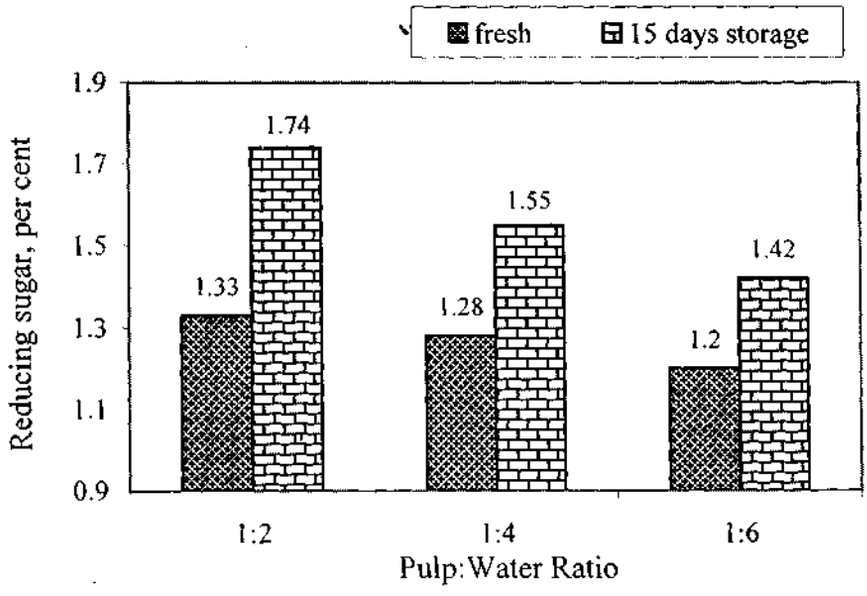

Fig. 4.4 Effect of different ratios on reducing sugar of banana beverages

beverage prepared in the ratio of 1:4. Similarly the scores are 172 for 1:2 ratio and 155 for 1:6 ratio of fresh banana beverages.

The beverage evaluated after a storage period of 15 days had the effect of storage as can be seen from Table 4.3. The total score for each of the beverages have been reduced which are 156, 179 and 130 for the beverages ratios of 1:2, 1:4 and 1:6, respectively. The average values of the sensory evaluation for the fresh and stored beverages of two replications are given in Appendix-E.

4.3 Physico-chemical properties of fermented banana beverages:

The fresh and stored fermented banana beverages were analysed for viscosity, yield, titrable acidity, total soluble solids, pH, reducing sugar, total sugar, non-reducing sugar, optical density, pellet per cent and alcohol content as well as sensory evaluation was carried out.

4.3.1 Physico-chemical properties of fresh fermented banana beverages:

The physico-chemical properties of fermented banana beverages are presented in Table 4.4.

Viscosity of fresh fermented banana beverage was observed that it decreased with the increasing ratios of pulp:water:sorghum. It was recorded higher in 1:2:0.5 (1.94 s), 1:4:0.83 (1.89 s) and 1:6:1.16 (1.84 s) ratios as compared to those of 1:2:0.25 (1.92 s), 1:4:0.41 (1.82 s) and 1:6:0.58 (1.75 s) ratios, respectively (Table 4.4).

Yield of fermented banana beverage was found to be highest in 1:6:0.58 ratio (83.61 %), followed by 1:4:0.41 ratio (78.95 %) and 1:2:0.25 ratio (75.04 %). Lowest yield was recorded 66.45 per cent in 1:2:0.5 ratio (Table 4.4).

Table: 4.4 Physico-chemical properties of fermented banana beverages

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity, (s)	1.94	1.92	1.89	1.82	1.84	1.75	0.25	-
2	Yield, (%)	66.45	75.04	69.88	78.95	72.00	83.61	3.64	1.51
3	Titrable acidity, (%)	0.68	0.68	0.64	0.62	0.52	0.53	0.01	0.03
4	TSS, (°Brix)	12.50	12.50	11.00	11.00	11.00	11.00	-	-
5	pH	3.50	3.50	3.50	3.50	3.40	3.40	0.08	-
6	Reducing sugar, (%)	2.72	2.70	2.41	2.36	1.90	1.86	0.10	0.35
7	Total sugar, (%)	63.97	63.61	59.19	57.97	52.57	52.22	2.58	-
8	Non-reducing sugar, (%)	60.85	60.91	56.78	55.61	50.67	50.36	2.56	-
9	Optical density, (520 nm)	0.33	0.31	0.22	0.14	0.17	0.09	0.02	0.06
10	Alcohol, (%)	7.78	6.06	4.36	3.95	3.11	2.05	0.28	1.01
11	Pellet, (%)	30.48	19.98	31.09	20.00	30.20	18.54	2.68	9.73

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

The content of total soluble solids was recorded to be 12.5, 12.5, 11.0, 11.0, 11.0 and 11.0° Brix in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively. The pH of the fresh fermented banana beverages was recorded 3.50, 3.50, 3.50, 3.50, 3.40 and 3.40 in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.4).

In the present investigation it was observed that the values of titrable acidity, reducing sugar, optical density and alcohol were found to be decreased significantly ($P < 0.05$) in the 1:2:0.5, 1:4:0.83 and 1:6:1.16 ratio as compared to the 1:2:0.25, 1:4:0.41 and 1:6:0.58 ratios, respectively, as mentioned in Table 4.4.

Total sugar of fresh fermented banana beverages have been observed was 63.97, 63.61, 59.19, 57.97, 52.57 and 52.22 per cent in the beverages prepared with 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.4)

The pellet per cent increased significantly ($P < 0.05$) 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios was 30.48, 19.98, 31.09. 20.00, 30.20 and 18.54, respectively (Table 4.4).

4.3.2 Physico-chemical properties of stored fermented banana beverages:

The effects of 15 days storage period on physico-chemical properties of fermented banana beverages are presented in Table 4.5.

Viscosity of stored fermented banana beverages was found to be decreased from 2.11, 2.08, 1.98, 1.95, 1.95s and 1.89 s in the pulp-water-sorghum ratios of 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58, respectively as shown in Fig. 4.5.

Table: 4.5 Physico-chemical properties of fermented banana beverages after 15 days storage period

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity, (s)	2.11	2.08	1.98	1.95	1.94	1.89	0.17	-
2	Titrable acidity, (%)	0.83	0.81	0.78	0.76	0.64	0.63	0.05	-
3	TSS, (^{o}Brix)	12.50	12.50	11.00	11.00	11.00	11.00	-	-
4	pH	3.30	3.30	3.30	3.30	3.20	3.20	0.25	-
5	Reducing sugar, (%)	3.57	3.54	3.20	3.17	2.76	2.71	0.24	-
6	Total sugar, (%)	49.94	49.83	45.08	44.38	42.64	42.62	0.95	3.46
7	Non-reducing sugar, (%)	46.37	46.29	41.88	41.21	39.88	39.91	0.98	3.58
8	Optical density, (52O nm)	0.52	0.51	0.40	0.21	0.27	0.14	0.03	0.12
9	Alcohol, (%)	8.01	6.24	4.46	4.03	3.26	2.14	0.30	1.12

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

The titrable acidity was higher in 1:2:0.5 ratio (0.83 %). Fig 4.6 shows that the titrable acidity of the beverages decreased from 0.83, 0.81, 0.78, 0.76, 0.64 and 0.63 in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively over a storage period of 15 days (Table 4.5).

Total soluble solids in the stored fermented banana beverages was 12.50, 12.50, 11.00, 11.00, 11.00 and 11.00° Brix in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively over a storage period of 15 days (Table 4.5). The pH of stored fermented banana be verges have been observed was3.30, 3.30, 3.30, 3.30, 3.20 and 3.20 in the beverages prepared with 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.5).

Figure 4.7 shows the increasing trend of optical density after storage period of 15 days. It was decreased significantly ($P < 0.05$) from 0.52, 0.51, 0.40, 0.21, 0.27 and 0.14 at 520 nm in the beverages prepared with 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1 16 and 1:6:0.58 ratios, respectively during storage of 15 days period (Table 4.5).

Figure 4.8 shows that the reducing sugar increased during storage of fermented banana beverages after 15 days period of storage. Reducing sugar of fermented banana beverages have been observed was 3.57, 3.54, 3.20, 3.17, 2.76 and 2.71 per cent in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively during storage of 15 days period. The total sugar decreased significantly ($P < 0.05$) in the all ratios of fermented banana beverages. It was recorded 49.94, 49.83, 45.08, 44.38, 42.64 and 42.62 in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.5).

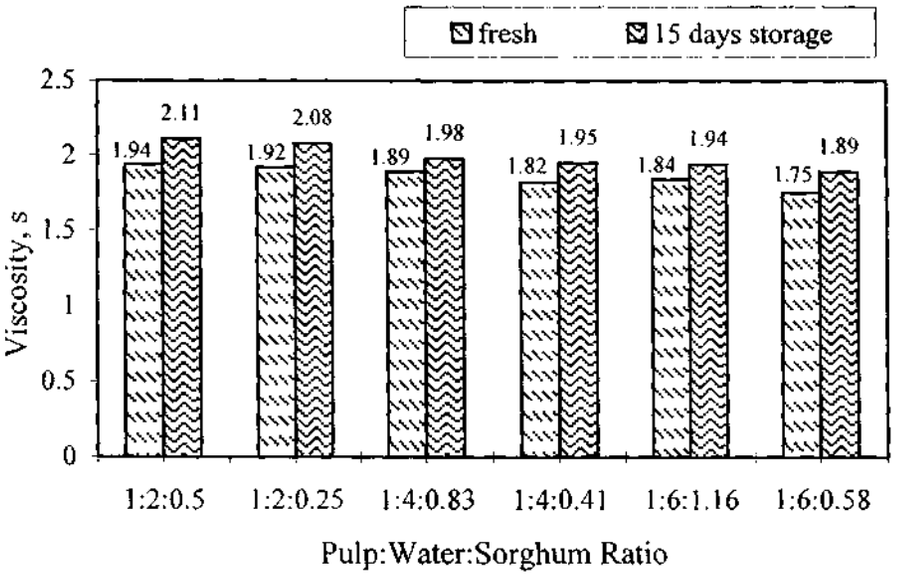

Fig. 4.5 Effect of different ratios on viscosity of fermented banana beverages

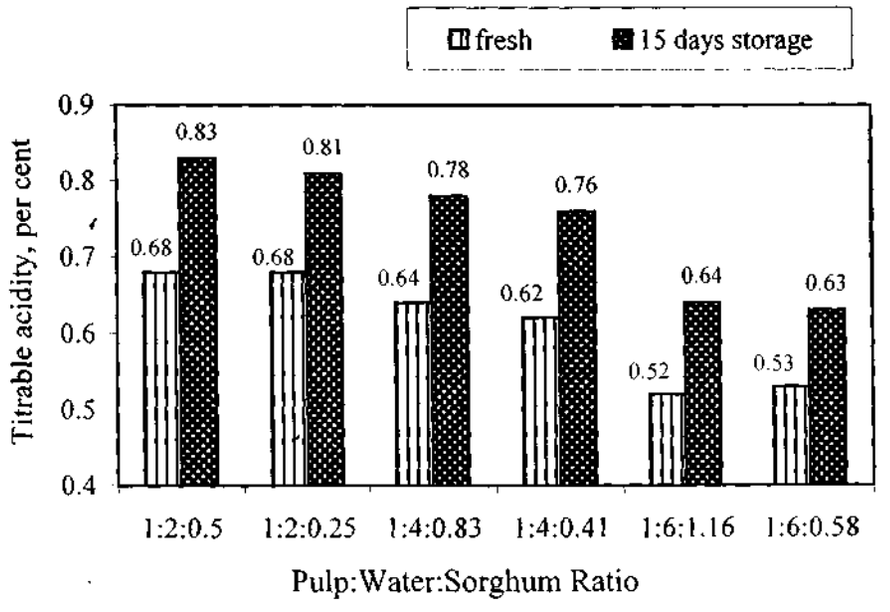

Fig. 4.6 Effect of different ratios on titrable acidity of fermented banana beverages

