PRODUCT DEVELOPMENT AND SHELF-LIFE EVALUVATION OF TAMARIND PASTE

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Declaration

The project work described in this thesis was carried out by me at Cathy Rich memorial Food Processing Training Centre, Yodhagama, Embilipitiya and Faculty Of Applied Sciences, Sabaragamuwa University Of Sri Lanka, under the supervision of Dr.K.K.D.S.Ranaweera and Mr. C.Edirisinghe.

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AFFECTIONATELY

DEDICATED TO

MY

EVER LOVING PARENTS

AND

TEACHERS

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ABSTRACT

Tamarind tree is a well-known tree and grows all over the Sri Lanka. As the tamarind tree is very large, there is a tendency for incomplete harvesting from the ground. The tree bear profusely and there is a glut of tamarind during the season, which is short. Part of which goes waste, and a scarcity during the greater part of the year. Shelled tamarind is quite 'wet'. In the retail outlets the material is heaped exposed. This mode of presentation in the exposed form results in the collection of dirt and dust and of course microbial contamination. As a result the product is clearly unhygienic. In the average household tamarind pulp is obtained via cold water extraction and squeezing by hand. This process is inconvenient, wasteful and time consuming. A study was carried out to prepare a value-added product that is the best tamarind paste formula with extended shelf life. At the same time we check the effect of packaging material type of raw material on its shelf life.

In two occasions, consumer idea was known for the paste development. A preliminary study was conducted to identify the consumer's preference for the paste recipe, other sensory characteristics of the paste and its packaging materials. Four tamarind paste formulae were prepared by changing the amount of the ingredient levels. In the second occasion a sensory evaluation was done with 30 judge for the selection of the best paste sample. But there is no significant different at 5 % level between paste samples. However, one best paste sample was selected by using mean score. Studies on the shelf – life revealed that product can be kept for more than 3 months At the same time, there was no effect by the types raw materials and packaging materials on the shelf life over 3 months. However further studies are recommended to carry out to investigate the actual shelf life of the product.

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CHAPTER 1

INTRODUCTION

1.1 Introduction to the study

Tamarind is an arboreal fruit of *Tamarindus indica* Linn, which belongs to the family Leguminosae or Caesalpiniaceae.Though every part of it is useful, the fruit is the most important part, which is a popular acidulant, used in the preparation of oriental dishes. It is used specially in cooking meat. In Sri Lanka, there is a special preference among the Tamil communities for tamarind over other commodities like **Goraka** (*Garcina gambogia*) and lime (*Citrus aurantifolia*).

Tamarind is the most acidic among all natural food fruits and contains a rather uncommon plant acid, tartaric acid (2,3-dihydroxybutanedioic acid / $C_4H_6O_6$), which has no nutritive value, but taste. Tartaric acid is the chief acid in the fruit and its content varies from 14-18%. In addition to tartaric acid, Potassium hydrogen tartarate and malic acid are also present. Other acids, lactic, oxalic, succinic, citric, quinic and unsaturated acids have also been found in small amount.

The fruit pulp contains mainly tartaric acid, reducing sugars, pectin, tannin, fibre, cellulosic material and polyphenols, which give the fruit a unique taste.

Tamarind fruit has been used as a raw material for the manufacture of several products. Tamarind pulp is the chief agent for souring food products like sauces, Chutneys, **Sambar**, **Rasam** and several other beverages. The fruit pulp is the important portion for the manufacture of tamarind band products such as tamarind pulp concentrate, tamarind paste, pulp powder, tartaric acid, tartarates, soft drinks etc.

In recent times, the demand for tamarind and tamarind-based products like drinks, jams and confectionery has been increased, hence there is a potential of producing a vast rang of products. Although it has been in commercial demand, there has been no research to improve the tamarind as a crop plant.

Despite the increasing demand for tamarind based products at the market, only a few research and development programs with yet established to improve the tamarind plant and its products.

Since the market potential extends locally and internationally, and the products developed by other countries are very competitive in terms of texture, stability, microbial quality, natural organoleptic properties of tamarind etc. The present investigations was carried out to develop a tamarind paste with improved quality and extended shelf life.

There for studies were carried out at the Cathy Rich, Food processing Training center, Yodhagamma, Embilipitiya to develop the methods for raw material (tamarind) to produce tamarind paste with extended shelf- life. But shelf – life evaluation practical were done in our faculty laboratory.

1.2 Objectives of the study

Major objectives:

1. Preliminary market survey about tamarind paste
2. To develop a Tamarind paste.
3. To extend the shelf life of the product.

Minor objectives:

1. To study the effect of packaging material on shelf life.
2. To study the effect of raw materials on the shelf life.

CHAPTER 2

LITERATURE REVIEW

2.1 Tamarind

2.1.1 Origin and distribution

Tamarind (*Tamarindus indica* L) is an economically important tree, which is found throughout the tropics and subtropics and has been naturalized at many places. The tree is indigenous to tropical Africa (Duke, 1981).

It is highly cross-pollinated crop and hence wide variability is common in this species. Plant breeding and selection programs need to be improving the quality, yield and earliness of fruiting (Geetha 1995,Saideswara Rao 1995).

Tamarind tree is found in the "dry" and arid zones of Sri Lanka being the highest concentrated distribution in the northwestern province (Duke, 1981).

Its lifespan is long and the average yield of tamarind is 80-90 kg of prepared pulp per tree. From 100 tree/ha, each yielding 100kg, 10 MT pulp/ha is possible (Duke, 1981).

2.1.2 Varieties

There are only a few varieties of tamarind grown in Sri Lanka. Some are less acidic (sweetish) and some are more acidic to taste and the colour of the pulp is usually brownish-red in the common variety and reddish in the so-called red variety. The red variety is not economically important, as it is not produced on a commercial scale. But, the red variety fetches better price and is preferred for the making preserves. Some of the improved varieties are grown in India (Geetha 1995,Saideswara Rao 1995).

2.1.3 Climatic requirement

The tree is not exacting as regards the soil in the places it has become naturalized even in rocky land. It however, thrives best on the deep alluvium. The tree generally prefers a warm climate and can withstand drought, but is sensitive to frost. Its strong, supple branches are little affected by wind, and it is known as a hurricane-resistant tree.

2.1.4 Fruiting

In tamarind foliage changes in March to April, flowering takes place in May to June and the fruits are available in February to March. A seedling tree will take 13-14 years for first flowering but a vegetatively propagated plant is precocious and comes into bearing in 7 to 10 years. As tree grows in size and age, productivity increases and continues to be productive for more than 60 years (Hanson and Ijas, 1972).

2.1.5 Harvesting

Fruiting generally mature in February to March in which exocarp gets hardened and separated from the pulp. Fruits are plucked individually or shaken off and collected-when harvested the fruits are almost semi-dried and do not spoil due to the high acidity. A fully developed tree can give production of 200 to 250 kg per annum (The wealth of India raw materials , 1976).

2.1.6 Post-harvest handling

After harvest the fruits are allowed to dry and their hard shell is removed. Such fruits are marketed. Some times the seeds are also are taken out and fruits are made into tamarind balls and marketed. Curing, processing and handling standards are required to be standardized. Tamarind pulp is also exported to Europe and America for preparing chutney and meat, sauces. Under ordinary conditions the pulp remains good for about a year provided it is kept in dry condition (Hanson and Ijas, 1972).

2.1.7 Description of fruit

The fruits are most important part of plant. They are straight or curved, brown, 5-18cm long and 1.5-2.25cm wide. They are somewhat flattened, constricted at intervals, with a thin brittle shell, containing a soft brownish or red pulp. The pods contain 3-12 seeds, which are ovate-oblong (1.5*0.8cm), glossy and smooth, flattened, brownish-ash in colour. The seeds are contained in loculi, enveloped by a tough, leathery membrane, the so-called endocarp. Outside the endocarp is the light brownish, red, sweetish, acidic edible pulp, traversed by a number of branched ligneous stands. The outer most covering of the pod (shell) is fragile and easily separable (The wealth of India 1976: Duke 1981).

2.1.8 Chemistry of fruit

On an average, the pod is composed of

Shell	15-25%
Pulp (flesh)	45-55%
Seeds	25-35%

Fiber 10-15%

The seed contains testa (seeds coat) and kernel(endosperm).In seed

Testa 25-30%

Kernel 70-75%

The fruit pulp contains mainly tartaric acid, reducing sugars, pectin, tannin, fiber and cellulosic material (J.Food Sci. Tecnol, 1998, Vol. 35, No. 3,Pg. 194) Table 2.1 shows the composition of edible portion of ripe fruit/ pod of tamarind.

Table 2.1. Composition of edible portion of ripe fruit/ pod of tamarind.

Constituent	**Percentage**
Moisture	62.50-69.20
Proteins	1.40-3.30
Fat/oil	0.27-0.81
Sugars, total	21.40-30.85
Sucrose	0.10-0.80
Cellulose	1.80-3.20
Ash	1.20-1.72
Tartaric acid, total	8.40-12.40
Total acidity, as tartaric Acid	17.10-18.40
pH	3.15
Pentose	4.20-4.80

Source:Duke(1981)

The edible portion of the ripe pod, before harvest, contains

Moisture 63.3%-68.6%,

Tartaric acid 8.4%-12.4%

Sugars 23%-30% and

pH around 3.15

But in dried pulp of commerce contains

Moisture	15%-30%,
Tartaric acid	18%
Sugars	25%-40%

Of the reducing sugars present, about 70% is glucose and 30%fructose.

Nearly 50% of the tartaric acid is in the combined form mainly as potassium bitartarate and to a small extent as Calcium tartarate, which is insoluble in cold water. There for, cold water extract of the pulp contains only a part of the available tartaric acid and hence hot water is to be used to extract the total acids in the pulp (J.Food Sci. Tecnol, 1998, Vol. 35, No. 3,Pg. 194).

About 2% of other acids are present in the pulp. There are as follow.

Malic acid
Oxalic acid
Succinic acid
Citric acid and
Quinic acid.
In which Malic acid is predominant. (The W ealth of India, 1976).

The tender fruits contain most of the tartaric acid in free form (unto 16%), which can be easily extracted with water. Unlike in other fruits, ripening in tamarind fruit is not accompanied by a decrease in acid content. But sweet taste during the process of ripening is accumulation of 30%-40% reducing sugars in the harvest fruit due to formation and breakdown of starch in a short period.(The wealth of India 1976; Lewis and Neelakantan 1964).

1.1.9 Formation of tartaric acid

Tartaric acid is an unusual plant acid. which perhaps is formed from the primary carbohydrate products of photosynthesis and once formed cannot be used further in the plant because of the absence of necessary enzymes.

The titrable acidity is low in young leaves, but increases with age and again comes down in old leaves. The total tartaric acid content in leaves decreases from 28 to 12% from May to December and the free tartaric acid disappears after the first three months and the alkalinity of the ash increases rapidly due to absorption of the Calcium and Potassium, which neutralizes the acid. Simultaneously, there is a shift in the pH of the leaf sap from 2.3 to 4.1% (Lewis and Neelakantan 1959, Lewis et al.1957).

Since oxaloacetate is the only tricarboxylic acid cycle intermediate found to be slowly oxidised by young tamarind leaves in respiratory studies, Ramakrishnan and Joshi (1960) have suggested that sugar gets converted to oxaloacetate through the operation of the tricarboxylic acid cycle enzymes and that oxaloacetate gets converted to tartrate via dihydroxyfumarate. In old leaves, the rate of oxidation for all intermediates is low, which suggests a general slow down of metabolism. Both young and old fruits oxidize all intermediates suggesting that the site of tartaric acid formation is in the leaves and the acids gets translocated to the fruits(J.Food Sci. Tecnol, 1998, Vol. 35, No. 3,Pg. 195).

Tartaric dehydrogenase is active only towards 1-tartaric acid and not dextro-and meso-form to dextro-form. The inability of dehydrogenase to attack dextro-tartaric acid is considered to be responsible for the accumulation of dextro-tartaric acid in fruits and leaves. (Lewis and Neelakantan 1964).

2.1.10 Acidity of tamarind

The so- called red variety of tamarind is sweeter than the common brown variety, evidently because it has a lower content of free acid. In the red variety, the acid is present in the combined form mostly as Potassium bitartrate and to a small extent as Calcium tartrate. The common variety has high proportion of free acid and less pectin content as compared to the red variety. An analysis of the pulp from red and common varieties should respectively, the following values:

Moisture	20.1 , 18.2 ;
Tartaric acid (free)	6.6 , 9.8 ;
Tartaric acid (combined)	11.4 , 6.7 ;
Invert sugars	36.4 , 38.2 ; and
Pectin	4.4 , 2.4% (The wealth of India 1976)

2.1.11 Tartaric Acid

Tartaric acid (2,3-dihydroxybutanedioic acid) $C_4H_6O_6$ is a dihydroxydicarboxylic acid with two chiral centres. It exists as the dextro-and levo-rotatory acid, the meso form (which is inactive owing to internal compensation) and the racenic mixtures. Tartaric acid that is present in tamarind and grape fruits is the natural, dextro-rotatory form L(+) tartaric acid, m.p 169-170°C, mol. Wt. 150.086 ; solubility 139g/100g water at 20°C; solubility of acid Potassium salt 0.84g/100g water at 25°C; solubility of Calcium salt 0.02g/100g water and it has four molecules of water in hydrate of Calcium salt.

The estimated total worldwide market (1991) for tartaric acid was 58000 tons and potassium bitartarate (acid basis) was 2000 tons(J.Food Sci. Tecnol, 1998, Vol. 35, No. 3,Pg. 195).

The consumption of tartaric acid is represented as follows.

Beverages (alcoholic)	30%
Emulsifiers	20%
Pharmaceuticals	15%
Foods	10%
Textiles	10%
Electro-Chemicals	10% and
Others	5%

(Source: Kirk-Othmer Encyclopedia 1995)

Potassium bitartarate (Cream of tartar) is primarily used in baking powders and mixes.

2.1.12 Colour of the tamarind pulp

During storage, the brownish-red coloured pulp becomes darker and after about a year , is almost black. This is perhaps due to the onset of Maillard reaction,since free amino acids and reducing sugars are present in the pulp.The anthocyanin pigment. chrysanthemin is responsible for the colour of the pulp in the red variety of tamarind and the common

variety contains leucocyanidin. The fruits have low content of anthoxanthin pigments lutein and apigenin.(Lewis et.al.1957:Lewis and Johar 1956; Lewis and Neelakantan 1962).

2.1.13 Flavour of tamarind pulp:

The chemical composition of tamarind pulp flavour depends on the method of extraction, raw pulp used and the method of analysis. This is the reason why different workers have given different versions of the flavour composition.

Lee et al. who identified 61 compounds first studied the volatile constituents of the fruits. The major constituents identified were hexanol, cis-3-hexen-1-ol, trans-2-hexen-1-ol, trans and cis-linalool oxides, 2-acetyl furan, benzaldehyde, linlool,4-terpineol,phenylacetaldehyde, alpha-terpineol,2-phenyl ethyl alcohol,dibutylphthalate and geraniol. Among which 2-acetylfuran was most abundant. These authors reported that this compound together with the minor constituents furfural and 5-methylfurfural appeared to contribute significantly to the overall aroma of tamarind.

Zhang and Ho, (1990) isolated the volatiles of tamarind pulp by simultaneous-steam distillation/ solvent extraction and analyzed by GC-MS. A total of 28 compounds were identified with furfural (123ppm); 5-methyl-2 (3H)furanone(10.61 ppm), phenyl acetaldehyde (10.11ppm) and 5-methyl furfural(8.60ppm) accounting for 88.74% of the total volatile (J.Food Sci. Tecnol, 1998, Vol. 35, No. 3,Pg. 195).

2.1.14 Medicinal value of the fruit

Tamarind has many curative values. The pulp is a cooling laxative and also a carminative; it is largely used in home remedies.

The unripe fruit is highly acidic. The ripe fruit a year or two old is used with other ingredients for jaundice or for lack of tension in the liver.

There are many decoctions in which tamarind is used as the basic ingredient, specially for habitual constipation and also for diarrhoea. It is given as a drink for intoxication.

A half-ounce of tamarind juice is given to correct bilious disorders.

A cooling drink called " Amlika pana" is prepared with tamarind. Boil one ounce of tamarind pulp in a quart of milk and add a few dates. Strain the liquid and add cloves, cardamom, pepper, and a little camphor to taste.

The drink is taken for inflammatory disorders such as fever, gastric affections, dysentery and loss of appetite. It is very effective to take tamarind pulp mashed and soaked in water and strained for sunstroke (Jawaweera, 1981)

2.1.15 Food value of fruit

Fruits are rich source of sugars, and an excellent source of B vitamins. A much higher Ca and P content than Oranges. High in iron and therefore useful in preventing anaemia. Contain small amounts of Vitamin C, and moderate amounts of Vitamin A (About the same as Oranges)

Seeds about as high in food value as maize or wheat, with about 63% starch, 16% protein and 5.55 oil, small amounts of sugar(Food and Agriculture Organization of the United Nations, Rame, 1988).

2.2 General characteristics of tamarind pulp

General characteristics

1. The tamarind pulp shall have been obtained from the mature fruits of *Tamarindus indica* by removing first the rind and then the fibrous skeleton enclosing the pulp and seeds
2. The pulp shall be well dried and compressed into cakes.
3. The pulp shall be free from insect infection or live insects, mold, rodent contamination and deleterious substances
4. In case of red to tinged brown colour tamarind, the colour of the cake shall be light red to tinged brown and, for black colour or mixed colour tamarind, the colour of the cake shall be light to dark black or mixture of light red to tinged brown and black colours or vice versa

(Source: Internet http://www.samexagency.com/tamar.html).

2.3 Grade designations and definition of quality of Dried Tamarind.

Table 2.2 Grade designations and definition of quality of Dried Tamarind

Special characteristics					
Trace name	Grade designation	Moisture percent by wgt	Seed content percent by wgt	Foreign Matter By Weight	
				Organic	Inorganic
Light red to tinged brown colour	Special	15.0	5.0	4.0	1.0
Black colour or mixed colour	Special	15.0	4.0	4.0	1.0

(Source:Internet http://www.samexagency.com/tamar.html).

2.4 Technology

2.4.1 Pulp preservation

The fruits are gathered when fully ripe and the brittle and hard pod shell is separated either manually or mechanically. Generally it is separated by manually

The fruit pulp is separated from the seeds and fibrous material and dried in the sun for a few days to reduce the moisture content. Then dried pulp is packed in leaf mats, Polyethylene, or jute bags or bamboo or wooden boxes and stored in a cool and dry place.
In some places, the salted (10%) pulp is trodden into a mass and made into balls as in picture x and exposed to the sun or steamed for a sort time and then exposed to the sun and dew for about a week.(The wealth of India, 1976).

Various methods of prolonging the storage life of whole and pulped tamarind were investigated by Chumsai-Silvanich el at (1991). For whole tamarind, steaming for five minutes followed by drying in a hot air oven at 80°C for 2 hours proved to be the most suitable method and the resultant fruits could be stored in plastic bags at room temperature for four months without affecting quality and acceptability. For pulped tamarind, after removal of peel, veins and any unwanted part, steaming for twenty minutes, followed by drying at 60°C for 2.5 hours, cooling and packaging in clear plastic bags gave the best results. The products could be stored at room temperature for three months with satisfactory quality and acceptability. (J.Food Sci.Technol,1998, vol 35,No3,193-208)

An improved procedure for extracting and preserving tamarind pulp is outlined by Benero et al (1972). Tamarind pulp can not be separated from the fruit by mechanical means alone, dilution being necessary. A 1:2 fruit: water ratio produced the highest yields of soluble and total solids. Pulps obtained at this dilution had about 13.2° Brix with excellent fruit flavour. (J.Food Sci,Technol,1998,vol.35,No3,Pg. 200). But in industrial level 1:1 Fruit : water ratio is used to extract the pulp from fruit (R.K.Guptha, 1993.)

The proportions of weights of pulp, seeds and shells in ripe tamarind fruit for processing were found to be 30,40,and30%. This mechanical extraction method for unpeeled tamarind fruits produced high quality tamarind fruit pulps with prolonged shelf life. A water-alcohol extract of tamarind having a pH of 2.0-3.5 and 80% solids has replaced the whole, shelled fruit formely shipped in 500 lb. wooden barrels. (Annon, 1969).

Drying is a good way to store and preserve small amounts of tamarind pulp. (Camphell 1983).
There is a technology to produce block-like cheese pulp. Mixing the shelled tamarind fruits with minimum amount of water and passing through a pulper removes residual seeds. fiber and cellulosic material. Drum drying of this soft homogeneous pulp and compressing it in molds gives block-like cheeses (Lewis and Neelakanthan,1964).

2.4.2 Products from tamarind fruit

Although all the parts of tamarind is useful, the following section will deal with products of tamarind fruit specially food products.

Tamarind fruit has been used as a raw material for the manufacture of several products like Tamarind juice concentrate (TJC), Tamarind pulp powder (TPP), Tamarind kernel powder(TKP), Tartaric acid, pectin, tartrates and alcohol. The yields of which are presented in table 2.4.

Table 2.3 List of products from tamarind fruit.

Product	Yield %
Tamarind juice concentrate (TJC)	75-80
Tamarind pulp powder (TPP)	80-85
Tamarind kernel powder (TKP)	55-65
Tartaric acid (TA)	8-10
Pectin	2-3.5
Tartrates	10-12
Alcohol	10-13

(Source: The wealth of India:Lewis et al (1964)).

The following sections will deal with technology of some important products.

2.4.2.1 Tamarind juice concentrate (TJC)

Extracting the tamarind pulp in boiling water and concentrating the filtered extract under vacuum, to jam-like consistency makes tamarind juice concentrate. It is then filled in 100 gm and 250 gm glass jars and bulk packs.(R.K.Gupta, 1998)

The process for the manufacture of tamarind concentrate has been developed by the Central Food Technological research Institute, (CFTRI) Mysore and several films are producing the concentrate on commercial scale. (Anon. 1982).

A process for extraction, concentration and preservation of sour principles from the fruits of tamarind was patented by Pillai(1973). The sour principle is extracted with hot water, filtered, clarified by bleaching with SO_2 and then evaporated in vacuum to required consistency and treated with vinegar or acetic acid (2%) to provide a storage stable extract (J.food sci. Tec 1998 vol 35, No3, pg 202).

Tamarind juice concentrate (TCJ) is a convenience product and it is easy to disperse and reconstitute well in hot water. The concentrate is hygienic and cam be stored well for longer periods.(J.food sci,Technol,1998,vol 35, No3, pg 201).

It contains the mellow flavoured Potassium acid in the tamarind fruit.(R.K.Guptha, 1998).

Jaleel et al (1990) used fungal pectic enzyme for the production of tamarind concentrate. The pulp was extracted with hot water, followed by squeezing through cloth. Pectin enzyme concentrate (PEC) was used for depectinising the pulp. After 15 hours of reaction time, the juice was expressed. Treatment with PEC gave a clear juice, which on concentration gave an acceptable non-viscous and free-flowing product. From 5kg pulp, 3.46kg of free- flowing concentrate was obtained with following characteristics: Brix 75^0, acidity 18.1/5 and pH 2.0.(J Food Sci Technol, 1998, Vol. 35, No 3, Pg 202).

2.4.2.2 Beverage

Beverages containing the extract with a lower pH have improved shelf life. Tamarind fruit can be used as a raw material for the preparation of wine-like beverages (Benk 1987; Latino and Vega 1986; Sanchez, 1985).