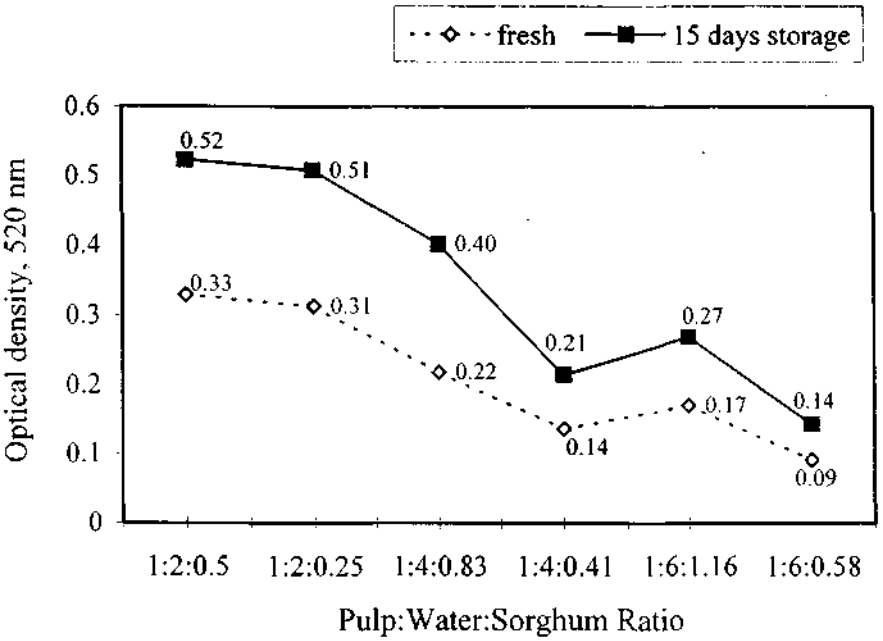

Fig. 4.7 Effect of different ratios on optical density of fermented banana beverages

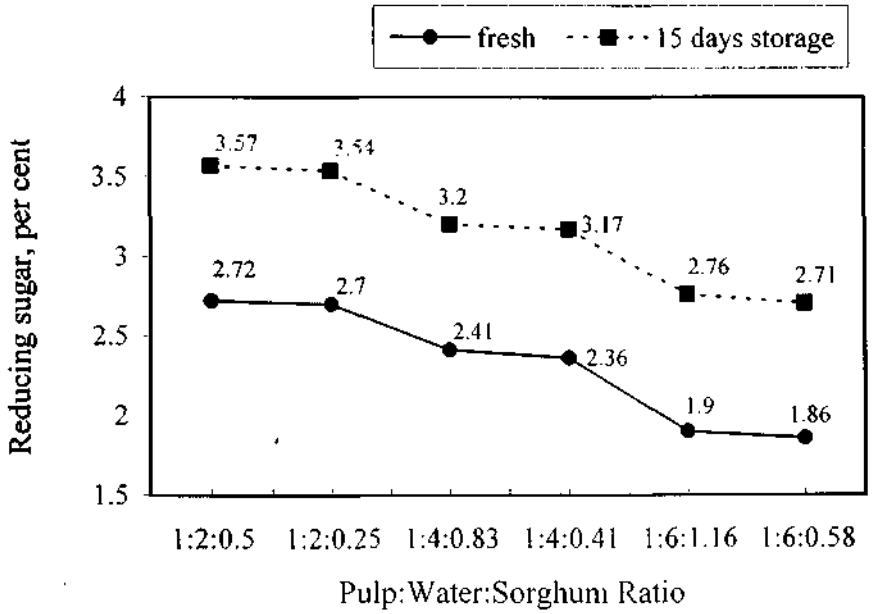

Fig. 4.8 Effect of different ratios on reducing sugar of fermented banana beverages

Alcohol per cent was found to be 8.02, 6.24, 4.46, 4.03, 3.23 and 2.14 in 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively during storage of 15 days period (Fig. 4.9). It shows that it was decr sed significantly ($P < 0.05$) in the all ratios of stored fermented banana beverages (Table 4.5).

4.3.3 Sensory evaluation of fresh and stored fermented banana beverages:

The banana beverages made out of pulp blended with water and sorghum in different ratios were used for sensory evaluation. Both, the fresh beverages and beverages after storage period of 15 days were used for the evaluation. Table 4.6 presents the total score of the panelists obtained for different beverages. It can be seen from the table that the highest ranking (258) has been given to the fresh beverage prepared in the ratio of 1:4:0.83. Similarly the scores are 244 for 1:4:0.41 ratio, 227 for 1:2:0.25 ratio, 217 for 1:6:1.16 ratio, 215 for 1:2:0.5 ratio and 208 for 1:6:0.58 ratio of fresh banana fermented beverages.

The beverages evaluated after a storage period of 15 days had the effect of storage as given in Table 4.6. The total score for each of the beverages have been reduced which are 204, 222, 255, 236, 208 and 192 for the beverages ratios of 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively. The average values of the sensory evaluation for the fresh and stored beverages of two replications are given in Appendix-F.

4.4 Physico-chemical properties of fermented enzyme treated banana beverages:

The fresh and stored fermented enzyme treated banana beverages were analysed for viscosity, yield, titrable acidity, total soluble solids, pH, reducing

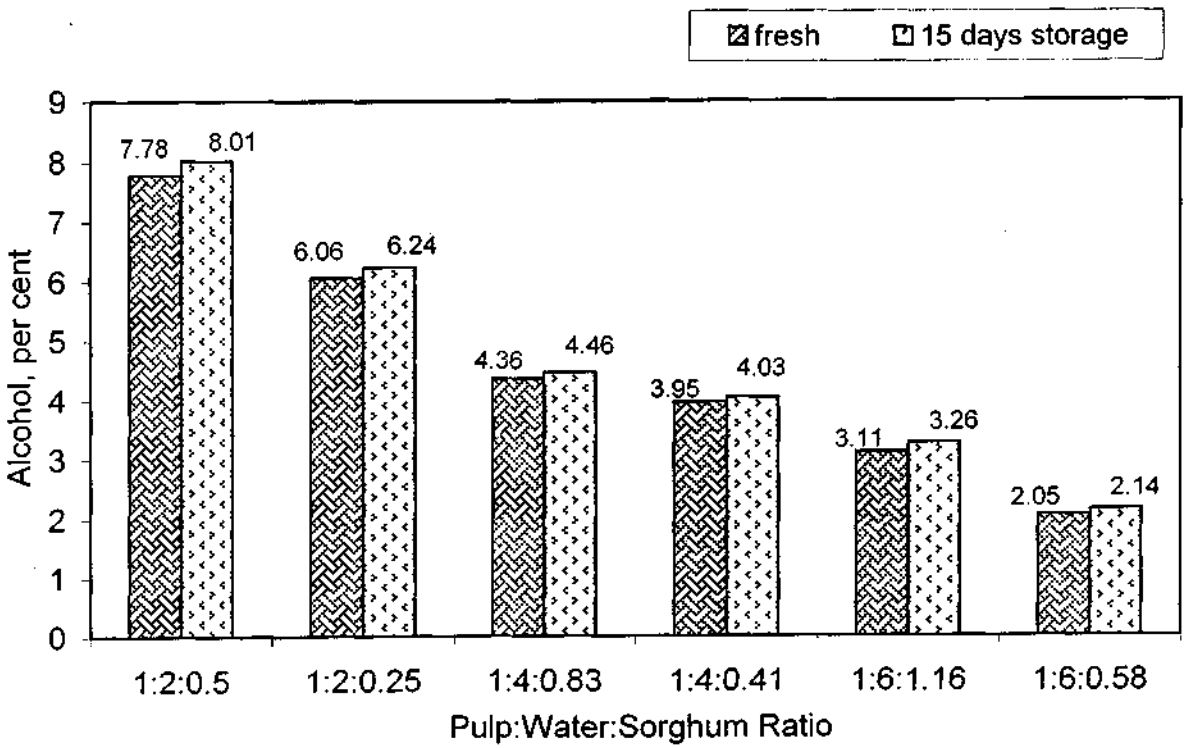

Fig. 4.9 Effect of different ratios on alcohol of stored fermented banana beverages

Table: 4.6 Total sensory score of fermented banana beverages

S. No.	Pulp:Water:Sorghum Ratio	Fresh	15 days stored
1	1:2:0.5	215	204
2	1:2:0.25	227	222
3	1:4:0.83	258	255
4	1:4:0.41	244	236
5	1:6:1.16	217	208
6	1:6:0.58	208	192

* - The values are the average of two replications given by six judges panel

sugar, total sugar, non-reducing sugar, optical density, pellet per cent and alcohol content as well as sensory evaluation was carried out.

4.4.1 Physico-chemical properties of fresh fermented enzyme treated banana beverages:

The physico-chemical properties of fermented enzyme treated banana beverages are given in Table 4.7 and 4.8.

Viscosity of fresh fermented amylase extract enzyme banana beverages was found to be higher in 1:2:0.25 (1.82 s), 1:4:0.83 (1.65 s) and 1:6:1.16 (1.46 s) ratios as compared to 1:2:0.5 (1.79 s), 1:4:0.41 (1.60 s) and 1:6:0.58 (1.44 s) ratios, respectively as can be given in Table 4.7. Similar trend was observed for α–amylase enzyme banana beverage in the all ratios (Table 4.8).

Yield of fermented enzyme treated banana beverage was found to be highest in the 1:6:0.58 ratio (84.11 %), 1:4:0.41 ratio (79.81 %) and 1:2:0.25 ratio (75.14 %) as compared to 1:6:1.16 ratio (72.3 %), 1:4:0.83 ratio (69.81 %) and 1:2:0.5 ratio (66.16 %), respectively in both enzymes treated banana beverages (Table 4.7 and 4.8).

It was observed that marginal differences recorded in the titrable acidity of fresh fermented amylase extract enzyme banana beverages and fresh fermented a-amylase enzyme banana beverages for different formulations. The highest titrable acidity of fermented amylase extract enzyme banana beverages and α–amylase enzyme banana beverages was found to be 0.67 per cent (Table 4.7) and 0.69 per cent (Table 4.8) in the 1:2:0.5 ratio, respectively.

The total soluble solids was recorded to be 13.0, 13.0, 11.0, 11.0, 11.0 and 11.0° Brix in the beverages prepared with 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41,

Table: 4.7 Physico-chemical properties of fresh fermented amylase extract enzyme treated banana beverages

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity, (s)	1.82	1.79	1.65	1.60	1.46	1.44	0.01	0.05
2	Yield, (%)	66.16	75.14	69.81	79.81	72.3	84.11	0.89	3.25
3	Titrable acidity, (%)	0.67	0.64	0.60	0.58	0.52	0.50	0.01	0.03
4	TSS, ^{o}Brix	13.00	13.00	11.00	11.00	11.00	11.00	-	-
5	pH	3.50	3.50	3.50	3.50	3.40	3.40	0.00	0.01
6	Reducing sugar, (%)	3.21	3.04	2.61	2.56	2.32	2.27	0.06	0.21
7	Total sugar, (%)	56.19	56.75	54.12	53.62	53.10	52.48	0.17	0.63
8	Non-reducing sugar, (%)	52.98	53.71	51.51	51.06	50.78	50.21	0.18	0.64
9	Optical density after centrifuge, (520 nm)	0.29	0.28	0.21	0.14	0.17	0.10	-	-
10	Optical density after treatment, (520 nm)	0.26	0.27	0.21	0.14	0.17	0.15	0.00	0.01
11	Alcohol, (%)	8.45	8.19	8.03	6.90	5.08	4.42	0.10	0.36
12	Pellet, (%)	31.88	19.70	29.67	17.94	27.52	16.78	0.67	2.42

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

Table: 4.8 Physico-chemical properties of fresh fermented α-amylase enzyme treated banana beverages

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity,(s)	1.82	1.78	1.68	1.66	1.44	1.41	0.02	0.06
2	Yield, (%)	66.16	75.14	69.81	79.83	72.37	84.11	0.89	3.25
3	Titrable acidity, (%)	0.69	0.66	0.63	0.60	0.54	0.52	0.01	0.04
4	TSS, (°Brix)	13.00	13.00	11.00	11.00	11.00	11.00	-	-
5	pH	3.50	3.50	3.50	3.50	3.40	3.40	0.00	0.01
6	Reducing sugar, (%)	3.21	3.04	2.61	2.56	2.32	2.27	0.02	0.08
7	Total sugar, (%)	56.19	56.75	54.12	53.62	53.10	52.48	0.14	0.51
8	Non-reducing sugar, (%)	52.98	53.71	51.51	51.06	50.78	50.21	0.14	0.49
9	Optical density after centrifuge, (520 nm)	0.29	0.29	0.21	0.14	0.17	0.10	-	-
10	Optical density after treatment, (520 nm)	0.25	0.24	0.20	0.14	0.16	0.14	0.00	0.00
11	Alcohol, (%)	8.36	7.55	6.88	5.91	4.42	2.35	0.07	0.26
12	Pellet, (%)	31.88	19.70	29.67	17.94	27.52	16.78	0.67	2.42

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

1:6:1.16 and 1:6:0.58 ratios, respectively in both the fresh fermented enzyme banana beverages (Table 4.7, 4.8). The pH was recorded 3.50, 3.50, 3.50, 3.50, 3.40 and 3.40 in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively in both the fresh fermented enzyme banana beverages (Table 4.7,4.8).