Tamarind drinks with 9-12% pulp concentration and 21.5^0 Brix and soursoptamarind blended drinks at 185- 190^0 F, canned and stored at 85^0F. Canned tamarind drinks kept well for 1 year and blended drinks for about 10 months blended drinks of 17^0 Brix, being in terms of acceptability. Alian et al (1983) has studied the bacteriostatic effect of tamarind extract. Ethanol extract from tamarind was the most effective inhibitor against all tested organisms in soft drinks (J.Food Sci Technol 1998, Vol. 35, No. 3. Pg 202)

2.4.2.3 Jujubes

Jujubes are prepared from tamarind seed jellose. The jellose is an excellent substitute for fruit pectin in the manufacture of jams, jellies and marmalades too. Because it forms gels with sugar concentrates as do fruit pectin. Since it don't have galacturonic acid or methyl-uronate groups, it can't be termed true pectin.

Normally in market, available by vegetarian. So production of jujubes by using jellose is important and cheaper one (Food Science,19??).

2.4.2.4 Tamarind sauce

Sauces are used to complement the flavour, texture and appearance of foods. Sauce manufactures abroad use the extract for giving an exotic flavour to some sauces like Worcestershire sauce.

There is no essential difference between sauces and ketchup. However sauces are generally thinner and contain more total solids (minimum 30%) than ketchup (minimum 28%).

Sauces are two kinds.

(1) Thin sauces of low viscosity consisting mainly of vinegar extract of following materials like herbs and spices.

(2) Thick sauces that are highly viscous.

(Source: Srivastava and Kumar, 1994)

2.4.2.5 Tamarind pulp powder(TPP)

Tamarind powder is one of the convenience food products developed from tamarind pulp. CFTRI has developed a process for the preparation of tamarind powder, which is free flowing in nature and retains its original colour and flavour characteristics for period up to 6 months. TPP composition is completely different from TJC (J.Food Sci Technol, 1998, Vol. 35, No. 3, Pg 202). Table 2.5 shows them.

Table2.4 Composition of TJC and TPP.

Constituent (%)	TJC	TPP
Moisture	30	3.5-8.8
Tartaric acid(Total)	13	8.7-11.1
Invert sugars	50	5.8-2.5
Protein	2	1.7-2.4
Starch	<1	20-41.3
Ash	<1	2.1-3.2
Crude fiber	2	-
Pectin	2	-

(source:Manjunath et.al, (1991); Nagaraja et.al, (1975)).

Among the minerals can be graded according to its characteristics such as:

Fineness

Colour

Odour

Viscosity

PH content

Moisture

Testa content

Protein

Fat

Crude fiber

Ash

Resin

(Source: Internet http://www.palanigroup.com/tkp-intro.html).

The general characteristics of good quality tamarind powder are that

(1) It will have flavouring characteristics of good tamarind pulp, when dissolved in water and will be free from burnt or any other undesirable flavour.

(2) It will have a good keeping quality and

(3) It will be free from fungal growth, live or dead insects and insect fragments (Manjunath et.al (1991).

2.4.2.6 Tamarind kernel powder

Tamarind seed has about 30% testa and 70% kernel. Testa has rich brown colour and kernel is of white colour. Testa is removed by roasting the seeds.

Kernels have ingredients like protein, crude fiber, carbohydrate ash and oil. It is learnt that minerals and carbohydrates in the tamarind kernels compare well with those of oats.
Preparation of tamarind powder is relatively simple operation. If requires decortication of seeds and pulverization of creamy white kernels.

Known uses are:
*Textile sizer.
The sizing property is due to the presence of a polysaccharide(jellose) to the extent of 60%.
*Thickner for textile printing and finessing.
*Soil stabilizer
*Briquettes.
Sawdust Briquettes for fuel have also been made by employing 20% of TKP as binder.
TKP has uses as in paper adhesiveness, explosives, plywood, match box, soap and detergent (G.Watt, 1983).

2.4.2.7 Pectin, Tartrates, tartaric acid and ethanol.

Studies about isolation of tartaric acid fermentation of sugars for useful by products like ethanol, lactic acid and citric acid were carried out (Lewis et al 1954).

Since the pulp also contains pectin, an integrated process has been worked out for the production of pectin, tartrates and ethanol from it. The pulp is repeatedly extracted with boiling water and the filtered extract is cooled to separate Potassium bitartrate. The supernatant is concentrated under vacuum and the pectin is separated by the addition of alcohol. The filtrate, after recovering alcohol is treated with lime to precipitate Calcium tartrate. The remaining sugars are fermented with yeast and alcohol is recovered. The recovery of about 2.5% pectin in addition to12% tartaric acid and 12% alcohol from tamarind pulp makes the process attractive (J.Food Sci: Technol, 1998,Vol. 35, No. 3, pg 201).

For the isolation of tartaric acid, the use of unripe green pods has been suggested, as they contain most of the acid in the free form. Krishna (1995) patented a process for the extraction of tartrates with acidified ethanol and subsequent extraction of pectin. After removal of alcohol, the residual syrup can be used for edible purposes.(Indian patent No.52, 1995).

2.4.2.8 Other products

Tender green fruits of tamarind are used to prepare tamarind pickles, as they are very acidic. The ripened fruit pulp is used in the manufacture of mixed fruit jams. The tamarind juice extract is also used in certain confectionery products like tamarind candy. (Sadasivam et al 1979; Girdharilal et al 1958; Gowramma et al 1968).

2.5 Tamarind paste

2.5.1 Importance of tamarind paste

Today's working woman, managing both the fronts-office and home, does not quite manage to extract long hours for cooking, especially from raw. At the same time, it still remains her job. So that introduction of a good quality tamarind paste helps her achieve her objective viz . a reasonably varied menu but no long slogging hours in the kitchen gains her unequivocal acceptance.

2.5.2 Tamarind paste preparation techniques

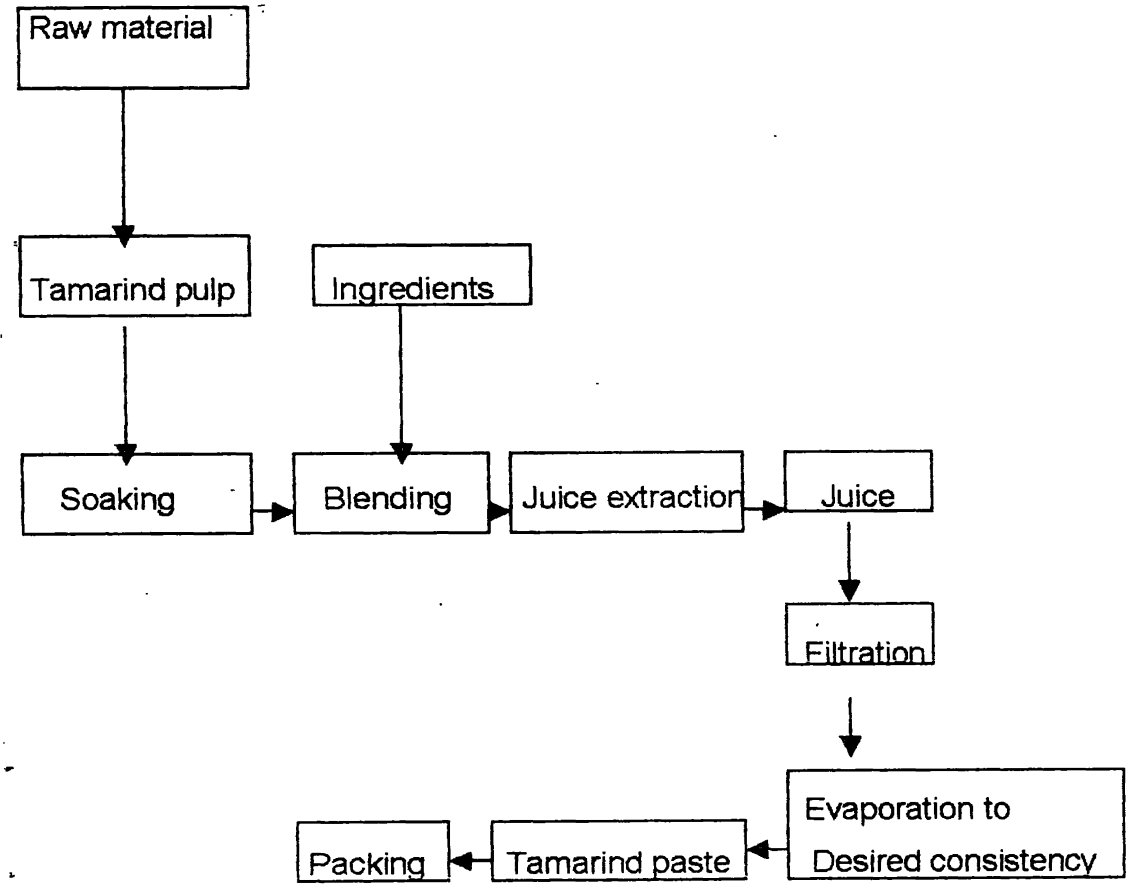
The process for production of tamarind paste is quite simple. First, the tamarind pulp is soaked in tanks specially provided for this purpose. The pulp is kept soaked for a couple of hours to sufficiently soften the pulp. This blender is poured into juice extraction kettles where the extraction of juice is carried out. This extracted juice is then filtered. The filtered

juice is evaporated to a degree of consistency. This tamarind paste is then packed in small bottles (R.K.Gupta, 1993).

Actually above method is suitable in large scale manufacturing process.

Figure 2.1 Model flow chart for product process

Model flow chart for product process



2.5.3 Commonly used ingredients and functions of them.

The chief raw material required for tamarind paste is tamarind. Other than tamarind is sugar, salt, SMS and spices.

Sugar-Colour, appearance, sucrose content, moisture, foreign matter and buffering powder are important.

Salt-Salt gives better taste to product. In this, case it act as preservatives. Salt should be used as food preservatives. Salt should be in pure form (Jayasinghe, 1998).

Preservatives- Sodium Meta Bisuphate(SMS).

The use of chemicals to prevent or delay the spoilage of foods. This is not to imply that any and all chemotherapeutic compounds can or should be used as food preservatives. It posses antimicrobial activity, it is also used in certain foods as an antioxidant.

SO_2 retards development of non – enzymatic browning or discoloration (after killing the enzymes) of the product. It is generally use in the form of its salts such as sulphite, bisulphite and metabisulphite (Srivastava, Sanjeev kumar, 1994).

The predominant ionic species of sulfurous acid depends on pH of medium, with SO_2 being favored by pH<3.0, HSO_3 by pH between 3.0 and 5.0.

With regard to its effect on microorganisms, SO_2 is bacteriostatic against *Acetobacter* spp and *Lactic acid* bacteria at low pH. In this case, the source of SO_2 was Sodium metabisufite

Banks and Board found that growth of *Salmonellae* and other *Enterobacteriaceae* were inhibited in British fresh sausage. Molds in their sensitivity to SO_2, and the more strongly aerobic species are generally more sensitive than the more fermentative species. Although the actual mechanism of action of SO_2 is not known, there is a suggestion that undissociated sulfurous acid or molecular SO_2 is responsible for the antimicrobial activity. Vas and Ingram suggested the lowering of pH of food. has grater preservative action It has been suggested that the antimicrobial action is due to the strong reducing power that allows these compounds to reduce oxygen tension to a point below that at which aerobic organisms can grow or by direct action on some enzyme systems SO_2 is also thought to be an enzyme poison, inhibiting growth of microorganisms by inhibiting essential enzymes. It helps to inhibit enzymatic browning(James M. Jay, 1998).

Table 2.6 The concentration of Sulphur dioxide required to prevent the growth of microorganisms at different pH level.

pH	Organisms and SO2 concentration in ppm	
	Penicillium (Mould)	Bacteria
2.5	300	100
3.5	600	300

(Source:Srivastava, Sanjeev kumar, 1994)

Spices-Spices contain natural preservatives that can extend the shelf-life of foods. This has been known for many years, both in the art of cooking and later in the science of preserving food. They have antimicrobial and antioxidant properties. Generally, the spices were more effective against Gram- Positive microorganisms (Gordon W. Fuller, 1994).