Reducing sugar was found to be nearly same both the fresh fermented amylase extract enzyme banana beverages and fresh fermented a-amylase enzyme banana beverages. It was highest in 1:2:0.25 ratio (3.21 %), followed by 1:2:0.5 (3.04 %), 1:4:0.83 (2.61 %), 1:4:0.41 (2.56 %) and 1:6:1.16 (2.32 %) ratios. Lowest reducing sugar was found be 2.27 per cent in 1:6:0.58 ratio (Table 4.7 and 4.8).

It was observed that there was a marginal difference recorded in optical density of fresh fermented amylase extract enzyme banana beverages and fresh fermented a-amylase enzyme banana beverages for different formulations. The optical density of fresh fermented amylase extract enzyme banana beverages was found to be 0.26, 0.27, 0.25, 0.14, 0.17 and 0.15 at 520 nm in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.7). Optical density of fresh fermented a-amylase enzyme banana beverages was found to be 0.25, 0.24, 0.20, 0.14, 0.16 and 0.14 at 520 nm in the 1:2:0.5, 1:2:0.25,1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.8).

The highest alcohol per cent of fresh fermented amylase extract enzyme banana beverages was recorded highest in 1:2:0.5 (8.45 %), 1:4:0.83 (8.03 %) and 1:6:1.16 (5.08 %) ratios as compared to 1:2:0.25 (8.19 %), 1:4:0.41 (6.90 %) and 1:6:0.58 (4.42 %) ratios, respectively (Table 4.7). Similar trend was observed

for the fermented α–amylase enzyme banana beverages for all the ratios of pulp-water-sorghum (Table 4.8).

The data revealed that there was significant ($P < 0.05$) effect of ratios on some of the physico-chemical properties *i.e.* viscosity, yield, titrable acidity, reducing sugar, total sugar, non-reducing sugar, optical density, alcohol and pellet per cent of both fermented enzyme treated banana beverages (Table 4.7 and 4.8).

4.4.2 Physico-chemical properties of stored fermented enzyme treated banana beverages:

The effect of 15 days storage period on physico-chemical properties of fermented enzyme treated banana beverages are presented in Table 4.9 and 4.10.

Viscosity of stored fermented amylase extract enzyme banana beverages was found to be decreased significantly ($P < 0.05$) from 1.93, 1.91, 1.79, 1.76, 1.49 and 1.47 s in the pulp-water-sorghum ratios of 1:2:0.5, 1:2:0.25,1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58, respectively over a storage period of 15 days (Table 4.9). Similar increasing pattern of viscosity was observed for the stored fermented a-amylase enzyme banana beverages in the all ratios as shown in Fig. 4.10.

Total soluble solids was recorded 13.00, 13.00, 13.00, 13.00, 11.00 and 11.00° Brix in the pulp-water-sorghum ratios of 1:2:0.5, 1:2:0.25,1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58, respectively in both the fermented amylase extract enzyme banana beverages given in Table 4.9 and 4.10.

Titrable acidity of stored fermented amylase extract enzyme banana beverages was found to be decreased significantly ($P < 0.05$) from 0.85, 0.83,

Table: 4.9 Physico-chemical properties of fermented amylase extract enzyme treated banana beverages after 15 days storage period

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity,(s)	1.93	1.91	1.79	1.76	1.49	1.47	0.02	0.07
2	Titrable acidity, (%)	0.85	0.83	0.73	0.70	0.67	0.66	0.01	0.04
3	TSS, (°Brix)	13.00	13.00	11.00	11.00	11.00	11.00	-	-
4	pH	3.30	3.30	3.30	3.30	3.20	3.20	0.00	0.00
5	Reducing sugar, (%)	3.70	3.65	2.75	2.72	2.54	2.48	0.04	0.15
6	Total sugar, (%)	44.26	44.08	43.29	43.08	42.68	42.62	0.59	-
7	Non-reducing sugar, (%)	40.56	40.43	40.54	40.36	40.14	40.14	0.57	-
8	Optical density, (520 nm)	0.42	0.41	0.29	0.19	0.22	0.18	0.01	0.05
9	Alcohol, (%)	9.02	8.53	8.15	7.02	5.12	4.56	0.08	0.30

* at 5 (%) level
SEm - Standard Error of mean
CD - Critical Difference

Table: 4.10 Physico-chemical properties of fermented α-amylase enzyme treated banana beverages after 15 days storage period

S. No.	Parameters	Pulp:Water:Sorghum Ratio						SEm (±)	CD*
		1:2:0.5	1:2:0.25	1:4:0.83	1:4:0.41	1:6:1.16	1:6:0.58		
1	Viscosity, (s)	1.91	1.89	1.80	1.78	1.47	1.44	0.04	0.15
2	Titrable acidity, (%)	0.86	0.84	0.74	0.72	0.69	0.68	0.04	0.15
3	TSS,(°Brix)	13.00	13.00	11.00	11.00	11.00	11.00	-	-
4	pH	3.30	3.30	3.30	3.30	3.20	3.20	0.00	0.01
5	Reducing sugar, (%)	3.70	3.65	2.75	2.72	2.54	2.48	0.03	0.12
6	Total sugar, (%)	44.26	44.08	43.29	43.08	42.68	42.62	0.24	0.85
7	Non-reducing sugar, (%)	40.56	40.43	40.54	40.36	40.14	40.14	0.24	-
8	Optical density, (520 nm)	0.40	0.37	0.28	0.19	0.21	0.18	0.00	0.01
9	Alcohol, (%)	8.54	7.75	6.98	6.01	4.44	3.07	0.09	0.31

* 5 (%) level
SE - Standard Error of mean
CD - Critical Difference

0.73. 0.70, 0.67 and 0.66 per cent in the beverages prepared with 1:2:0.5, 1:2:0.25,1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively over a storage period of 15 days as can be indicated by Fig. 4.11. Similar significant ($P < 0.05$) increasing trend of titrable acidity was observed for the stored fermented a-amylase enzyme banana beverage for all the ratios (Table 4.10).

Figure 4.12 shows that the optical density increased during storage period of 15 days in both enzymes treated banana beverages. Optical density of stored fermented amylase extract enzyme banana beverages decreased significantly ($P < 0.05$) found to be 0.42, 0.41, 0.29, 0.20, 0.22 and 0.18 at 520 nm in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively as can be given in Table 4.9. The values of stored fermented a-amylase enzyme banana beverages over a storage period of 15 days was decreased significantly ($P < 0.05$) found to be 0.40, 0.37, 0.28, 0.19, 0.21 and 0.18 at 520 nm in the beverages prepared with 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.10).

Figure 4.13 depicted the reducing sugar decreased significantly ($P < 0.05$) from 3.7, 3.65, 2.75, 2.72, 2.54 and 2.48 per cent in the pulp-water-sorghum ratios of 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58, respectively in both the stored fermented enzymes treated banana beverages over a storage period of 15 days.

Alcohol per cent of stored fermented amylase extract enzyme banana beverages was decreased significantly ($P < 0.05$) 9.02, 8.53, 8.15, 7.02, 5.12 and 4.56 per cent in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively during storage period of 15 days (Table 4.9). Similar

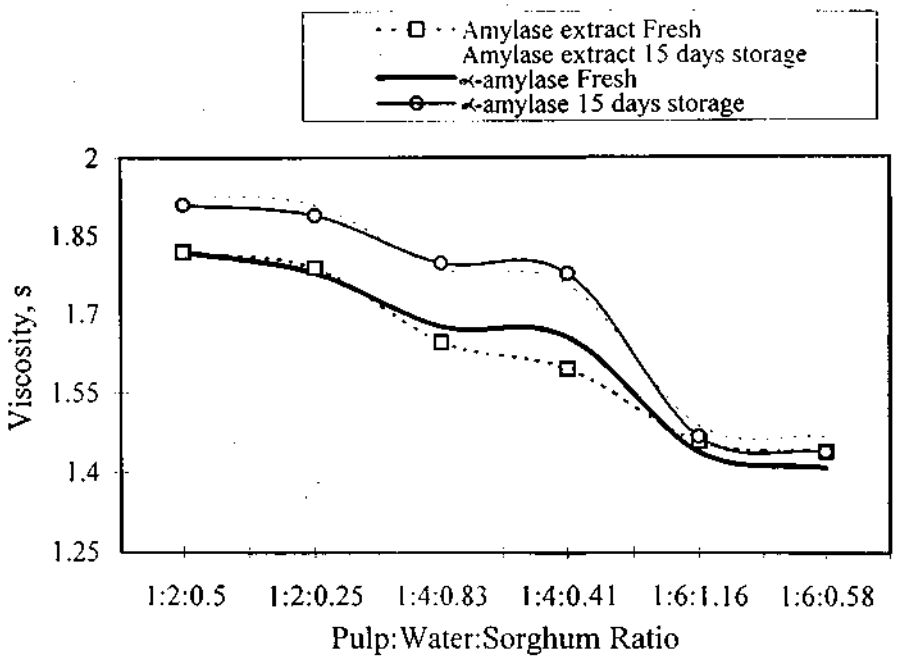

Fig. 4.10 Effect of different ratios on viscosity of fermented enzyme treated banana beverages

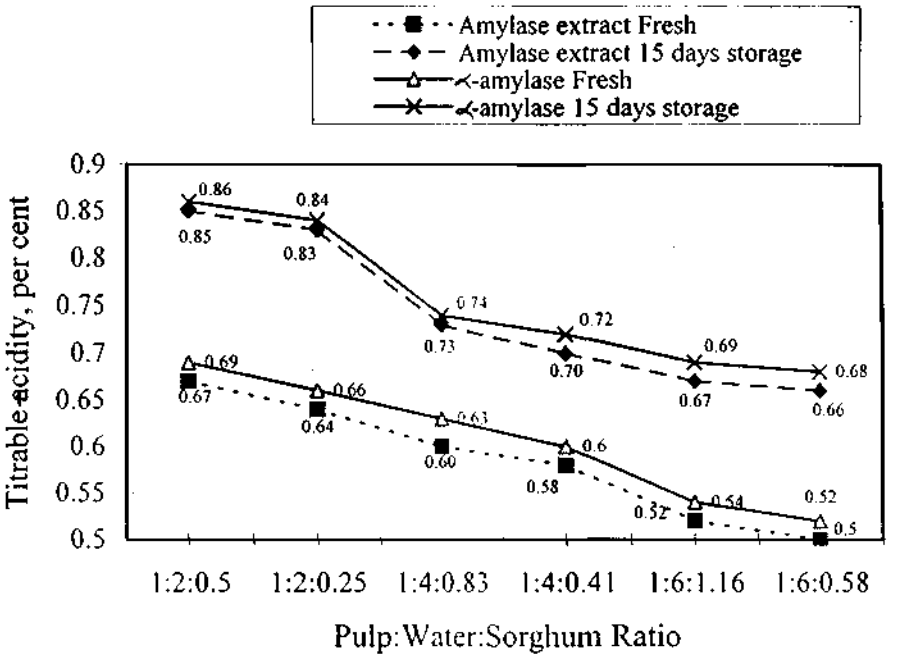

Fig. 4.11 Effect of different ratios on titrable acidity of fermented enzyme treated banana beverages