Although used primarily as flavoring and seasoning agents in foods, many spices posses significant antimicrobial activity. In all instances, antimicrobial activity is due to specific chemicals or essential oils.

It would be difficult to predict what antimicrobial effects, if any are drived from spices as they are used in food product. However, they have effectiveness against most-poisoning organisms, including mycotoxigenic fungi.

The fungi appear to be in general more sensitive than gram-negative bacteria. Some gram negatives, however, are highly sensitive.

Antimicrobial substances vary in content from the allicin of garlic (with a range of 0.3-0.5%) to eugenol in cloves (16-18%). (James M.Jay, 1998). In tamarind paste molds growth specially *Aspergillus*, *Parasititicus* are inhibited by spices specially cinnamon and clove, by chemicals specially cinnamic aldehyde, and by euginol(James M. jay, 1998).

2.5.4 Tamarind-Related patents

Eight patents were issued in India from 1974 to 1990. In fact, most of the granted patents stand expired today. It may be appreciated that increased number of tamarind-related patents indicate the possibility of using tamarind products in more number of ways than known hither to. It is difficult to include all the patents of tamarind fruit and its derivatives or products. Some of the important patents are listed in the following table 2.6.

Table 2.6 Patents on Processes, Products and Uses of Tamarind

Patents granted/ Application field	Assignee/ Applicant	Year
Patents granted (India)		
Method of preparation of tamarind powder	S.Chakarapani and J.Chakarapani.	1974
A new process for the preparation of tamarind juice concentrate	CSIR	1974
An enzymatic process for preparing tamarind juice concentrate	CSIR	1979
A Process for making tamarind pickles	Dilip Shantharam Dahanukar	1995
A process for preparing tamarind extract in the form of paste or jam	Shoki Kobayashi	1996
A manufacturing process for tamarind paste and concentrate	Yelantinaga	1996
A new process for recovery of tartaric acid and other products	CSIR	1996
Patents granted (USPTO)		
Method for preparing tamarind oligosaccharides	Lafayette applied chemistry Inc;U.S.A	1995
Beverages using tamarind extract and methods of making such beverages	Nutra Sweet Co; U.S.A	1995

Source: TIFAC Bulletin-Intellectual Property Rights (ipr), Vol 3. No9. 1997.

2.5.5 Total export of tamarind from Sri Lanka in 1995.

Total export of tamarind from Sri Lanka in 1995 is tabulated table 2.7.

Table 2.7 Total export of tamarind (Fruit and dried fruit) from Sri Lanka in 1995 .

Country	Quantity(kg)	Values(Rs)
Kuwait	500	22483
Lebanon	400	18614
Madive Islands	189	14883
Oman	120	6017
Pakistan	1965175	29648843
Singapore	75	3886
U.A.E	20299	604887
France	1500	83045
Germany	590	44309
Italy	150	68469
Netherlands	440	14288
Norway	170	9142
Switzerland	896	49836
U.K	413	32086
Canada	437	43674
Elsalvador	21	1947
U.S.A	59	4163
Bostwana	1	150
Australia	2738	170860
New Zealand	48	2380
Total	1994191	30844422

Source: External Trade Statistics, (1995)

Table 2.8 Total export of tamarind (Other products of Tamarind) from Sri Lanka in 1995 .

Country	Quantity(kg)	Values(Rs)
Afghanistan	500	21284
Bahrein Island	7400	274943
Brunei	200	7927
India Republic	1457560	68247347
Japan	88	6383
Kuwait	650	37688
Lebanon	462	41835
Malaysia	10	375
Madive Islands	611	29939
Oman	8010	418464
Quatar	300	14300
Saudi Arabia	20500	1127366
U.A.E	66289	2391814
France	105	4186
Italy	350	17337
Norway	60	3144
U.K	526	42762
Canada	487	43413
U.S.A	3196	119270
Australia	1234	92568
Total	1575866	75291646

Source: External Trade Statistics, (1995)

2.6 Changes in the tartaric acid induced by microorganisms

Tartaric acid is the major acid content in tamarind. With the time there are some chemical changes take place. Between 1857 and 1876 Pasteur showed that microorganisms were responsible for the chemical changes that take place in foods and beverages. Not all groups of microorganisms are of equal interest to the tamarind. Since tamarind is acidic one, fungi has high affinity to tamarind than bacteria.

2.6.1Changes induced by microorganisms growth in tartaric acid are briefly outlined below:

Although there are several organic acids are present in tamarind, tartaric acid and its salts are the most stable of the organic acids with respect to micro-organisms. By mid 19th century, however the French students of the subject had already noted the ability of some bacteria to decompose tartaric acid and tartarates in wine. Studies show that the decomposition of tartarates is due to the bacteria *Bacterium tartraophorum*. A number of species of *Aerobacter* has an ability to decompose tartrate and the bacteria could be differentiated into distinct groups according to the strength of gas production. *Bacterium succinicum*, produces large quantities of succinic acid during the decomposition of tartrate. As a result of other investigations , it is believed that *Bacterium succinicum* is closely related to those representatives of the genera *Aerobacter* and *Eschrichia*. Tartrate decomposition by *Pseudomonas incognita* was also described by means of tracer techniques.

The ability to metabolize tartrates does not appear to be as widely distributed among bacteria as it is among molds. Studies of a large number of molds for their tartrate-metabolizing ability have shown that representative genera *Aspergillus*, *Penicillium* and *Fussarium* are very active in the decomposition of Calcium tartrate, Potassium tartrate and tartaric acid. *Aspergillus niger*, have shown that the decomposition of tartrates and tartaric acid in a synthetic medium begins only after a lag period of 5 days, by which time a heavy mold pad had developed, and that the decomposition of tartrates proceeds in a regular manner at the great differences in the behavior of various strains of mold with respect to tartaric acid and tartrates. Yeast are incapable of utilizing either tartrates or tartaric acid(Mark and Stewart, 1959).

2.6.2 Coliform bacteria

Coliform bateria is primarily used to indicate the faecal cotamination of the foods. Natural habitat of the family *Enterobacteriaceae* to which these bacteria belong is the faeces of man and other mammals thereby indicating faecal contamination. Unlike most bacteria, they have the capacity to ferment lactose with the production of gas, and this characteristic alone is sufficient to make presumptive determination of Coliforms (John Garbutt, 1997).

2.7 New food product

2.7.1 Introduction

What is new product? There is no single definition that fits perfectly. A simple definition for a new product might be a product not previously marketed or manufactured by a company; however, this breaks down if one includes new packaging(shape or size) or if one enters a product into a new market niche – the food service sector(Gordon W.Fuller 1994).

2.7.2 Classification of new food products

New food products fall into one of the following classifications(Gordon W.Fuller, 1994).

Line extensions
Repositioned existing products
New form of existing products
Reformulation of existing products
New packaging of existing products
Innovative or added – value products
Creative products

2.7.2.1 Reformulation of existing products

The "new, improved..." product is typical of this category. Reformulation of a product to make some improvement (e.g.: better colour, better flavour, greater stability) has a high probability of technical success. Reformulation may be necessary for any number of reasons. For example, a raw material may have become unavailable or new sources of an ingredient must be invested. Reformulation may be needed to lower costs to meet the

challenge of cheaper competitions. It could also allow a company to take advantage of ingredients with vastly improved characteristics and properties.

Reformulation may also be necessary to satisfy the consumer's demand for a healthier product, such as one with fewer calories. This could also create a new market niche for existing products(Gordon W.Fuller, 1994).

2.7.3 Why go into new food product development?

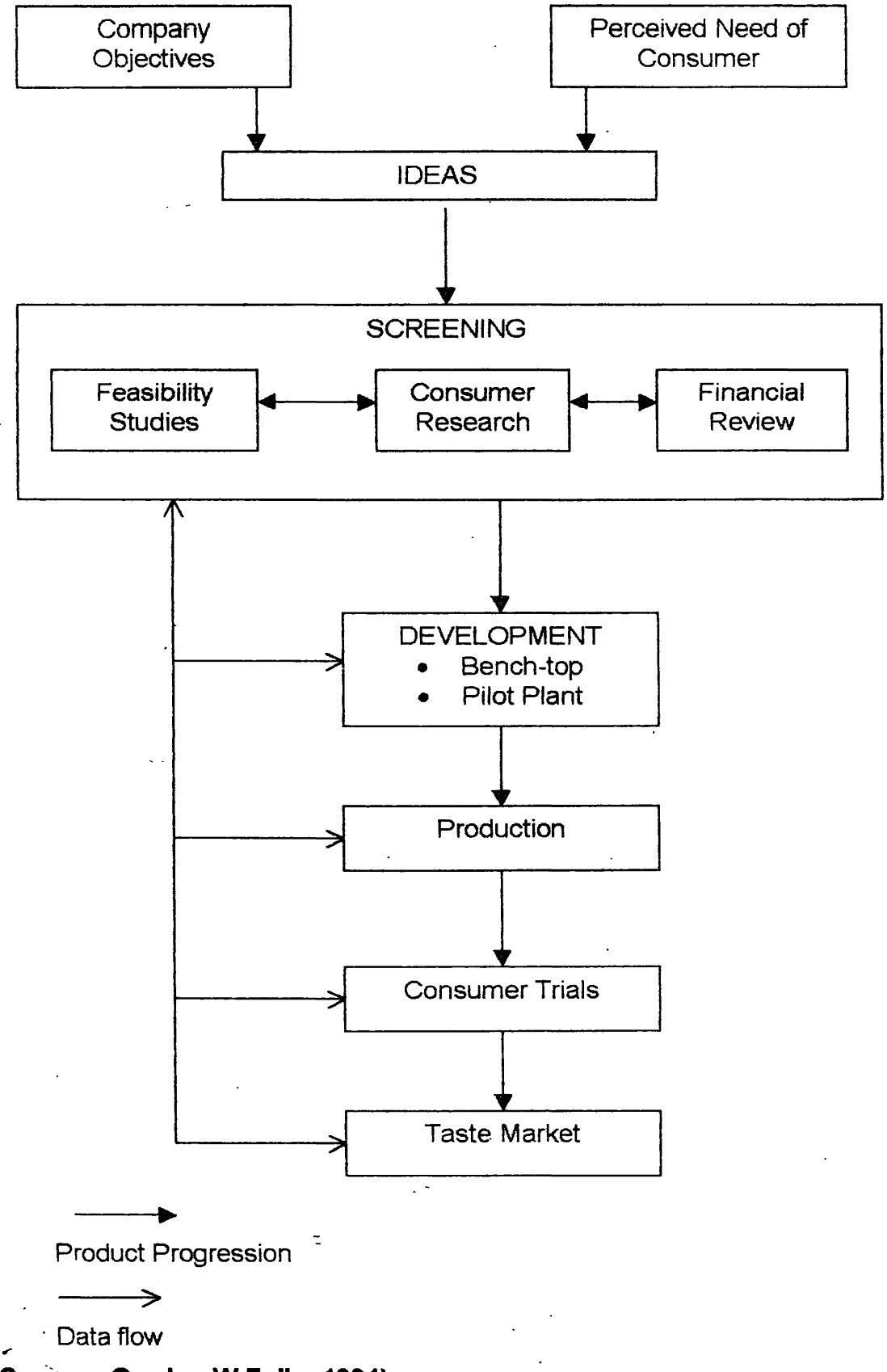
As John Maynard Keynes put it so succinctly in A Treatise on Money, " The engine which drives Enterprise is not Thrift, but Profit". New food products are the major avenues open to a food company to be profitable and to survive. Some marketers would argue that new food product development is the only path the Food Company can follow for survival(Gordon W.Fuller 1994).

2.7.4 Ten commandments for new product development

1. Use quality ingredients
2. Project an image of quality and value
3. Project a healthful image
4. Make each product taste as fresh as possible.
5. Make every products close to natural as possible.
6. Don't use any additive or chemical substance unless absolutely necessary.
7. Provide as much information as possible on the label, but no more than the consumer wants to know.
8. Be absolutely truthful with product names and claims.
9. Give each product high- quality, tamper-proof packing.
10. Be aggressive in employing new food processes, Packing and technology.

2.7.5 Phases in new food product development

Figure 2. 2 Phases in new food product development.



(Source : Gordon W.Fuller 1994)

2.8 Preliminary Market Survey

Market survey is a kind of research, which determines the customer's acceptance of a new product. It is very helpful to develop a new product as consumer acceptable product.

2.9 Evaluation and Statistical tests

2.9.1 Sensory Evaluation

Consumers' sensory impressions of food begin in the market place where visual, odour and tactile senses, and perhaps taste are used in food selection. Although there are several factors, sensory factors are the major determinant of the consumers' subsequent purchasing behavior.

Information on consumer likes and dislikes, preferences, and requirements for acceptability can be obtained using consumer-oriented testing methods and untrained sensory panels.

Consumer-oriented testing

In true consumer testing, a large random sample of people representative of the target population of potential users is selected to obtain information on consumers' attitudes or preferences.

In pilot consumer panels, usually consists of 30 to 50 untrained panelists selected from personnel within the organization, where the product development or research is being conducted. A group of panelists, who are similar to the target population of consumers who use the product, should be chosen.

The identification of changes caused by storage requires the identification and measurement of sensory properties. This type of product oriented quantitative information is obtained in the laboratory using trained sensory panels. These panels usually consist of 5-15 panelists who have been selected for their sensory acuity and have been specially trained for the task to be done.

Trained panelists should not be used to assess food acceptability. Their special training makes them more sensitive to small differences than the average consumer and teaches

them to set aside personnel likes or dislikes when measuring the sensory parameters. (Watts et al, 1989).

2.9.1.1 Uses of sensory evaluation

Sensory analysis is used to establish difference and to characterize and measure the sensory attributes of products or, to establish whether product differences are acceptable and noticeable to consumer. In product development and quality control, understanding, determining and evaluating the sensor characteristics of products are important in many applications. These include shelf life studies, product matching, product mapping, product specifications and quality assurance, product reformation, testing for taint potential and determining product acceptability (Elizabeth Larmond, 1977).

2.9.1.2 Hedonic Tests

Hedonic tests are designed to measure degree of liking for a product. Category scales ranking from like extremely, through neither like nor dislike, to dislike extremely with varying numbers of categories, are used. Panelists indicate their degree of likening for each sample by choosing the appropriate category (Watts et al, 1989).

2.9.2 Shelf life evaluation

Foods are perishable by nature. Numerous changes take place in foods during processing and storage. It is well known that conditions used to process and store foods may adversely influence the quality attributes in foods. Upon storage for a certain period one or more quality attributes of a food may reach an undesirable state. At that instant the food is considered unsuitable for consumption and it is said to have reached the end of its shelf life. (C.M.D.Man amd a.a.Jones, 1994).

Shelf life testing

A product is shelf life is a verification of the stabilizing system designed into the product. Food companies cannot release new products into a market, especially a test market, without knowing how stable that product will prove to be. That is, the company must have some idea of what the product shelf life is (Gordon W. Fuller, 1994).

During storage, there may be chemical, physical and microbiological changes take place. All these changes lead to food deterioration and reduce shelf life. In some cases the food may become unsafe for consumption (C.M.D.Man and A.A.Jones, 1994).

The loss of some functional property of the product, such as its ability to color. Like this there are several quality characteristic of food will degrade at different rates. Therefore, choosing the correct criterion or criteria to follow during the determination of shelf – life stability becomes very important (Gordon w. Fuller, 1994).

CHAPTER 3

METHODS AND MATERIALS

3.1 Materials For

3.1.1 Preliminary market survey.

Tamarind consuming consumers and questionnaire papers(Appendix 1).

3.1.2 Tamarind paste preparation.

3.1.2.1 Raw materials

- Tamarind was purchased from the collectors at Empilipitiya area or Was picked from trees grown in our campus and Sooriyawawa area.
- Spices such as Cinnamom, Cardomom, Pepper and Cloves, which were purchased from Embilipitiya Aurvedic shop.
- Water
- Table salt (powdered form)
- Table sugar

3.1.2.2 Apparatus

- Mechanical balancer
- Gas cooker.
- pH meter(Hanna, H1 8519 pH meter)
- Hand refractometer(Erma Hand, range 0 – 32^0)

3.1.2.3 Vessels

- Measuring cylinder (500 ml)
- Silver pots/balls
- Sterilized half Jam bottles
- Stainless steel pans
- Jam bottle lids.

3.1.3 Sensory evaluation for selecting best product

- Questionnaire format prepared according to Watts et al, 1989.
- **Rasam** prepared according to four type of tamarind paste recipes.

- Table spoons
- cups
- White porcelain plates
- Cream cracker biscuits
- Water glasses
- Panelists, who were selected from the Faculty and given instruction

3.1.4 Preparation of best tamarind paste formula selected in3.1.3.

Raw materials and items needed are as same as those mentioned under 3.1.3.
And additionally the following items were used.

- Autoclave (Oswaa)
- Yogurt cups
- Raw materials picked from trees which is grown in our campus (A special attention is given to pick raw material from the trees directly in order to prevent microbial contamination).

3.1.5 Shelf – life evaluation

3.1.5.1 Microbial analysis

3.1.5.1.1 Preparation of culture media

(1). Pototoes Dextrose Agar (PDA)

- Peeled potatoes
- Dextrose
- Agar
- Distilled water
- Amoxcylin
- Cloxyclin

(11). Nutrient Agar (NA)

- NA powder
- Distilled water

(111). MacConkey Broth

- MacConkey Broth - 3.5g
- Distilled water - 100ml

3.1.5.1.2 Serial dilution solution

- Ringer's tablet
- Distilled water
- Test tubes
- Autoclave(Oswaa)
- Tamarind Paste
- 1ml, 10ml pipette

3.1.5.1.3 Pour Plates

- PDA sterilized
- NA sterilized
- Borosil Petridishes (10 cm diameter)

3.1.5.1.4 Inoculation of the culture (Sample to media) media.

- PDA, NA poured plates
- Test tubes with MacConkey broth
- Tamarind paste samples
- 1ml and 10ml Borosil pipettes
- L Shape Glass rod
- Parafilm
- Durham tubes, boiling tubes

3.1.5.1.5 Other instruments/ apparatus used for microbial analysis

- Autoclave (Oswaa) used to sterilize the equipments, Ringer's solution and culture medium. 120 ^{0}c and 15 psi pressure was used to autoclave. However duration of autoclaving varied depending on the item autoclaved.
- Laminar airflow (HWS Laminar airflow) was used to provide an aseptic environment, in which, the culture media were transferred to the plates and sample was inoculated to culture media.
- Incubator (Paramount incubator) was used to provide fixed temperature for maintaining the cultures of microorganisms desired constant temperature for their optimum growth.
- Colony counter (Paramount) was used to count the colonies in the plates.
- Microscope – A light microscope (Olympus) was used to examine the bacteria. 10X, 40X lenses and 15X eyepieces were used.

- Miscellaneous items – Several other equipment such as microscope slides, cover slips, cotton wool, Aluminum foil, Sprit lamp were used as well

3.1.5.2 Chemical analysis

3.1.5.2.1 Total Solids Determination

- Analytical balance (LIBROR AEG – 220G)
- Oven (Memmert)
- Moisture cans (8cm diameter)
- Tamarind paste

3.1.5.2.2 Total Soluble Solids Determination

- Tamarind paste
- Hand refractometer (Erma Hand, range 0 -32^0)

3.1.5.2.3 Titrable Acidity Determination

- Phenolphthalein indicator
- 0.1 M NaOH solution
- Conical flask(250ml)
- 50ml, Vensil burettes
- 100ml, measuring cylinder
- Beakers
- Spatula

3.1.5.2.4 pH Value

- pH meter (Hanna, H18519 pH meter) (plate 3.2)

3.1.5.3 Sensory Analysis

- Four various types of tamarind paste (see in page no 38)
- Four various types of tamarind pastes were prepared prior to the sensory analysis.
- Table spoons
- Questionnaire formats.

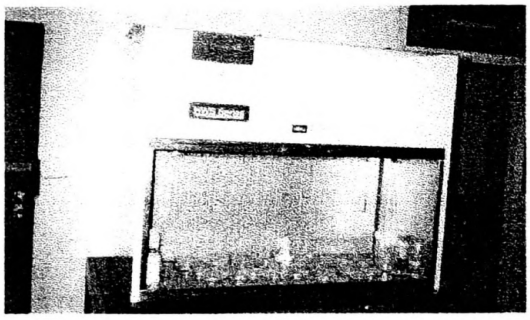


Plate 3.1. HWS Laminar airflow

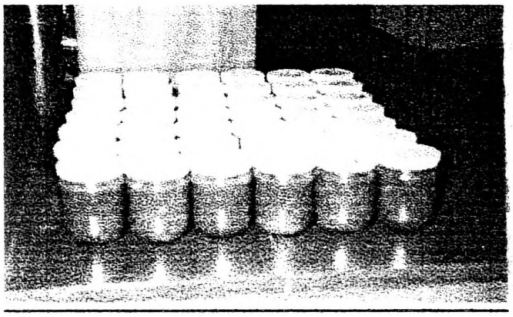


Plate3.3 Tamarind paste sampl in jam bottles

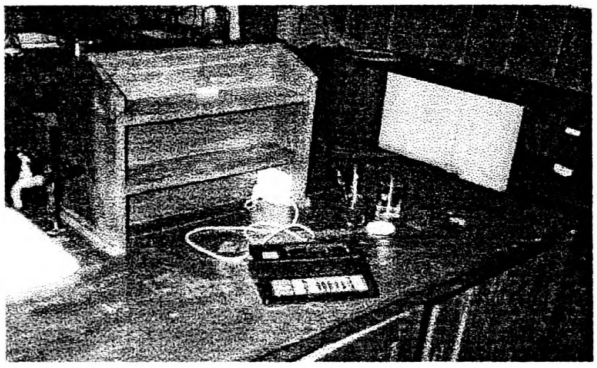


Plate 3.2 pH meter (Hanna, H18519 pH meter)

Plate3.4 Tamarind paste sample yoghurt cups

3.2 Method

3.2.1 Method of preliminary market survey

Questionnaire was prepared with open end close end questions (Appendix 1). Consumers, who are willing to purchase or eat tamarind paste, were interviewed. They consisting of 30 members were questioned as for questionnaire and the forms were filled by interviewers at Cargills at Bandarawella

3.2.2 Preparation method of Tamarind paste samples

Insect segments and fungal contaminant visual to the naked eyes were removed from tamarind. Then it was mixed with same weight of water and was allowed to soak for 2 hours. Subsequently tamarind pulp was filtered through a stainer (mesh size no is 12) .

Extracted Tamarind pulp was mixed with salt, sugar, spices and Sodium Metabi Sulphate(SMS) and the mixture were blended to get homogeneous pulp. Then again it was filtered through a strain (mesh size no is 25) to remove large particles.

The mixture was heated, while stirring. When tamarind pulp was reached to 37 °Brix, heating was stopped. Then heated tamarind paste was hot filled to half jam bottles and bottles were sealed.

Bottle sterilization was done by autoclaving the bottles at 120 °C at 15 psi for 15 – 20 minutes.

Four various types of tamarind paste were prepared by combining ingredients as follow (in table 3.1).

Table 3.1 Ingredients contents in tamarind paste preparation

Tamarind	2.5kg
Water	2.5kg
Sugar	50g
Spices	50g
Salt	25g
SMS	1.25g

Combination of spices in four different tamarind paste is shown in table 3.2.