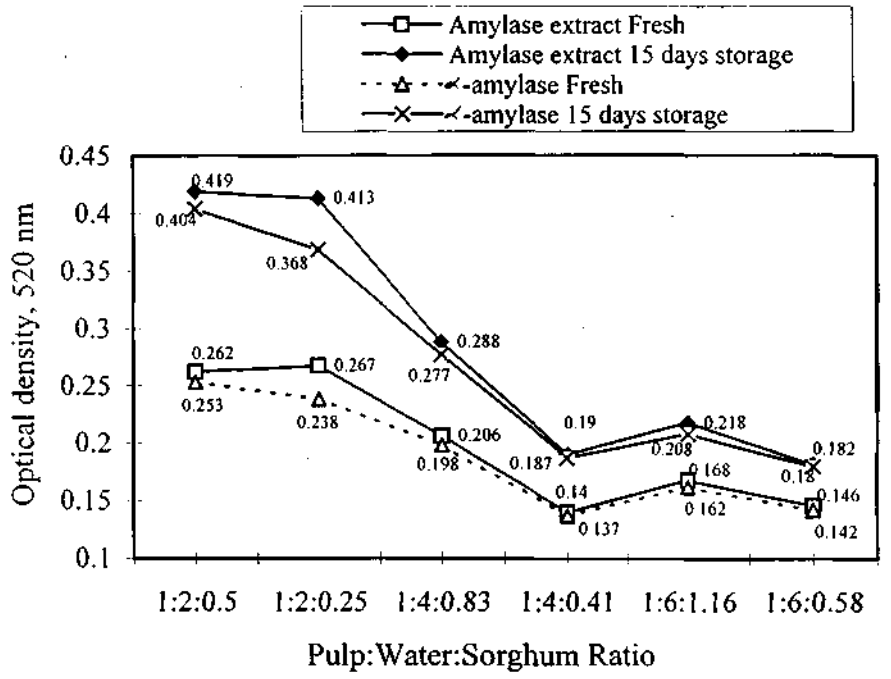

Fig. 4.12 Effect of different ratios on optical density of fermented enzyme treated banana beverages

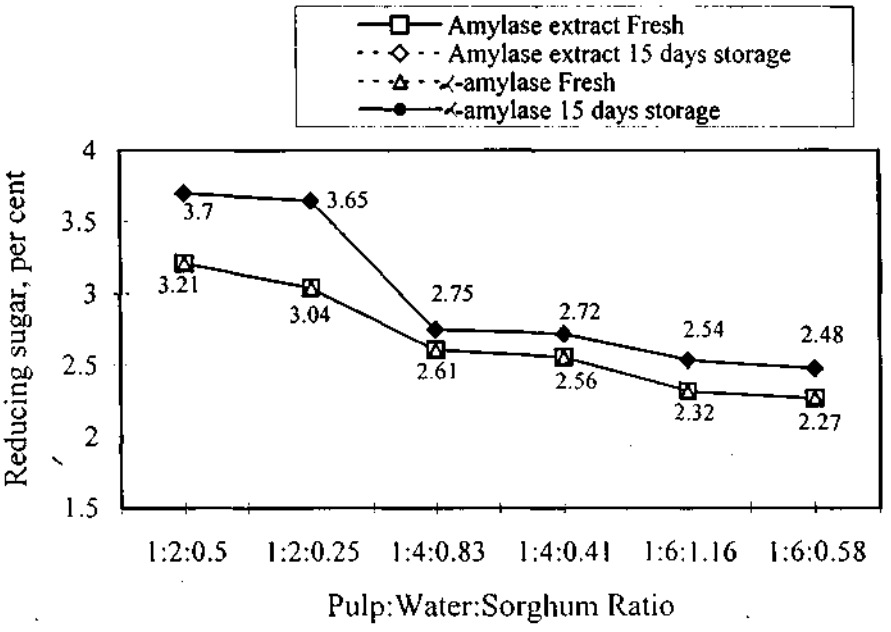

Fig. 4.13 Effect of different ratios on reducing sugar of fermented enzyme treated banana beverages

significantly ($P < 0.05$) decreasing trend of stored fermented α–amylase enzyme banana beverages was observed over a storage period of 15 days (Fig. 4.14).

4.4.3 Sensory evaluation of fresh and stored fermented enzyme treated banana beverages:

The banana beverages made out of pulp blended with water and sorghum in different ratios were used for sensory evaluation. Both, the fresh beverages and beverages after storage period of 15 days were used for the evaluation. Table 4.11 presents the total score of the panelists obtained for different beverages. It can be seen from the table that the highest ranking (240) has been given to the fresh beverage prepared in the ratio of 1:4:0.83. Similarly the scores are 232 for 1:4:0.41 ratio, 218 for 1:2:0.25 ratio, 208 for 1:6:1.16 ratio, 206 for 1:2:0.5 ratio and 194 for 1:6:0.58 ratio of fresh banana fermented amylase extract enzyme banana beverages. The average values of the sensory evaluation for the fresh and stored beverages of two replications are given in Appendix-G.

Also, it can be seen from the Table 4.11 that the highest ranking (228) has been given to the fresh beverage prepared in the ratio of 1:4:0.83. Similarly the scores are 210 for 1:4:0.41 ratio, 208 for 1:2:0.25 ratio, 200 for 1:2:0.5 ratio, 182 for 1:6:1.16 ratio and 180 for 1:6:0.58 ratio of fresh banana fermented a-amylase enzyme banana beverages. The average values of the sensory evaluation for the fresh and stored beverages of two replications are given in Appendix-H.

The beverage evaluated after a storage period of 15 days had the effect of storage as can be seen from Table 4.11. The total score for each of the beverages have been reduced which are 196, 205, 232, 222, 192 and 176 for the beverages

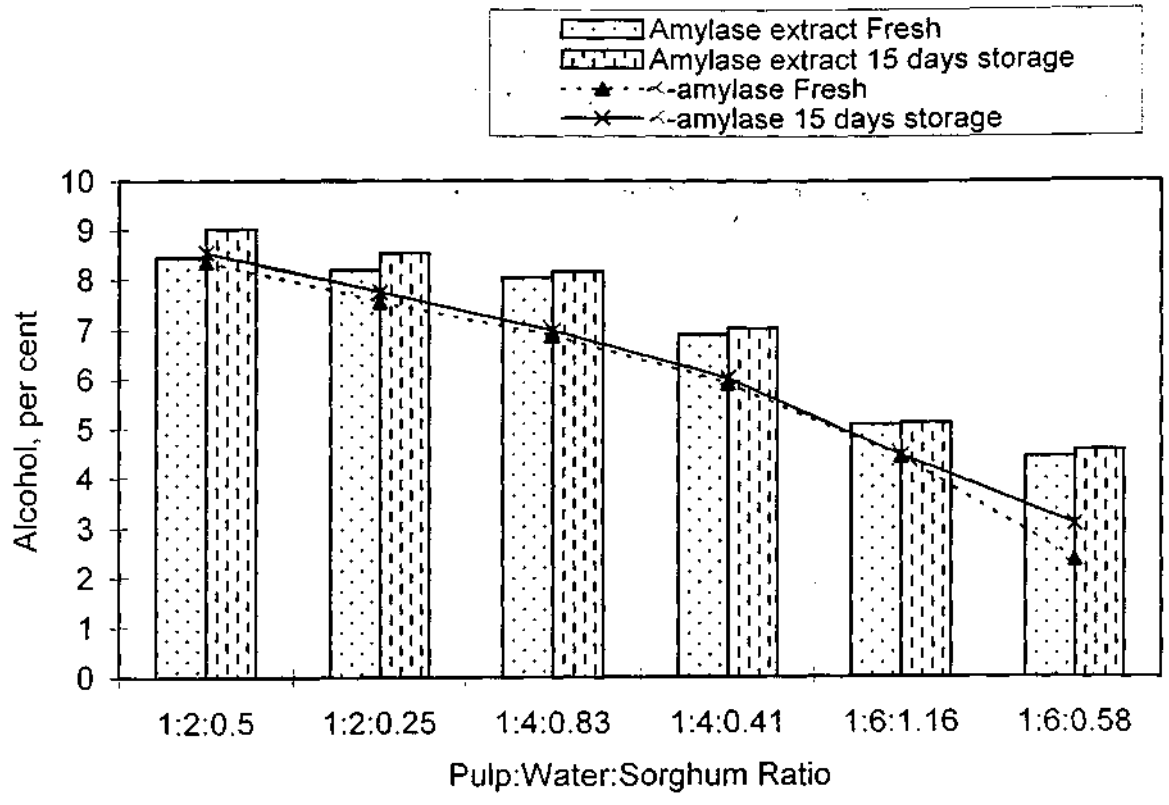

Fig. 4.14 Effect of different ratios on alcohol of fermented enzyme treated banana beverages

Table: 4.11 Total sensory score of fermented enzyme treated banana beverages

S. No.	Pulp:Water:Sorghum Ratio	amylase extract enzyme		α-amylase enzyme	
		Fresh	15days stored	Fresh	15 days stored
1	1:2:0.5	206	196	200	186
2	1:2:0.25	218	205	208	186
3	1:4:0.83	240	232	228	217
4	1:4:0.41	232	222	210	196
5	1:6:1.16	208	192	182	166
6	1:6:0.58	194	176	180	160

- The values are the average of two replications given by six judges panel

ratios of 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0,58 ratios, respectively of stored fermented amylase extract enzyme banana beverages.

Also, it was found that the total score for each of the beverages have been reduced which are 186, 186, 217, 196, 166, 160 for the beverages ratios of 1:2:0.5, 1:2:0.25, 11 0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively of stored fermented α–amylase enzyme banana beverages (Table 4.11).

4.5 By product / waste utilization:

By product and waste material obtained during preparation of banana beverages are given in Table 4.12.

Banana peel was found to be 480 kg/t from the banana fruit. It was observed that highest by product *i.e.* pellet was found to be 213.00 kg/t in 1:2 ratios, followed by 110.00 kg/t in 1:4 ratio of banana beverage. Lowest pellet was found be 78.00 kg/t in 1:6 ratio of banana beverage (Table 4.12).

It was observed that the pellet was higher in 1:2:0.5 (353.00 kg/t), 1:4:0.83 (364.40 kg/t) and 1:6:1.16 (352.07 kg/t) ratio as compared to 1:2:0.25 (219.00 kg/t), 1:4:0.41 (216.16 kg/t) and 1:6:0.58 (200.82 kg/t) ratios, respectively of fermented banana beverages as can be given in Table 4.12.

4.6 Cost analysis of banana beverages for one tonne per day unit:

The details of cost analysis of banana beverages for one tonne per day unit are presented in Appendix-I.

The cost to preparation of banana beverages was found to be Rs. 13.00 per kg, Rs. 8.00 per kg and Rs. 6.00 per kg in the 1:2, 1:4 and 1:6 ratios, respectively as can be presented in Table 4.13.

Table: 4.12 specific solid by product and waste generation during processing of banana beverages

S. No.	Types of waste	Fresh weight, kg/t	Dry weight, kg/t
1	Peel	480.00	70.00
2	Banana beverage pellet		
	1:2	213.00	27.00
	1:4	110.00	9.70
	1:6	78.00	6.00
3	Fermented banana beverage pellet		
	1:2:0.5	353.00	128.00
	1:2:0.25	219.00	82.70
	1:4:0.83	364.40	160.10
	1:4:0.41	216.16	85.72
	1:6:1.16	352.07	165.07
	1:6:0.58	200.82	85.82

Table: 4.13 Cost analysis of" banana beverages for one tonne per day unit
(in Rupees)

S. No.	Particulars	1:2 Ratio	1:4 Ratio	1:6 Ratio
1	Total capital investment	3243720.00	3243720.00	3243720.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	4157125.00	4157125.00	4157125.00
4	Total manufacturing cost	13.00	8.00	6.00
5	Ex factory price of product	15.00	10.00	7.00
6	Total sales revenue	5797725.00	6743250.00	6451690.00
7	Cost of by product	193010.00	264671.00	254520.00
8	Gross profit	971713.00	1988899.00	1725028.00
9	Net profit	485856.50	994449.50	862514.00
10	Return on investment	14.97 %	30.65 %	26.59 %
11	Pay back period	2.19 year	1.63 year	1.75 year
12	Break even point			
	1.Production, kg/ year	2509511.00	430948.5	861897
	2.No. of days of production/ year	250.95	430.94	861.89
	3.sales revenue, lakh	37642.66	4309.48	6033.27

The cost of fermented banana beverages was Rs. 18.00 per kg. Rs.17.00 per kg, Rs.l 1.00 per kg, Rs.10.00 per kg, Rs.8.00 per kg, and Rs.7.00 per kg, in the 1:2:0.5, 1:2:0.25. 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively (Table 4.14 A and B).