Table 3.2 Combination of spices in different tamarind pastes

Cinnamon	Cardamom	Pepper	Clove	Four types of Tamarind paste
10g	10g	10g	10g	Tamarind paste sample number 1
20g	10g	10g	10g	Tamarind paste sample number 2
10g	10g	10g	20g	Tamarind paste sample number 3
10g	20g	10g	10g	Tamarind paste sample number 4

Four various types (formulae) of tamarind paste were prepared. In all four tamarind paste formulae, all the contents were same but, only the spice mixture was different. Spices content in tamarind paste formua1, formula2, formula3 and formula4 were same as in Tamarind paste sample number 1, Tamarind paste sample number 2, Tamarind paste sample number 3 and Tamarind paste sample number 4 respectively in table 3.2.

3.2.3 Sensory evaluation method for selecting best product

Sensory evaluation was carried out to select the best product among four different tamarind pastes formulae. For this, four recipes **Rasam** were prepared by using above four types of tamarind paste formulae in which ingredients are variable (spices combination) which the tamarind content is constant. All the **Rasam** were prepared under same conditions.

Sensory evaluation was done in food laboratory of our Faculty at about 11 '0' clock. Four Rasam varieties, which were prepared by four different tamarind pastes, were provided to each panellist in porcelain cups. Aim of the sensory evaluation and rules were explained to all panellists prior to the to evaluation.

Tablespoons were provided to each Rasam sample. Cream cracker biscuits were also provided to use as carrier and a cup of water was provided to each panelist. They were required to fill the Ballot papers (Appendix 2) for sensory evaluation.

Finally sensory evaluation data was analysed according to Hedonic method of .Watts B M et . al ., 1989.

3.2.4 Statistical analysis of results of the sensory evaluation

Nine – point hedonic scale was used to scale the panelists's preference. In which the panelists expressed their degree of liking or disliking. Model is shown in Appendix ii.

Table 4.01 shows Tabulated category scores for Hedonic Test. SAS Program was done to confirm whether there is a significant difference among four types of tamarind paste. That program was given in appendix 3 and out put was given in appendix 4.

3.2.5 Selected product sample preparation for shelf – life evaluation

By using the best recipe of tamarind paste, la series of tamarind paste samples were prepared for the shelf – life evaluation. Preparation method was the same as the previous method. At the same time, we wanted to know if there is any significance difference between the kinds of raw materials used and to know there is any significance difference between the types of packaging material used.

Raw materials after purchased from local market or picked from tree were decontaminated. Tamarind paste was prepared by using the above raw material separately to study on the shelf – life. In this case, only the raw materials were different while, the methods and conditions are same as discussed in 3.2.2.

Those two types of tamarind paste were filled into sterilized jam bottles and yoghurt cups separately to know whether there is any significance influence of packaging material on the shelf – life of the product.

Data of sample preparation and testing dates were tabulated in appendix 5.

3.2.6 Microbial analysis for shelf life evaluation

3.2.6.1 Sterilization of Glassware.

Sterilization was done to destroy or remove all unwanted living organisms without damaging or altering the substances being sterilized.

All the glassware including petridises, dilution bottles, pipettes, test tubes were thoroughly washed and wrapped in Aluminum foil and sterilized in an oven at 180 ^{0} C for 2-3 hours. After sterilization the oven was kept closed and allowed to cool slowly. Then the glassware were stored. Needles, spatulas and forceps were sterilized under Bunsen burner.

3.2.6.2 Media preparation

3.2.6.2.1 Potato Dextrose Agar for Fungus Enumeration

(A) Composition

- Potatoes 200g
- Dextrose 20g
- Agar 20g
- Distilled water 1 liter
- Amoxycilline 25mg/ml
- Croxycilline 25mg/ml

(B) Procedure

The good quality potatoes were washed, peeled and cut into small pieces. About 200g of cut pieces were weighed and boiled in a beaker containing 500ml distilled water. Potato infusion was obtained. The distilled water (500ml) was taken in to a conical flask and heated over water while adding agar. Heating process was continued until agar was completely dissolved. Then potato extract and dextrose were added into it, and stirred well. The volume was adjusted to 1 liter by adding distilled water.

The mouth of the conical flask was plugged with non - absorbent cotton wool and then wrapped by an Aluminum foil. Then it was sterilized at 15psi and at 121 ^{0}c for 15-20 minutes in an autoclave.

After it became cooled to 55 ^{0}C and it poured into 10 cm diameter sterilized petridishes, which were tilted gently to spread the medium evenly.

3.2.6.2.2 Nutrient Agar for Bacterial count

(A) Composition

- Beef extract 1.5g
- Peptone 2.5g
- Agar 7.5g
- Distilled Water 500ml

(B) Procedure

Nutrient agar powder was available in our laboratory. So there was not need to prepare the nutrient agar medium by using above composition. 28g nutrient agar powder was suspended in 1l distilled water and stirred in a magnetic stirrer to dissolve the contents It was boiled with agitation just sufficiently to completely dissolve the ingredients. Then it was sterilized in an autoclave at 121^{0}C for 15-20 minutes at 15 psi . The medium was cooled to 45^{0}C and poured into sterile petridishes of 10cm diameter.

3.2.6.2.3 Test for presumptive Coliforms

(A) Composition

- MacConkey broth - 3.5g
- Distilled water - 100ml

(B)Procedure

The dehydrated MacConkey broth powder was suspended in distilled water and stirred in a magnetic stirrer to dissolve the contents. 10ml portions were filled into test tubes, having inverted Durham tubes. The media was sterilized at 121^{0}C for 15 minutes at 15 lbs. Before autoclaving, the test tubes were plugged with cotton wool, which were then covered with Aluminum foil.

3.2.6.3 Dilution of samples

3.2.6.3.1 Apparatus

- Analytical balance(LIBROR AEG – 220G)
- Sterile pippettes of 1ml, 10ml(total flow)
- Ringer's tablets
- Distilled water
- Dilution bottles
- Autoclave(Oswaa)

3.2.6.3 .2 Preparation of Diluent

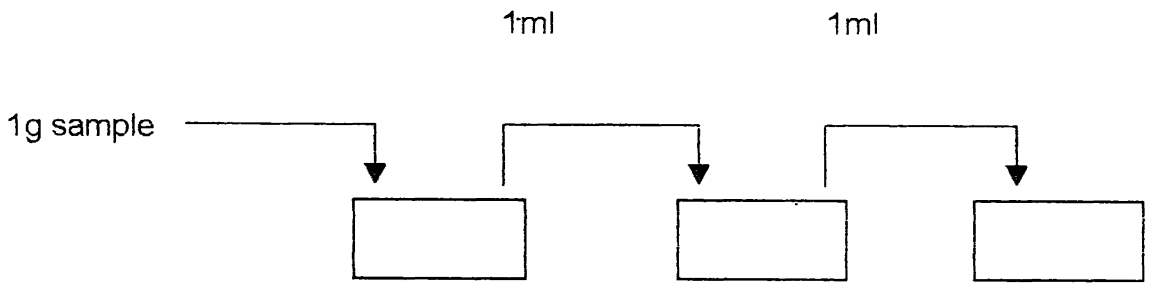
One Ringer tablet was dissolved in 500ml distilled water. For each set of practical, sterilized test tubes were used. Teat tubes containing 9ml of Ringer's solution. were autoclaved at 121 ^{0}C for 15 minutes at 15psi. All the test tubes were plugged with non-absorbent cotton wool followed by Aluminum foil before they were kept in an autoclave for sterilization.

3.2.6.3 .3 Dilution of samples

Four types of Tamarind paste samples (page 45) were taken into serial dilution. Each type of sample were taken three times (replications) from three Tamarind paste bottles/cups.

Each sample of 1g from the bulk sample was transferred into 9ml of Ringer's solution, which were in a sterilized dilution tubes, under sterile conditions using a sterilized pipette. (10^{-1}). It was well dissolved in the Ringer's solution. This bottle was shaken thoroughly and 1ml from the above solution was pipetted using a sterile pipette into another dilution tubes, containing 9ml of Ringer's solution (10^{-2}). Further dilution was done (10^{-3}) by transferring 1ml from 10^{-2} dilution, into another 9ml of Ringer's solution (Fig 3.2). While making dilutions, the mouth of the test tubes was flamed as soon as opened it and just before closing it. A new sterile pipette was used for each dilution All these procedures were done in the laminar air flow (plate 3 1).

Fig: 3.2 Diagrammatic form of 10 Fold Serial Dilution



	9ml Ringer's solution	9ml Ringer's solution	9ml Ringer's solution
Dilution	1:10	1:100	1:1000
Dilution exponential	10^{-1}	10^{-2}	10^{-3}
Dilution factor	X 10	X 100	X 1000

3.2.6.4 Plating of Medium

(A) PDA Medium

Aliquot 1ml from 10^{-3} dilution was pipetted onto sterile petridish containing solidified PDA, using clean, dry, sterile 1ml pipette under aseptic conditions (laminar flow). The samples were spreaded using a sterile L shaped glass rod. A separate pipette and L shaped glass rod were used for each plate. This procedure was done for the following four types of Tamarind paste with three replications. A blank control plate was also prepared by pouring the same amount of medium into a petridish. All the petridishes were incubated at 37°C for 48 hours in the inverted position.

Four types of tamarind pastes

(1) Tamarind paste which were prepared from Tamarind get directly from tree
(Jam bottles used as Packaging material).

(2) Tamarind paste which were prepared from Tamarind get directly from tree
(Yoghurt cups used as packaging material).

(3) Tamarind paste which were prepared from Tamarind purchased from the local market at Embilipitiya
(Jam bottles used as Packaging material).

(4) Tamarind paste which were prepared from Tamarind purchased from local market
(Yoghurt cups used as packaging material).

(B) Nutrient Agar Medium

The procedure was as same as described under plating of PDA medium.

(C) Inoculation of MacConkey Broth

A 9ml of single strength MacConkey sterilized test tubes were arranged for each dilution series of the original sample. Aliquots of 1ml from the desired dilution (10^{-3}) were transferred to each of 5 tubes, using 1ml of sterile pipette under aseptic conditions. The cotton wool was plugged on the tubes, which were then covered with Aluminum foil and they were incubated at 37^{0}C for 48 hours. This procedure was done for above four types of Tamarind paste with three replications.

3.2.6.5 Counting the colonies on plates

3.2.6.5.1 Total Fungal Count

A colony counter (Quebec) was used to count the colonies after 48 hours of incubation. The number of fungi of the original sample was calculated from the number of colonies on the plates, with the aid of magnification under uniform and properly controlled artificial illumination. The count was obtained as the average of 3 petridishes. This procedure was done for the four types of tamarind (see page 45) with time duration as mentioned in appendix iv .

3.2.6.5.2 Total bacterial count

The procedure was as same as done in 3.2.6.5.1

3.2.6.5.3 Observation for Coliforms

The inoculated test tubes were observed after 48 hours of incubation for gas formation or colour change.

3.2.6 Chemical analyses for shelf life evaluation

For the shelf life evaluation of the product, chemical analyses were carried out with time duration for four types of tamarind pastes (page 45). For each chemical analyses were done with 3 replicates.

3.2.6.1 Determination of Total Solid

Sample was weighed in to a moisture can and was spread over the bottom as thin layer. Then the sample was dried at 70 ^{0}C in an oven. The weighing was made at an hour intervals until do not vary the weights more than 1 mg. Before measure the dried sample, it should be allowed to cool in desicator.

Calculation

$$\text{Total solid} = \frac{\text{Sample weight} - \text{Weight loss}}{\text{Sample weight}}$$

3.2.6.2 Determination of Total Soluble Solids (TSS)

It was directly measured by using a Hand refractometer(Erma Hand, range $0-32^{0}$).

3.2.6.3 Method of acidity determination

Standard 0.1M NaOH was prepared by dissolving 4g NaOH crystals in 1 l distilled water Indicator was prepared by dissolving 0.5g of phenolphthalein in 200 ml of 50% ethyl alcohol by volume.

Five grams of Tamarind paste was weighed and was transferred to a conical flask with 50ml of distilled water. It is stirred until all paste dissolved. Then 2 or 3 drops of phenolphthalein indicator solution was added and was titrated with standard NaOH

Calculation

$$\text{Acidity (as tartaric acid) present by mass} = \frac{15\ n\ V}{M}$$

Where V = Volume in ml. of standard Sodium hydroxide required for titration.

n = Normality of standard Sodium hydroxide solution.

M = Mass in gram of the paste taken for the test.

3.2.6.4 pH Value

pH was measured directly from a calibrated pH meter(plate 3.2).

3.2.8 Sensory analyses

The four types of tamarind paste sample (see page 45) were evaluated for the organoleptic properties in the cooked form (**Thambum hodi**).

3.2.6.8.1 Preparation of Samples for Sensory Evaluation

Two samples of " Thambum hodi " were prepared from each type (see page no 45 to see four types) of tamarind paste. In each type, one sample was prepared from tamarind paste just prior to making (**Thambum hodi)** where as the other was produced by using tamarind paste of 3 month old.

3.2.8.2 Serving of Samples

Two different forms of each set of " Thambum hodi" were served at a time in white cups with code of 3 numbers, obtained from the random number table. The code numbers of each types (see page 46) are as following.

Type 1	472	523
Type 2	312	419
Type 3	312	419
Type 4	519	623

In each type, first and second numerical coded numbers are denote the samples prepared from the tamarind paste made just before the sample preparation and the other after 3 months of shelf life time respectively. The panelists were provided with distilled water and asked to rinse their mouth after each tasting. Four hedonic scale-scoring papers were provided to each panelist. (See sensory evaluation questionnaires at Appendix 5, 6, 7, 8).

3.2.8.3 Testing Criteria

A paired test was used to determine, if there was a difference in tastiness between each set of tamarind paste samples. The 9 point hedonic scale was used to evaluate the degree of liking for preference. A grade of 9 represented ' like extremely ' and 1 represented ' dislike extremely '.

3.2.8.4.Statistical Analysis

Results of hedonic scale scores for each type of tamarind paste were summarized, in Appendix 10, 11, 12, 13. For the analysis of the results of hedonic scale, the ratings for each sample were given numerical values ranging from like extremely (9) to dislike extremely (1). Since, only two samples of each set (type) were evaluated, the mean scores received by each were compared using the T- test. The tabular t-values were found out from statistical chart (Appendix 15) under the column headed 0.05 (for 5% level of significance).

CHAPTER 4

RESULTS AND DISCUSSION

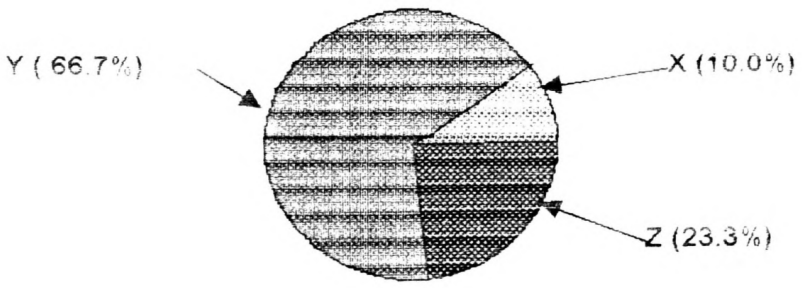
4.1 Preliminary Market Survey

4.1.1 Frequency of using tamarind by consumers

In order to studying the consumer preference for preferable form of tamarind and acceptable packaging material to the tamarind paste a preliminary marketing survey was conducted. Results obtained from the survey can be displayed as figure 4.1

Out of the total 66.7% consumers use tamarind once a week in their meals and 23.3% consumers use tamarind occasionally and the rest of consumers use in every meal (figure 4.1).

Figure 4.1 How often consumers use the tamarind in the day today life

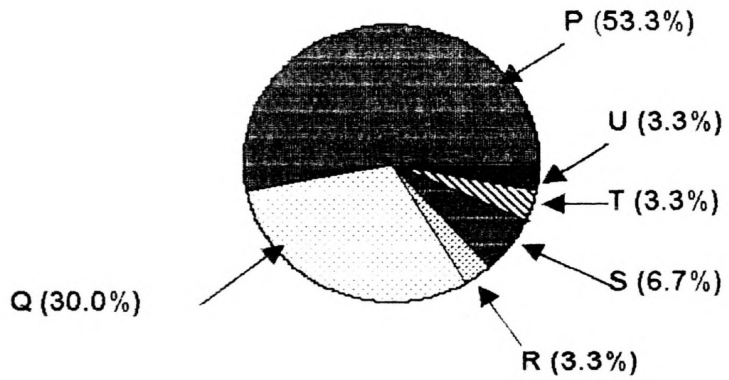


Where X denotes In every meal
Y denotes Once a week
Z denotes Occasionally

4.1.2 Consumer preference of tamarind form

According to the result obtained about consumer preference of tamarind consuming form (figure 4.2), 53.3% consumers out of total interviewed preferred to have tamarind as tamarind paste form(P) whereas 30.0% consumers have tamarind as shelled tamarind (Q) preference for other form like is not that much big.

Figure 4.2 Consumer preference of tamarind consuming form



Where P denotes Tamarind as paste form

Q denotes Tamarind as shelled tamarind

R denotes Tamarind as pod form

S denotes Tamarind as shelled and deseed form

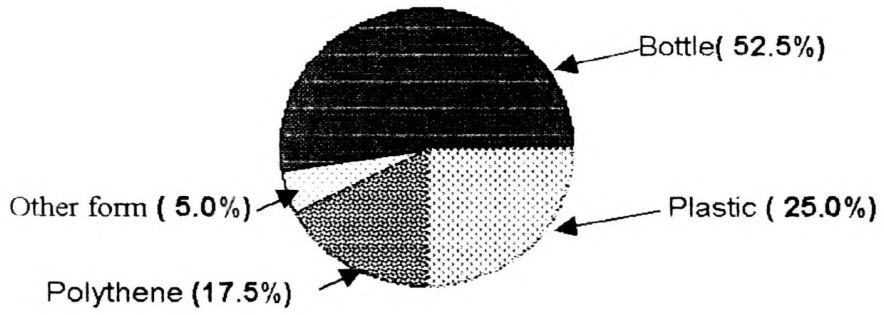
T denotes Tamarind as powder form

U denotes Other form of tamarind

4.1.3 consumer acceptable packaging materials

Out of total interviewers, 52.5% preferred the paste be bottle as package. 25% preferred the paste to be in plastic containers (figure 4.3).

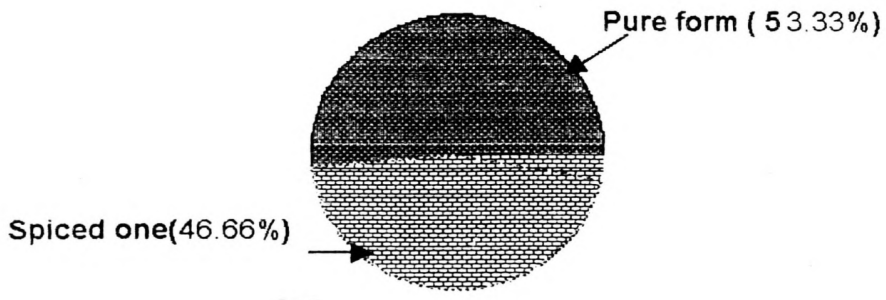
Figure 4.3 Consumer acceptable packaging materials



4.1.4 Consumer acceptable form of tamarind paste

53.33% would like to consume tamarind in pure form, where as the rest would like to consume tamarind paste incorporated with spices (Figure 4.4).

Fig 4.4 Consumer acceptable form of tamarind paste



4.2 Sensory evaluation for selecting best tamarind paste formula.

The following table shows converted descriptive scores of four tamarind paste formulae from hedonic test results.

Table 4.01 Tabulated Category Scores for Hedonic Test

Rasam Prepared by Various tamarind Pastes

Panelist	208	318	415	523	Panelist Total	Panelist Mean
1	5	6	7	8	26	6.5
2	3	4	6	7	20	5
3	5	2	6	7	20	5
4	8	8	7	9	32	8
5	4	6	5	8	23	5.75
6	7	8	6	4	25	6.25
7	9	9	3	1	22	5.5
8	9	8	3	4	24	6
9	8	7	7	9	31	7.75
10	8	7	6	5	26	6.5
11	7	9	7	6	29	7.25
12	8	7	6	9	30	7.5
13	7	8	8	9	32	8
14	8	7	8	9	32	8
15	6	7	4	6	23	5.75
16	4	7	6	3	20	5
17	5	4	7	9	25	6.25
18	7	7	9	8	31	7.75
19	7	1	9	9	26	6.5
20	7	6	7	6	26	6.5
21	3	4	6	8	21	5.25
22	7	6	8	8	29	7.25
23	2	6	7	6	24	6
24	5	6	9	4	24	6
25	6	7	6	6	25	6.25
26	6	7	5	4	22	5.5
27	7	9	8	6	30	7.5
28	5	6	6	9	26	6.5
29	6	7	7	8	28	7
30	8	6	5	9	28	7
Tretment total	195	192	194	204		
			Grand Total			780
Treatment mean	6.5	6.4	6.47	6.8		

* Highest seore=9=like extremely
- Lowest score=1=dislike extremely

Four types of tamarind pastes were prepared, having different combination ratios of spices

Four types of tamarind pastes were prepared, having different combination ratios of spices as shown in Table 3.1 and table 3.2. When evaluated by the mean scores of panelists by the 1 to 9 hedonic scales, the formula 4 is best. It means score is 6.8 (Table 4.01).

In order to confirm if there is any significant differences among four formulae, data were analysed by a SAS programme (Appendix 3, 4). The samples tested were not significantly different. So, all the tamarind paste formulae can be used for tamarind paste preparation. However, when considering mean scores formula 4 coded with 523 was the best. But economically formula 1 coded with 208 is the best because the cost of production is low in formula 1, as the Cardamom content incorporated in this formula is less than formula 4. Cardamom is an expensive spice.

4.3 Shelf life evaluation

4.3.1 Microbial analyses

Microbial test were carried out to see whether there are fungal, bacterial spoilage in the product during the study.

The samples were tested by using PDA, NA and MacConkey broth. For the test samples were taken periodically at two weeks intervals. No more microbial growth were observed through out the study lasting for 3 months (Table 4.01, 4.02, 4.03 and 4.04). And also presumptive coliform tests were negative for all four types of samples.

Table 4.02 Determination of microbial count with time duration of tamarind paste sample type 1.

Time duration(wks)	Fungus count in PDA plates	Bacterial count in NA plates	Observations for Coliforms
0	0	0	Negative
2	0	0	Negative
4	0	0	Negative
6	0	0	Negative
8	0	0	Negative
10	0	0	Negative
12	0	0	Negative

Table 4.03 Determination of microbial count with time duration of tamarind paste sample type 2.

Time duration(wks)	Fungus count in PDA plates	Bacterial count in NA plates	Observations for Coliforms
0	0	0	Negative
2	0	0	Negative
4	0	0	Negative
6	0	0	Negative
8	0	0	Negative
10	0	0	Negative
12	0	0	Negative

Table 4.04 Determination of microbial count with time duration of tamarind paste sample type 3.

Time duration(wks)	Fungus count in PDA plates	Bacterial count in NA plates	Observations for Coliforms
0	0	0	Negative
2	0	0	Negative
4	0	0	Negative
6	0	0	Negative
8	0	0	Negative
10	0	0	Negative
12	0	0	Negative

Table 4.05 Determination of microbial count with time duration of tamarind paste sample type 4.

Time duration(wks)	Fungus count in PDA plates	Bacterial count in NA plates	Observations for Coliforms
0	0	0	Negative
2	0	0	Negative
4	0	0	Negative
6	0	0	Negative
8	0	0	Negative
10	0	0	Negative
12	0	0	Negative

All the values are mean of three replicates.

Reasons for the absence of microbes may be due to low pH of samples, incorporation with spices, preservatives (SMS) used and heat treatment.