The cost analysis of the data was revealed that there was fall in the cost of fermented enzyme treated banana beverages with the different formulations. The cost of preparation was found to be Rs. 23.00 per kg, Rs. 22.00 per kg, Rs. 16.00 per kg, Rs. 15.00 per kg, Rs. 13.00 per kg and Rs. 12.00 per kg, in the 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios, respectively as can be . seen in (Table 4.15 A, B, C and D).

Table: 4.14 (A) Cost analysis of fermented banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:2:0.5 Ratio	1:2:0.25 Ratio	1:4:0.83 Ratio
1	Total capital investment	3506700.00	3423540.00	3556538.40
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	5939125.00	5655625.00	6348628.00
4	Total manufacturing cost	18.00	17.00	11.00
5	Ex factory price of product	21.00	20.00	13.00
6	Total sales revenue	7912201.50	7901712.00	8555989.00
7	Cost of by product	387860.44	279643.60	561566.56
8	Gross profit	1499039.90	1663833.60	1907033.60
9	Net profit	749519.97	831916.80	953516.78
10	Return on investment	21.67 %	24.29 %	26.81 %
11	Pay back period	1.82 year	1.73 year	1.75 year
12	Break even point			
	1.Production, kg/year	287299.00	287299.00	430949.00
	2. No. of days of production/year	287.29	287.29	430.94
	3.sales revenue, lakh	6033.27	5745.98	56023.30

Table: 4.14 (B) Cost analysis of fermented banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:4:0.41 Ratio	1:6:1.16 Ratio	1:6:0.58 Ratio
1	Total capital investment	3507738.20	3549330.05	3469927.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	5844625.00	6695125.00	6033625.00
4	Total manufacturing cost	10.00	8.00	7.00
5	Ex factory price of product	12.00	10.00	8.00
6	Total sales revenue	8313435.00	9525600.00	8217191.20
7	Cost of by product	377713.30	5455696.00	408324.00
8	Gross profit	1984626.30	2514147.60	1729993.20
9	Net profit	992313.15	1257073.80	864996.60
10	Return on investment	28.28 %	35.42 %	24.93 %
11	Pay back period	1.71 year	1.52 year	1.81 year
12	Break even point			
	1.Production, kg/year	430949.00	430949.00	861897.00
	2.No. of days of production/year	430.94	430.949	861.89
	3.sales revenue, lakh	5171.38	4309.49	6033.27

Table: 4.15 (A) Cost analysis of fermented amylase extract enzyme banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:2:0.5 Ratio	1:2:0.25 Ratio	1:4:0.83 Ratio
1	Total capital investment	3674460.00	3651090.00	3887100.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	7746625.00	7551875.00	9518625.00
4	Total manufacturing cost	23.00	22.00	16.00
5	Ex factory price of product	27.00	26.00	19.00
6	Total sales revenue	10172831.00	10272226.00	12546954.00
7	Cost of by product	387860.44	279643.60	561566.56
8	Gross profit	1952168.90	2138097.60	2727998.60
9	Net profit	976084.47	1069048.80	1363999.30
10	Return on investment	26.56 %	29.28 %	35.09 %
11	Pay back period	1.68 year	1.60 year	1.47 year
12	Break even point			
	1. Production, kg/year	215474.25	215474.25	287299.00
	2. No. of days of production/year	215.47	215.47	287.29
	3. sales revenue, lakh	58178.04	560233.30	5458.68

Table: 4.15 (B) Cost analysis of fermented amylase extract enzyme banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:4:0.41 Ratio	1:6:1.16 Ratio	1:6:0.58 Ratio
1	Total capital investment	3845220.00	4096980.00	4060508.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	9169625.00	11267625.00	10963625.00
4	Total manufacturing cost	15.00	13.00	12.00
5	Ex factory price of product	18.00	15.00	14.00
6	Total sales revenue	12470153.00	14288400.00	14380085.00
7	Cost of by product	377713.30	545569.60	408324.00
8	Gross profit	2816343.80	14833970.00	2962886.60
9	Net profit	1408171.90	7416984.80	1481443.30
10	Return on investment	36.62 %	55.23 %	36.48 %
11	Pay back period	1.44 year	0.48 year	0.32 year
12	Break even point			
	1.Production, kg/year	287299.00	430948.50	430948.50
	2. No. of days of production/year	287.29	430.94	430.94
	3.sales revenue, lakh	5171.38	64642.27	6033.27

Table: 4.15 (C) Cost analysis of fermented α-amylase enzyme banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:2:0.5 Ratio	1:2:0.25 Ratio	1:4:0.83 Ratio
1	Total capital investment	3674460.00	3651090.00	3887100.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	7746625.00	7551875.00	9518625.00
4	Total manufacturing cost	23.00	22.00	16.00
5	Ex factory price of product	27.00	26.00	19.00
6	Total sales revenue	10172831.00	10272226.00	12546954.00
7	Cost of by product	387860.44	279643.60	561566.56
8	Gross profit	1952168.90	2138097.60	2727998.60
9	Net profit	976084.47	1069048.80	1363999.30
10	Return on investment	26.56 %	29.28 %	35.09 %
11	Pay back period	1.68 year	1.60 year	1.47 year
12	Break even point			
	1.Production, kg/year	215474.25	215474.25	287299.00
	2. No. of days of production/year	215.47	215.47	287.29
	3.sales revenue, lakh	58178.04	560233.30	5458.68

Table: 4.15 (D) Cost analysis of fermented a-amylase enzyme banana beverages for one tonne per day (in Rupees)

S. No.	Particulars	1:4:0.41 Ratio	1:6:1.16 Ratio	1:6:0.58 Ratio
1	Total capital investment	3845220.00	4096980.00	4060508.00
2	Total annual fixed cost	861897.00	861897.00	861897.00
3	Total annual variable cost	9169625.00	11267625.00	10963625.00
4	Total manufacturing cost	15.00	13.00	12.00
5	Ex factory price of product	18.00	15.00	14.00
6	Total sales revenue	12470153.00	14288400.00	14380085.00
7	Cost of by product	377713.30	545569.60	408324.00
8	Gross profit	2816343.80	14833970.00	2962886.60
9	Net profit	1408171.90	7416984.80	1481443.30
10	Return on investment	36.62 %	55.23 %	36.48 %
11	Pay back period	1.44 year	0.48 year	0.32 year
12	Break even point			
	1.Production, kg/year	287299.00	430948.50	430948.50
	2.No. of days of production/year	287.29	430.94	430.94
	3.sales revenue, lakh	5171.38	64642.27	6033.27

CHAPTER - V

DISCUSSION

CHAPTER - V

DISCUSSION

The finding of present investigation entitled "development of process technology for preparation of banana beverages" have been discussed and interpreted in this chapter with reference to the past research work as and when needed.

5.1 Physico-chemical properties of fresh banana beverages:

In order to explore the possibility of consumption of any fruit beverages it is important to evaluate the physico-chemical properties of different beverages.

The findings of the present investigation given in Table 4.1, 4.4, 4.7 and 4.8, data revealed that the viscosity of banana beverages, fermented banana beverages and fermented enzyme treated banana beverages decreased gradually with the increasing water ratio. This was mainly due to the dilution of the beverage to break down of large sugar molecules to smaller ones. These results are in agreement with the findings of Thomson (1995) reported for banana beverages

The yield of different beverages was found to be increased as the content of water increased and obviously with the sorghum content too. Increased quantity of water and addition of sorghum, reduced the pellet per cent and finally increased the recovery. Similar observations have also been reported by Bardiya *et al*., (1974) and Kundu et *al*., (1976).

Effect of ratios on titrable acidity showed in Table 4.1, 4.4, 4.7 and 4.8 it was observed that the titrable acidity gradually decreased with the increase of

water content in all the types of banana beverages as prepared by using various combinations. This was due to the fact that addition of water and reduction in pH. These results are in agreement with the findings of Singh (1998), who reported that acidity of kinnow juice decreased with the decreasing of total soluble solids. Similar findings have also been concluded by Sandhu and Bhatia (1985) for banana concentrated juice.

Reducing sugar was found to be higher in 1:2 ratio and it continuously decreases with the increase of water content as mentioned in Table 4.1, 4.4, 4.7 and 4.8. This is due to the fact that water content increases with the increase in dilution. Initially reducing sugar was higher due to inversion of non-reducing sugar with the pulp content after that pulp content diluted in higher proportion this reduces the inversion of sugar. These results are in agreement with findings of Joshi *et al.,* (1995) for apple beverage. Kundu *et al.,* (1976) reported that the rate of reducing sugar was more in the banana wine containing higher amount of non-reducing sugars. However, Akingbala *et al,* (1994) reported that total fermentable sugar content depended on the degree of ripeness of fruit.

Effect of ratios on optical density presented in Table 4.1, 4.4, 4.7 and 4.8. This indicates that turbidity in beverages fall down with the increase in dilution. When pulp tissue mixed with water, it was break down into smaller ones that is eventually responsible for the decrease of optical density, and it was reduced due to certain inter-chemical reaction between sugar and proteins. This result is in agreement with the findings of Sims *et al.,* (1994) and Floribeth (1998) for banana juice.

Table 4.1, 4.4, 4.7 and 4.8 revealed that the alcohol per cent was higher in 1:2:0.5, 1:4:0.83 and 1:6:1.16 ratio as compared to 1:2:0.25, 1:4:0.41 and 1:6:0.58 ratios. This was due to the fact that the rate of fermentation decreases with the increasing dilution. Dilution of the pulp affects the rate of fermentation by decreasing cell mass of the cultures. These result are in agreement with findings of Bardiya *et al*., (1974) for guava wine and Kundu *et al*., (1976) for banana wine.

5.2 **Physico-chemical properties of stored banana beverages:**

During storage at 5-7° C temperature in refrigerated condition, viscosity was found to be increased. This may because of gelatinization of pectin due to enzymes reaction added for clarification. Similar results have also been reported by Jaleel (1978) for banana puree.

Titrable acidity was increased significantly in all the samples (Table 4.2, 4.5, 4.9 and 4.10). This was mainly due to the formation of acetic acid by the action of microflora growing during the storage of the samples and reduces disaccharides (Maltose, Fructose *etc*.) and converted into alcohol and acetic acid. Similar observations have been reported by Ahmed (1996) and he was found that the acidity of the banana beverages decrease marginally during the storage period. However, similar findings was reported by Singh (1998) for kinnow juice.

The optical density increased gradually during the storage period 15 days because of the enzymatic oxidation of polyphenols and formation of complex molecules of protein and sugar and leads to browning reaction in the all beverages with different ratios as mentioned in the Fig. 4.3, 4.7 and 4.12. Similar type of experiment conducted by Mabesa (1985), Sims and Bates (1994) and

Ahmed (1996) for the similar type of banana beverage and found similar results during the experiment.

In the present study it was observed that the reducing sugar increased significantly over a storage period of 15 days (Fig. 4.4,4.8 and 4.13). This may be because of hydrolysis of sugar added during the course of investigation. These results are in agreement with the findings of Sandhu *et al*., (1985). They have conducted on experiment for the preparation of concentrated juice from mango, banana and pineapple and observed that the inversion of non-reducing sugars during the storage period. Similar findings have also been reported by Akingbala (1994) for banana and mango juice.

Figure 4.9 and 4.14 depicted that after 15 days of storage period of the product alcohol content was estimated and found that the alcohol content significantly increased in the product. This may be due to the amines and saccharides degradation by the enzymes added during the course of investigation in all the combinations, which leads to formation of alcohol in the product. Similar result are given by Kundu *et al*., (1976) for banana wine; Gautam *et al*., (1978) for sapota wine; Joshi *et al*., (1995) for kinnow wine and Jawahar *et al*., (2001) for guava juice.

5.3 **Sensory evaluation of fresh and stored banana beverages:**

The aim of sensory evaluation of different banana beverages was to find out the acceptability and rejection of the samples by the panelist. The evaluation included various attributes *viz;* colour, taste, appearance, flavour and overall acceptability.

Based on the scores given in Table 4.3, 4.6 and 4.11 for all the ratios, it was compared and decided whether products are liable to accept or reject after the stipulated period of storage.

During the sensory evaluation it was observed that 1:4 ratio of fresh banana beverage recorded highest score for colour (42), taste (38) and over-all acceptability (40) as compared to 1:2 and 1:6 ratios, similarly for stored samples highest score was observed for 1:4 ratio for the colour (38), taste (36) and over-all acceptability (35) as compared to 1:2 and 1:6 ratios (Appendix-E). The highest score indicates the quality of fresh beverage as well as 15 days stored sample having excellent and described its over-all acceptability. Our findings are in agreement with the findings reported by Joshi (1995) for kinnow wines.

In the fermented banana treated with *S. cerevisiae* with the addition of sorghum flour in different concentrations and combination were made *viz;* 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 ratios. The beverage with the ratio of 1:4:0.83 recorded highest total score (258) among the above all combinations of fresh fermented banana beverages. This was due to higher perception of colour (53), taste (52) and over-all acceptability (53), whereas sensory evaluation was carried out after 15 days storage period all these samples we have found that highest sensory score was found for 1:4:0.83 sample among the rest of the combinations as given in Appendix-F. The highest score was found in all the combinations, because of higher sensory scores obtained for colour (53), taste (51) and over-all acceptability (52) which gives an idea for consumer preference on the basis of nutritional status at the time of fermentation and lower alcohol content (4.5 %) among the all beverages were prepared with different

combinations as indicated in Table 4.4 and 4.5. The gradual decreasing rate of sensory score of the product may be because of gradual spoilage of the product due to exponential growth of microorganisms in the products during storage period.

The sensory scores for the amylase extract enzyme treated samples given in Table 4.11 for all the fresh and stored samples. Table 4.11 reveals that amylase extract enzyme treated banana beverage with a combination of 1:4:0.83 got highest sensory scores for fresh and 15 days stored sample among the all combinations as developed during the course of investigation. Highest sensory scores were indicates better in colour (49), taste (49) and over-all acceptability (49) of the product (Appendix-G). These results are similar to sensory score reported by Joshi (1995).

a-amylase enzyme treated banana beverages were made with several combinations such as 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58 and found that maximum sensory score was 228 and 217 for fresh and stored banana beverages for 1:4:0.83 ratio, respectively. It was observed that higher (228) sensory score was earned during 15 days storage period of a-amylase enzyme treated banana beverages on the basis of flavour (43), taste (44) and over-all acceptability (47) (Appendix-H). This may be because of increasing alcohol content and decomposition of inherent nutrients of the beverage. This is an indication proves to reduced the score of colour, flavour, taste and over-all acceptability of the product. Similar types of the findings have been reported by Joshi (1995) for kinnow wines.

5.4 By product / waste utilization:

The by-product obtained after the products preparation was also used for calculation of techno economic feasibility of the products.

Pellets obtained from different banana beverage preparation were found to be decreased as the content of water increased. This was due to the fact that the increased quantity of water that results dry matter content of pulp goes with juice and decreased the pellets percentage.

Peel and pellets can be used as a cattle feed. The present study shows the effective utilization of some of these wastes resulting in the economy in the cost of production of the main product. Clavaija and Maner (1975) reported that fresh whole ripe banana, dried green banana peel, and spoiled bananas have been used successfully as animal feed.

5.5 Cost analysis of banana beverages for one tonne per day unit:

The cost of banana beverages decreased gradually with increasing water ratio along with the sorghum flour. It observed that the cost of fermented banana beverage of the ratio 1:4:0.83 was Rs. 11.00 per kg, and was more cheaper than the other types of beverages prepared during the course of investigation.

The present finding was an attempt to find out the information for the cost of one tonne per day capacity unit, which may serves as a basis and guideline for future research project and industrial development in the field of banana beverages industry. It was suggested that the success or failure of a project depends on detailed design and engineering aspects of the processing unit. Increase profit margin through reduction of post harvest losses, efficient and judicious use of utilities, full capacity utilization and better management of the processing plant.

CHAPTER - VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

CHAPTER - VI

SUMMARY, CONCLUSIONS AND SUGGESTIONS FOR FUTURE RESEARCH WORK

Banana is relatively cheapest and most nourishing of all the fruits. Banana is available in most of the tropical household compounds and are readily acceptable and digested. In fact banana is the first solid food fed to the infants. Banana has a high carbohydrate and low fat contents. Banana, an excellent source of energy, vitamins and minerals and popular for its delicacy, flavour and relished for its soft texture.

Banana has a short shelf life, processing is important, and range of techniques were used on commercial scale are less economical. Today processing and value addition are the need for any fruits and vegetables. A large number of processed fruits and vegetable products are available in the market even then the demand for a new product always exists. Keeping this in view, the present research work on the "development of process technology for preparation of banana beverages" and its storability has been formulated with the following objectives:

1. To standardize the process for the preparation of banana beverage.
2. To evaluate the physico-chemical properties of fresh and stored products.
3. To work out the techno economic feasibility for one tonne per day banana processing unit.

The Present investigation was carried out at Central Institute of Agriculture Engineering, Bhopal. One particular variety of fresh ripe bananas

procured from the market have been used for the experiment. The study included three types of formulations v/z; banana beverage, fermented banana beverage and fermented enzyme treated banana beverage.

Banana pulp was blended with water (w/v) in three different ratios. *i.e.*1:2, 1:4, 1:6 ratios at room temperature.. The diluted pulp was clarified by centrifugation process at 9000 rpm for 30 min at 15° C and filtrate beverage was pasteurised at 65° C for 15 min. Potassium meta-bisulphite preservative (@ 1g/lit) was added in pasteurised beverage and kept in refrigerator at 5-7° C for 15 days storage period.

Banana fermented beverage was prepared by three different ratios of pulp, water (w/v) and sorghum flour (w/w) *i.e.* 1:2:0.5, 1:2:0.25, 1:4:0.83, 1:4:0.41, 1:6:1.16 and 1:6:0.58. Thereafter, *S. cerevisiae* (10^5-10^6 cfu/ml) culture @ 5 ml/200 ml was added in each treatment and was kept for 24 h at room temperature. Clarification of beverage was achieved by centrifugation at 9000 rpm for 30 min at 15° C. Filtrate beverage was pasteurised at 65° C for 15 min and potassium meta-bisulphite preservative (@ 1g/lit) was added and kept in refrigerator at 5-7° C for 15 days storage period.

Banana fermented enzyme treated beverages were prepared by using the same method as that of fermented beverage process, till filtration. Filtrate beverage was treated with α-amylase enzyme @ 0.2 per cent (v/w) and amylase extract enzyme @ 0.2 per cent (v/v) and kept in incubator for 30 min at 35° C. Enzyme treated beverages were pasteurised at 65° C for 15 min and potassium meta-bisulphite preservative was added (@ 1g/lit) and kept in refrigerator at 5-7° C for 15 days storage period.

All the beverages were analysed for different physico-chemical analysis as fresh and after a period of 15 days storage. Banana beverages were analysed for different physico-chemical properties namely, total soluble solids, titrable acidity, reducing sugar, total sugar, non-reducing sugar, pH, viscosity, optical density and alcohol content. Sensory evaluation and cost analysis were assessed for all the prepared products. The present investigation led to the following results:

1. Viscosity of banana beverages was found to be 2.54, 1.87 and 1.11 s in the pulp, water ratio of 1:2, 1:4 and 1:6, respectively.
2. Titrable acidity, reducing sugar and optical density were found to be higher in 1:2 ratios and less in 1:4 and 1:6 ratios.
3. It was observed that in fermented banana beverages, the values of viscosity, titrable acidity, reducing sugar, optical density and alcohol were higher in the ratio 1:2:0.5, 1:4:0.83 and 1:6:1.16 as compared to the ratio 1:2:0.25, 1:4:0.41 and 1:6:0.58, respectively.
4. It was observed that in fermented enzyme treated banana beverages, the values of viscosity, optical density and alcohol were higher and titrable acidity was lower in case of amylase extract enzyme banana beverages as compared to α-amylase enzyme banana beverages.
5. The effect of storage on physico-chemical properties showed that the viscosity, optical density, titrable acidity, reducing sugar, alcohol were increased and pH was found to be decreased over a storage period of 15 days in banana beverages, fermented banana beverages and fermented enzyme treated banana beverages.
6. The sensory evaluation of banana beverages, fermented banana beverages and fermented enzyme treated banana beverages showed that fresh fermented banana beverages of the ratio 1:4:0.83 was highly acceptable by the six judges on 9 point Hedonic scale.
7. The cost of preparation of 1:4 ratio of banana beverages, 1:4:0.83 ratio of fermented banana beverages and 1:4:0.83 ratio of fermented amylase

enzyme treated banana beverages was calculated on basis of fixed and variable cost as Rs. 6.00 per kg, Rs.11.00 per kg and Rs.16.00 per kg, respectively.

From the present study in the light of the aforesaid findings, it can be concluded that the banana fruit could be successfully utilized for the preparation of banana beverages with the manipulation of pulp and water ratio with the incorporation of sorghum flour. Basically, three types of banana beverages namely banana beverages, fermented banana beverages and fermented enzyme treated banana beverages were prepared using fresh banana pulp, fermented pulp and treated with enzyme respectively. The physico-chemical properties of beverages were found to be significantly ($P < 0.05$) changed as the water and sorghum quantity changed. These beverages could be stored safely in glass bottles at 5-7° C for about 15 days period without any appreciable deterioration in the qualities. Fermented beverage of the ratio 1:4:0.83 was ranked first by the judges on the basis of physico-chemical properties and sensory evaluation among the all preparations. Also, on the basis of cost analysis, fermented banana beverage of the ratio 1:4:0.83 was found to be the best among the all preparations.

Based on the results obtained during the investigation from the present study, some suggestions for future research work are given as below.

1. A similar work may be undertaken for screening of different banana varieties for beverage preparations.
2. Banana fermented beverage can be carried out at different concentration of *S. cerevisiae*, temperatures, fermentation period and enzyme treatment.

3. Research work may be initiated for banana waste for useful utilization as a feed and food supplementations.
4. As a business point of view, low cost mix fruit beverages can be prepared to earn more profit and encourage for products diversification.

ABSTRACT

ABSTRACT

The present investigation entitles "development of process technology for preparation of banana beverages" was undertaken with the object to develop the process technology and evaluate the product for its shelf life.

Basically three types of beverages were prepared *viz;* banana beverages, fermented banana beverages and fermented enzyme treated banana beverages by manipulating the ratio of banana pulp, water and sorghum flour. Fresh prepared beverages were subjected for physico-chemical analysis and sensory evaluation. The beverages were then filled in glass bottles and stored in a refrigerator at 5-7° C for 15 days. After 15 days all the beverages were again analysed for physico-chemical changes and also evaluated by the panel of six judges on nine-point hedonic scale.

All the samples stored have shown the significant variation in major physico-chemical properties. In the preparations like viscosity, titrable acidity, reducing sugar, total sugar, optical density, alcohol content and pellet per cent were found to have been changed significantly where as the other properties like pH and total soluble solids did not show any significant change. The data on sensory evaluation of all the beverages also show some deterioration in the quality as indicated by the scores given to the samples. Out of 21 different types of beverages, 1:4 ratio of banana beverages, 1:4:0.83 ratio of fermented banana beverages and 1:4:0.83 ratio of fermented amylase extract enzyme banana beverages were found to have been accepted highly after 15 days storage period. The beverage 1:4:0.83 was found to be the best among all upon sensory evaluation after 15 days storage. However, the beverages could be stored safely at 5-7° C for about 15 days without any appreciable deterioration in the quality.

It can be concluded that 1:4:0.83 (Pulp:Water:Sorghum flour) ratio of fermented banana beverage was found to be the best on the basis of cost, overall acceptability and other physico-chemical properties.

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a

APPENDICES

Appendix - A

Standard Plate Count Method

The plate count method (Ranganna, 1977) was used for estimating the number of viable microorganisms in a given sample that are capable in a specified medium.

The number of visible colonies in the medium is equal to the number of microorganisms, which is always expressed as the number of viable microorganisms per milliliter of single strength juice. Potato dextrose agar medium is used for estimation of number of colonies present in fermented juice.

Procedure:

1. Prepare serial dilution of the juice so the number of colonies per plate ranges from 30 to 300.
2. Inoculate at least two petric dishes of the different dilutions.
3. Mix the medium with the sample in the dishes and leave the plates until the medium solidify.
4. Place them in the incubator at 37°C for 48h.
5. Remove the plate from the incubator and count the colonies.

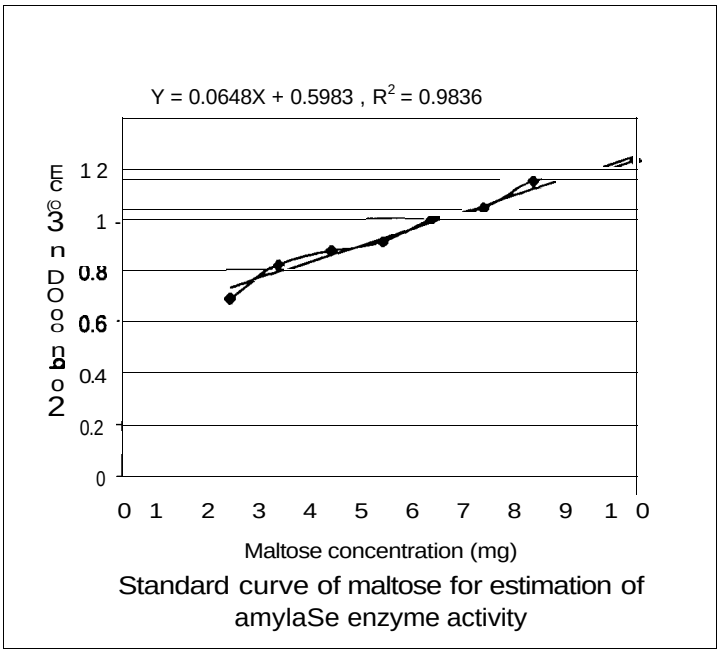
Calculation:

Number of viable organisms per ml of sample = Number of colonies X Dilution factor

Appendix - B

Estimation of Amylase By Measurement of Reducing Groups

Standard curve is prepared (Rick and Stegbauer, 1974) method by taking maltose stock solution 1g/100ml



Standard curve of maltose for estimation of amylaSe enzyme activity

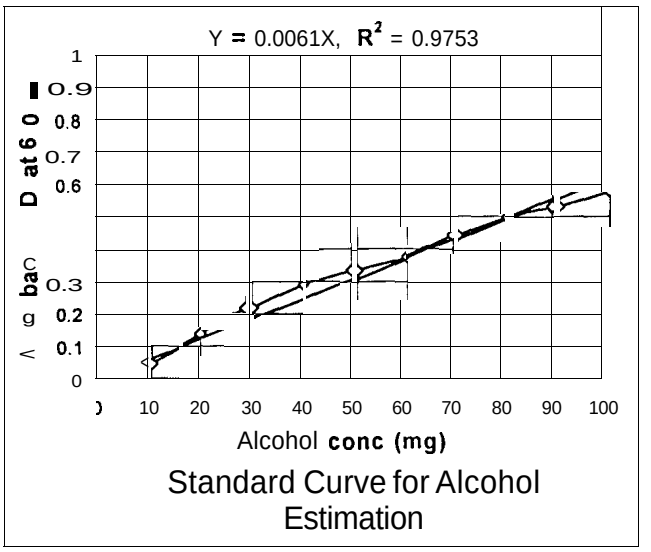
Appendix - C

Standard Curve for Alcohol ***Estimation***

Standard curve is prepared (Caputi et.al.,1968) method

by taking ehanol stock solution(100mg/ml)

Density of ethanol is 0.789kg/l=789mg/ml



Standard Curve for Alcohol Estimation

Appendix - D

Sensory Evaluation

HEDONIC RATING TEST

Specimen evaluation card

Hedonic scale	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like not dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Score card

Sample No.	Appearance	Colour	Flavour	Taste	Overall acceptability

Remarks:

Date: Name of panelist

Appendix - E

Sensory score of fresh and stored banana beverages

Fresh banana beverages

S. No.	Panelists	1:2 Ratio						1:4 Ratio						1:6 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	5.5	5.5	5.5	6	5.5	28	7	7.5	6.5	6.5	7.5	35	5.5	6	5	5.5	5	27
2	2	6	6	5.5	6	5.5	29	6	7	6.5	7	6.5	33	5.5	5.5	4.5	5	5	25.5
3	3	6	6	6.5	6.5	6	31	5.5	6.5	6	6	6	30	6	5.5	5	5	5.5	27
4	4	6	6.5	5.5	6	5.5	29.5	6	7.5	6.5	6.5	6.5	33	5.5	5.5	4.5	5	5	25.5
5	5	5.5	5.5	5.5	5.5	5.5	27.5	6	6.5	6	6	6.5	31	5.5	6	4.5	5	5	26
6	6	6	6	5	5	5.5	27.5	6.5	7	6.5	6	7	33	5	5.5	4.5	4.5	4.5	24
	Total	35	35.5	33.5	35	33.5	172.5	37	42	38	38	40	195	33	34	28	30	30	155

Stored banana beverages

S. No.	Panelists	1:2 Ratio						1:4 Ratio						1:6 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	5.5	5.5	5	5	4.5	25.5	6.5	7	6	6	6	31.5	4.5	5	4	4	4	21.5
2	2	5.5	6	5.5	5.5	5	27.5	6	6	6	6.5	6	30.5	5	4.5	4	4	4.5	22
3	3	5.5	5.5	5.5	5	5	26.5	5.5	6.5	6	6	5.5	29.5	4.5	5	4	4	4.5	22
4	4	5.5	6	5	5	5	26.5	6	6	6	6	6	30	4.5	4.5	4	4	4.5	21.5
5	5	5.5	5.5	4.5	5	4.5	25	5.5	6.5	6	6	6	30	5	4.5	4	4	4.5	22
6	6	5.5	5.5	4.5	4.5	5	25	5.5	6	5.5	5.5	5.5	28	4.5	4.5	4	4	4	21
	Total	33	34	30	30	29	156	35	38	35.5	36	35	179.5	28	28	24	24	26	130

A - Appearance, C - Colour, F - Flavour, T - Taste, O - Over-all acceptability

*- The values are the average of two replications

Appendix - F

Sensory score of fresh and stored fermented banana beverages

Fresh fermented banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	7	6	7	8	8	36	7	7	8.5	8.5	8	39	8.5	9	8.5	9	9	44	8	8.5	8.5	9	9	43	7	8.5	6.5	7.5	7.5	37	7.5	7.5	7.5	8	7.5	38
2	2	6.5	6	7.5	7.5	8	35.5	6.5	6.5	7.5	7.5	7.5	35.5	8	8.5	7.5	8.5	8.5	41	8	8	8	8.5	8	40.5	7	8	7.5	7.5	7	37	6	6	6.5	7	6.5	32
3	3	6.5	6	7.5	7.5	8	35.5	7.5	7	8	8.5	8	39	8.5	9	8.5	8.5	9	43.5	7.5	8.5	7.5	7.5	8	39	6.5	8	6.5	7	7	35	7	7	6.5	7.5	7	35
4	4	6.5	5.5	7	8	8	35	6.5	6.5	8	8	8	37	8.5	9	8.5	8.5	9	43.5	7.5	8	7.5	8	8	39	7	8.5	6.5	7	7	36	6.5	6.5	6.5	8	7	34.5
5	5	7	6.5	7.5	8	8 5	37.5	7	6.5	7.5	8	8	37	8.5	9	9	9	9	44.5	8	8.5	8	7.5	8	40	7	7.5	8	7.5	7.5	37.5	6.5	6.5	6.5	7.5	7	34
6	6	6.5	6	7.5	8	7.5	35.5	7.5	6.5	8.5	8	8.5	39	8	8.5	8	8.5	8.5	41.5	8	8.5	8.5	8.5	9	42.5	6.5	7.5	7	7	6.5	34.5	6.5	6.5	6.5	8	7	34.5
	Total	40	36	44	47	48	215	42	40	48	49	48	227	50	53	50	52	53	258	47	50	48	49	50	244	41	48	42	43.5	42.5	217	40	40	40	46	42	208

Stored fermented banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	6.5	5.5	7	7	7.5	33.5	7.5	7	8	8.5	8.5	39.5	8.5	9	8	9	8.5	43	8	8	8	8	8.5	40.5	6.5	7	7.5	6.5	6.5	34	6.5	7	8	6.5	6.5	34.5
2	2	6	5	7.5	7	7.5	33	7	6	7.5	7.5	8	36	8.5	9	8	9	8.5	43	7.5	7.5	8	8	8	39	7	7.5	8	7	7	36.5	6	6	7	5.5	6	30.5
3	3	6	5	7.5	7	7.5	33	6.5	6.5	7.5	7.5	7.5	35.5	8.5	9	8	8.5	8.5	42.5	7.5	8	7.5	7.5	8	38.5	6.5	7	7.5	6.5	6.5	34	6	6.5	7.5	6	6	32
4	4	6.5	5.5	7	7.5	7.5	34	6.5	6.5	7.5	7.5	7.5	35.5	8	8.5	8.5	8.5	9	42.5	7	8	7.5	8	8	38.5	7	7.5	8	7	7	36.5	5.5	6.5	7	6.5	6.5	32
5	5	6.5	5.5	7.5	8	8	35.5	7	6.5	7.5	7.5	8	36.5	8	8.5	8.5	8	9	42	7.5	8.5	8	8	8.5	40.5	6.5	6.5	7.5	6.5	6.5	33.5	6	6	7.5	5.5	6	31
6	6	6.5	5.5	7.5	7.5	8	35	7.5	7.5	8	8.5	7.5	39	8.5	9	8	8	8.5	42	7.5	8	8	7.5	8	39	6.5	6.5	7.5	6.5	6.5	33.5	6	6	8	6	6	32
	Total	38	32	44	44	46	204	42	40	46	47	47	222	50	53	49	51	52	255	45	48	47	47	49	236	40	42	46	40	40	208	36	38	45	36	37	192

A - Appearance, C - Colour, F - Flavour, T - Taste, O - Over-all acceptability

*- The values are the average of two replications

Appendix - G

Sensory score of fresh and stored fermented amylase extract enzyme banana beverages

Fresh fermented amylase extract enzyme banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	6.5	6	8	8	8	36.5	8	7.5	7	7.5	7	37	7.5	8.5	8	8.5	8	37	7.5	8	8	8.5	8	40	6.5	6.5	6.5	7.5	7.5	34.5	6.5	6.5	6.5	7	7	33.5
2	2	6.5	5.5	7.5	7	7.5	34	8	7	6.5	7.5	6.5	35.5	7.5	8.5	8	8.5	8	40.5	6.5	7.5	6.5	7.5	7.5	35.5	6.5	6.5	6	7	7.5	33.5	6	6.5	6.5	7.5	6.5	33
3	3	6	5	7.5	7	7.5	33	8	7	7	7.5	7	36.5	7.5	8	8	8	8.5	40	6.5	6	8	7.5	7.5	35.5	7	6.5	6.5	7.5	8	35.5	6.5	6	6	7	6.5	32
4	4	6.5	5.5	7.5	7	8	34.5	8	6.5	6.5	7.5	6.5	35	7.5	8	8	8	8.5	40	7.5	8	8	8	8.5	40	6.5	7	6	7.5	7.5	34.5	6	6	6	7	6.5	31.5
5	5	6	5	7.5	7	7	32.5	7.5	6.5	7	8	6.5	35.5	7.5	8	8	8	8	39.5	7.5	8.5	8	8	8	40	7	7	6	8	8	36	6.5	6.5	6	7	6.5	32.5
6	6	6.5	5	8	8	8	35.5	8.5	7.5	7	8	7.5	38.5	7.5	8	8	8	8	39.5	7.5	7.5	8	8	8	39	6.5	6.5	6.5	7	7.5	34	6.5	6.5	6	7	6	32
	Total	38	32	46	44	46	206	48	42	41	46	41	218	45	49	48	49	49	240	43	47	47	48	48	231.5	40	40	37.5	44	46	207.5	38	38	37	43	39	194

Stored fermented amylase extract enzyme banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	6.5	6	7.5	7	7	34	8	7	6.5	7.5	6.5	35.5	7.5	7.5	7.5	8	8	38.5	7.5	8	7.5	8	7	38	6.5	6	6.5	7	6.5	32.5	6	6	5.5	6.5	6	30
2	2	6	6	7	7	6.5	32.5	7.5	6.5	6	7.5	6.5	34	7.5	7.5	8	8.5	8.5	40	6.5	7	7.5	7.5	6.5	35	6	6	7	7	6	32	5.5	6	5.5	6	6	29
3	3	7	5.5	6.5	7	6	32	7.5	6.5	6.5	7.5	6.5	34.5	7	8	7.5	8	8.5	39	6.5	7.5	7.5	8	6.5	36	6.5	5.5	6.5	6.5	6	31	5.5	5.5	5.5	6.5	6	29
4	4	7	5.5	7.5	7	6.5	33.5	8	6.5	6	7	6.5	34	7	8	7.5	8	8	38.5	7	8.5	7.5	8	7	38	5.5	6.5	6	7	6	31	6	6	5	6	6	29
5	5	5.5	5.5	6.5	7	6	30.5	7	6.5	6	7	5.5	32	7	7.5	8	8	8	38.5	7	8.5	7.5	8	7	38	6.5	6	7	7	6	32.5	5.5	6.5	5	6.5	6.5	30
6	6	6.5	5.5	7.5	7.5	6.5	33.5	8	7	6	7	6.5	34.5	7	7.5	7	7.5	8	37	6.5	7	7.5	8.5	7	36.5	6.5	6	7	7	6	32.5	5.5	6	5.5	6.5	6	29.5
	Total	39	34	43	43	39	196	46	40	37	44	38	205	43	46	46	48	49	232	41	46.5	45	48	41	222	37.5	36	40	41.5	36.5	192	34	36	32	38	37	176

A - Appearance, C - Colour, F - Flavour, T - Taste, O - Over-all acceptability

*- The values are the average of two replications

Appendix - H

Sensory score of fresh and stored fermented α-amylase enzyme banana beverages

Fresh fermented α-amylase enzyme banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	6	5.5	6.5	7.5	6.5	32	7	6.5	7.5	7.5	7.5	36	7	8	8	8	8.5	39.5	7	7	6.5	7	7.5	35	6	6	5.5	6	6	29.5	6.5	6.5	5.5	6	6	30.5
2	2	6	5.5	7	7.5	6.5	32.5	6.5	6.5	7.5	7	7	34.5	7	7.5	8	8	8.5	39	7	6	7	8	7	35	6.5	6	5.5	6.5	6	30.5	6.5	6	5.5	6	6	30
3	3	6.5	6	7.5	7.5	7.5	35	6.5	6	6.5	7.5	7	33.5	6.5	7	7.5	7.5	7.5	36	7	7	6.5	7	7	34.5	6	6	5.5	6	5.5	29	6.5	6	5.5	6	6	30
4	4	6	5.5	7	7.5	7	33	7	6.5	7	7	7	34.5	7.5	8	8	7.5	8.5	39.5	7	6.5	7	8	7	35.5	6.5	6.5	5.5	6.5	6	31	6	6	5.5	6	6	29.5
5	5	6	6	7.5	7.5	7	34	6.5	7	6.5	7.5	7	34.5	7	7.5	8	7.5	8	38	6.5	6.5	6.5	7	7	33.5	6.5	6.5	5.5	6.5	6.5	31.5	6.5	6.5	5.5	6	6	30.5
6	6	6	6	7.5	7.5	7	34	7	7.5	7	7	7.5	36	7	7	7.5	7.5	7.5	36.5	7.5	7	7	7.5	7.5	36.5	6.5	6	5.5	6.5	6	30.5	6	6	5.5	6	6	29.5
	Total	37	35	43	45	42	200	41	40	42	44	43	208	42	45	47	46	48	228	42	40	41	45	43	210	38	37	33	38	36	182	38	37	33	36	36	180

Stored fermented α-amylase enzyme banana beverages

S. No.	Panelists	1:2:0.5 Ratio						1:2:0.25 Ratio						1:4:0.83 Ratio						1:4:0.41 Ratio						1:6:1.16 Ratio						1:6:0.58 Ratio					
		A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total	A	C	F	T	O	Total
1	1	6.5	5.5	7	6.5	6	31.5	6.5	6	7	7	5.5	32	6.5	7	7	7.5	8	36	6.5	5	7	6.5	7.5	32.5	5.5	5.5	5.5	5	5	26.5	5.5	5.5	5	5.5	5	26.5
2	2	6	6	7	6	5.5	30.5	5.5	5.5	7	6.5	5.5	30	6.5	7	6.5	7	7	34	6.5	5.5	7	6.5	7.5	33	5.5	5	6	5.5	6	28	6	5.5	5.5	5.5	5	27.5
3	3	6	5	7	6	5.5	29.5	6	6	7	6.5	5.5	31	7	7	7	7.5	8	36.5	6.5	5	7	6.5	7	32	5.5	6	6	5	5.5	28	5.5	5	5	5.5	5	26
4	4	6.5	5.5	7	7	6	32	6.5	6	7	7	5.5	32	7	7	6.5	7	7.5	35	56	5.5	7	6.5	7	82	5.5	5	6	5.5	5	27	5	5.5	5	5.5	5	26
5	5	6.5	5.5	7	6.5	5.5	31	6	5.5	6.5	7	5.5	30.5	7.5	7.5	7	7.5	8	37.5	6	5.5	7.5	7	7	33	5.5	5.5	6	6	5.5	28.5	5	5.5	5	5.5	5	26
6	6	6.5	6	6.5	7	5.5	31.5	5.5	5.5	7	7	5.5	30.5	7.5	7.5	7.5	7.5	8	38	6.5	5.5	7.5	7	7	33.5	5.5	6	6	5.5	5.5	28.5	6	6	5.5	5.5	5	28
	Total	38	34	42	39	34	186	36	35	42	41	33	186	42	43	42	44	47	217	38	32	43	40	43	196	33	33	35.5	32.5	32.5	166	33	33	31	33	30	160

A - Appearance, C - Colour, F - Flavour, T - Taste, O - Over-all acceptability

*- The values are the average of two replications

APPENDIX - I

Sample cost **analysis for 1:2** ratio **of banana beverage**

1. Capacity : 1 t/day

2. Number of days : 250

Financial brek-up

It is assumed that the entrepreneur shall invest 25 percent of the total investment. The break up of financial requirement is;

A) Fixed Capital

i) Cost of machinery and equipment, Rs. (Table 1)	1486000.00
ii) Installation charges @ 10 per cent, Rs.	148600.00
iii) Cost of land (1000 m^2) @ 200 Rs/m^2, Rs.	200000.00
iv) Building cost shall be assumed as 40 per cent of the equipment cost, Rs.	594400.00
Total	Rs.2429000.00
B) Working capital for 30 days, Rs. (Table 2, 3)	426300.00
C) Instrumentation Assuming the instrument cost 12 per cent of equipment cost, Rs.	178320.00
D) Contingencies Contingencies factor may be assumed as 10 per cent of equipment cost, Rs.	148600.00
E) Total capital investment (A+B+C+D), Rs.	3182220.00
F) Capital to be taken as loan (75 per cent of total capital), Rs.	2432790.00
Capital share of entrepreneur (Unpaid interest 16 per cent), Rs.	810930.00

COST ANALYSIS

A. Annual fixed cost

i) Depreciation @ 10 per cent of equipment cost, Rs.	148600.00
ii) Depreciation @ 5 per cent of building cost, Rs.	29720.00
iii) Insurance	
(a) @ 2 per cent of building cost, Rs.	11888.00
(b) @2 per cent on equipment cost, Rs.	29720.00
iv) Interest @ 17.5 per cent on total capital investment, Rs.	567651.00
v) Repairs and maintenanace @ 5 per cent of equipment cost, Rs.	74300.00
Total annual fixed cost, Rs.	861897.00

B. Variable cost (Rs. / year basis)

i)Raw material cost for 250 days @ Rs. 12160.00/ day, Rs.(Table 2)	4157125.00
ii) Management and labour wages for 12 months @ 61,500/ month, Rs. (Table 5.2)	738000.00
iii) Electricity charges @ Rs. 2400/30 days, Rs.	20000.00
iv) Water charges @ Rs. 3000/30days, Rs.	25000.00
v) Other charges (land, lease and miscellaneous) @ Rs. 500/30 days, Rs.	5000.00
vi) Publicity / advertising and marketing cost @ Rs. 0.50/kg of product, Rs.	329125.00
Total annual variable cost, Rs.	4157125.00

C) Total cost (A+B), Rs.	5019022.00
Cost / kg product (for 386515 kg),Rs.	12.98 say 13.00

D) Ex-factory price of product per kg, Rs. (assuming 15 per cent profit margin) 14.95 say 15.00

E) Total sales revenue/ year, Rs. 5797725.00

F) Cost of by product

(a) Peel @ 4 Rs./kg (For 9460 kg/year), Rs. 37840.00

(b) Pellet @ 4 Rs./kg (For 38792.5 kg/year), Rs. 155170.00

Cost of total product sold in the market, Rs. 5797725+193010= 5090735.00

G) Gross profit, Rs. = Total cost of product - Total cost

= 971713.00

G) Net profit, Rs. 485856.50
(Assuming 50 per cent income tax)

$$\text{Return on investment} = \frac{\text{Net profit}}{\text{Capital invetsment}}$$

= 14.97%

$$\text{Pay back period} = \frac{\text{Capital invetsment}}{\text{Net profit} + \text{Depreciation} + \text{Unpaid interest}}$$

= 2.19 years

I) Break- even point (BEP)

1. In terms of production in kg/year

$$\frac{\text{Annual fixed cost}}{\text{Weighted unit sales price} - \text{Weighted unit variable cost}}$$

= 2509511.00

2. In terms of no. of days of production @1000 kg/day = 250.9511 days/year

3. At BEP, the sales revenue, Rs. 3764266500.00

Table: 1 Equipment/ machinery requirement for banana beverage 1:2 Ratio

S. No.	Equipment	Capacity	Unit required (No.)	Price (Rs.)
1	Blender	100 kg/h	1	3000.00
2	Centrifuge	50 lit/h	2	1100000.00
3	Oven	Temp. range 200-260° C, 27m^3	2	34000.00
4	Weighing balance	0-200 kg	1	1000.00
5	Auto clove	500 X300 mm	2	52000.00
6	Refrigeration unit		1	50000.00
7	Pasteurization unit		1	100000.00
8	Incubator	Stainless steel 27 m	2	17000.00
9	Bottling plant		1	100000.00
10	Miscellaneous			20000.00
				Total Rs. 1486000.00

Table: 2 Daily requirement of raw material

S. No.	Raw material	Quantity (kg)	Rate (Rs.)	Price(Rs.)
1	Banana	1020	8.00	8160.00
2	Miscellaneous			4000.00
				Total Rs. 12160.00

Table: 3 Management and labour wages per month

S. No.	Personnel	No.	Pay per head (Rs.)	Amount (Rs.)
1	Production manager	1	15000.00	15000.00
2	Food process engineer	1	8000.00	8000.00
3	food chemist	1	6000.00	6000.00
4	Mechanic	1	4000.00	4000.00
5	Skilled labour	3	2500.00	7500.00
6	Unskilled labour	3	2000.00	6000.00
7	Store keeper	1	3000.00	3000.00
8	Clerk	2	3000.00	6000.00
9	Security guards	3	2000.00	6000.00
				Total Rs. 61500.00