Spices contain natural preservatives that can extend the shelf – life of the tamarind paste since they have antimicrobial and antioxidant properties. In tamarind paste, molds growth especially *Aspergillus, Parasiticus* are inhibited by spices specially Cinnamon and Clove by chemicals specially Cinnamic aldehyde, and euginol (James. M. Jay, 1998).

SO_2 is also responsible for the preserving the product because of its antimicrobial activity. Vas and Ingram suggested the lowering of pH of food, has greater preservative action and also it helps to inhibit enzymatic browning (James, M. Jay, 1998).

All four types of tamarind pastes remained microbiologically acceptable for over 3 months. To study on the shelf life, further studies extended for a longer period should be carried out.

However, according to microbiological study conducted with a sample purchased from a super market, it was revealed that samples can be contaminated with bacterial growth. According to morphological features and internet experts' comments the causal agent is possibly is a *Pseudomonas* spp .

4.3.2 Chemical analyses

The use of tamarind paste by consumers is mainly intended to enhance the flavour of other recipes. So that, our chemical analysis was focused on Titrable acidity, pH, Total Soluble Solid and Total solids.

Chemical changes with time duration in 4 types (see page 45) of tamarind paste products are showed in following tables.

Table4.07Chemical changes with time duration of tamarind paste sample type1

Time duration (wks)	Titrable acidity as tartaric acid %	pH	TSS (Brix)Value	Total solids (%)
0	8.2	2.37	37	49.8
2	8.2	2.35	37	49.7
4	8.1	2.40	37	48.5
6	8.0	2.37	37	47.0
8	8.1	2.38	37	48.2
10	8.2	2.36	37	48.1
12	8.1	2.37	37	48.0

Table 4.08 Chemical changes with time duration of tamarind paste sample type 2.

Time duration (wks)	Titrable acidity as tartaric acid %	pH	TSS (Brix)Value	Total solids (%)
0	8.2	2.37	37	49.0
2	8.1	2.36	37	48.0
4	8.1	2.4	37	48.2
6	8.0	2.36	37	48.5
8	8.2	2.34	37	49.0
10	8.2	2.36	37	48.9
12	8.1	2.35	37	48.7

Table 4.09 Chemical changes with time duration of tamarind paste sample type 3.

Time duration (wks)	Titrable acidity as tartaric acid %	pH	TSS (Brix)Value	Total solids (%)
0	7.8	3.42	37	50.1
2	7.7	3.42	37	49.9
4	7.8	3.41	37	49.0
6	7.7	3.41	37	49.5
8	7.7	3.40	37	50.0
10	7.7	3.45	37	50.1
12	7.7	3.44	37	49.8

Table 4.10 Chemical changes with time duration of tamarind paste sample type 4.

Time duration (wks)	Titrable acidity as tartaric acid %	pH	TSS (Brix)Value	Total solids (%)
0	7.9	3.42	37	50.0
2	7.9	3.41	37	49.8
4	7.8	3.41	37	49.7
6	7.9	3.42	37	50.0
8	7.8	3.42	37	49.5
10	7.8	3.40	37	50.1
12	7.8	3.40	37	50.0

There is no significant change in chemical parameters, namely Titrable acidity, pH, Total Soluble Solid and Total Solid in four types of tamarind pastes So, all the four types of tamarind pastes are acceptable for over 3 months, which was the period of our study. Therefore in order to study the shelf life of these products an extended study should be carried out.

In type 1 and type 2 samples, the pH value is somewhat less than that in type 3 and type 4.

The results of pH are more or less compatible with the result of pH of edible part of tamarind (Table 2.1). The reasons for this difference can be many; use of different tamarind varieties, purchase of tamarind from different places of the local market, and incorporation with different types of salt etc.

The titrable acidity (as tartaric acid) of tamarind paste is within the range of 7.7 – 8.2 in all types. These result of titrable acidities are more or less compatible with the results reported by Lewis and Neelakantan (1964), that the dried pulp of tamarind (paste) contains 8 – 18% and the fruit pulp contains about 8.4 – 12.4%.

Reasons for the less amount of tartaric acid in the paste may be due to method of extraction, because, the tartaric acid is found in two forms combined form and free form. More than 50% are in combined form mainly as Potassium bitartrate and to less extent as Calcium tartrate, which is insoluble in cold water. Cold-water extraction was used for the tamarind pulp extraction. If hot water extraction is used for pulp extraction, tannin and pectin substances may come into the product that may lead to a bitter tastiness in the product.

4.3.3 Sensory analyses

This helps to check whether there is a sensory quality change after 3 months time of the preparation. For that, a tamarind paste sample was prepared newly and was compared with 3 months old tamarind paste sample.

4.3. 3.1 Responses for preference

Following figures 4.5, 4.6, 4.7, 4.8 give the intensity of preference of each type of tamarind pastes.

To determine the degree of preferences a 9-point hedonic scales were used.

9 - like extremely
8 - like very much
7 - like moderately
6 - like slightly
5 - neither like nor dislike
4 - dislike slightly

3 - dislike moderately

2 - dislike very much

1 - dislike extremely were the scores allocated in the statistical analysis of the results

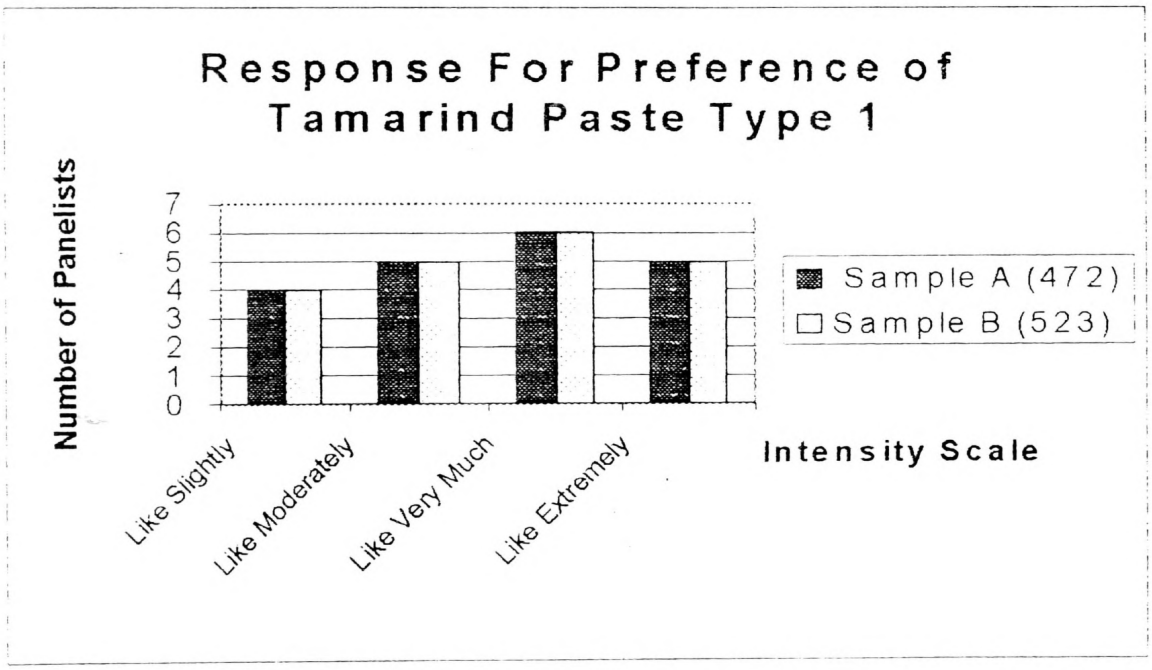
When comparing tamarind paste samples A (472),B(523) figure 4.5 was used.

Where

A(472) - Tamarind paste just prepared in which raw tamarind was get from tree(decontaminated) and packed in Jam bottle

B(523) - tamarind paste ,which was prepared and packed in the same of Above but, 3 months before prepared one.

Figure 4.5 Response for preference of tamarind paste type 1



From these observations, it can be interpreted that the number of responses on intensity scale of preferences are same for sample A(472) and sample B (523). So there are no changes in sensory parameters of the product up to 3 months. At the same time, no effect of raw materials and packaging materials on the shelf life of the product.

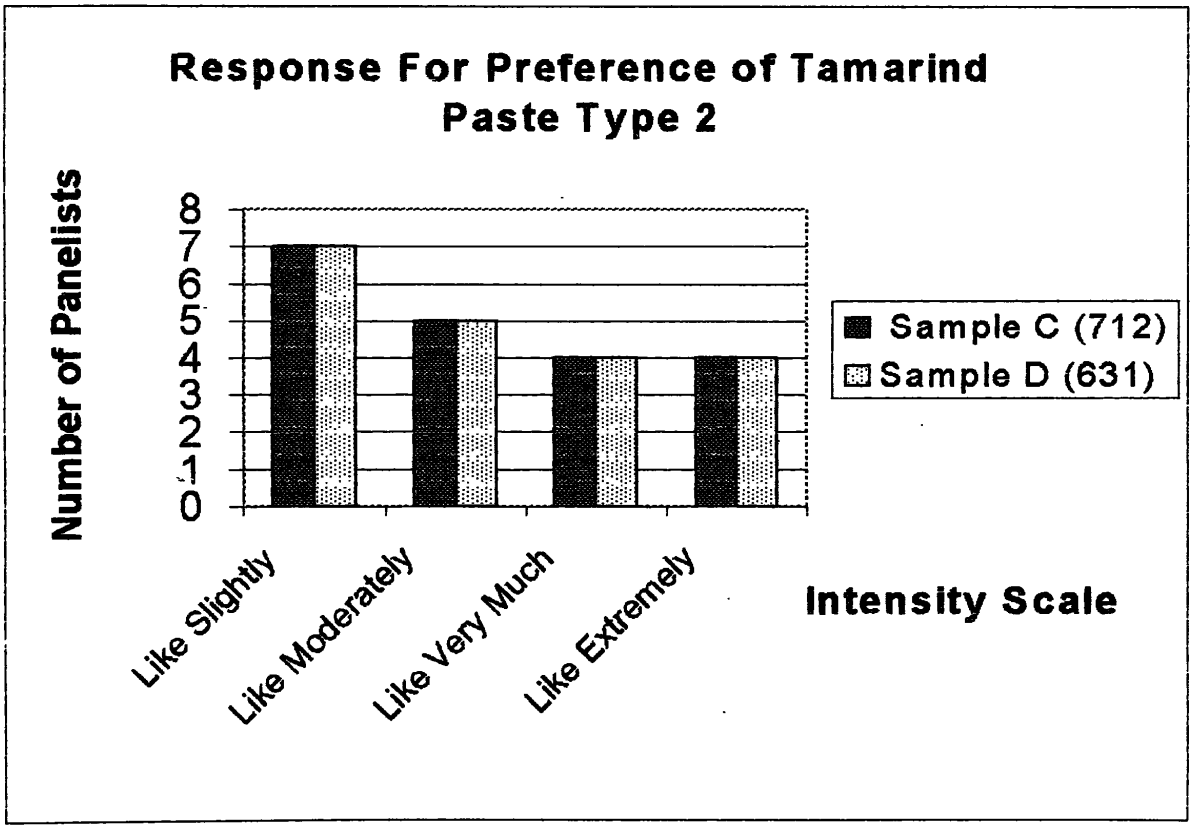
When comparing tamarind paste samples C (712),D (631), figure 4.6 was used.

Where

C (712) - Tamarind paste just prepared in which raw tamarind was get from tree(decontaminated) and packed in Yoghurt cups.

D (631) - tamarind paste ,which was prepared and packed in the same way of Above but, 3 months before prepared one.

Figure 4.6 Response for preference of tamarind paste type 2



According to the results obtained, it can be interpreted that that the number of responses on intensity scale of preferences are same for sample C(712) and sample D (631). So there are no changes in sensory parameters of the product up to 3 months. At the same time, no effect of raw materials and packaging materials on the shelf life of the product.

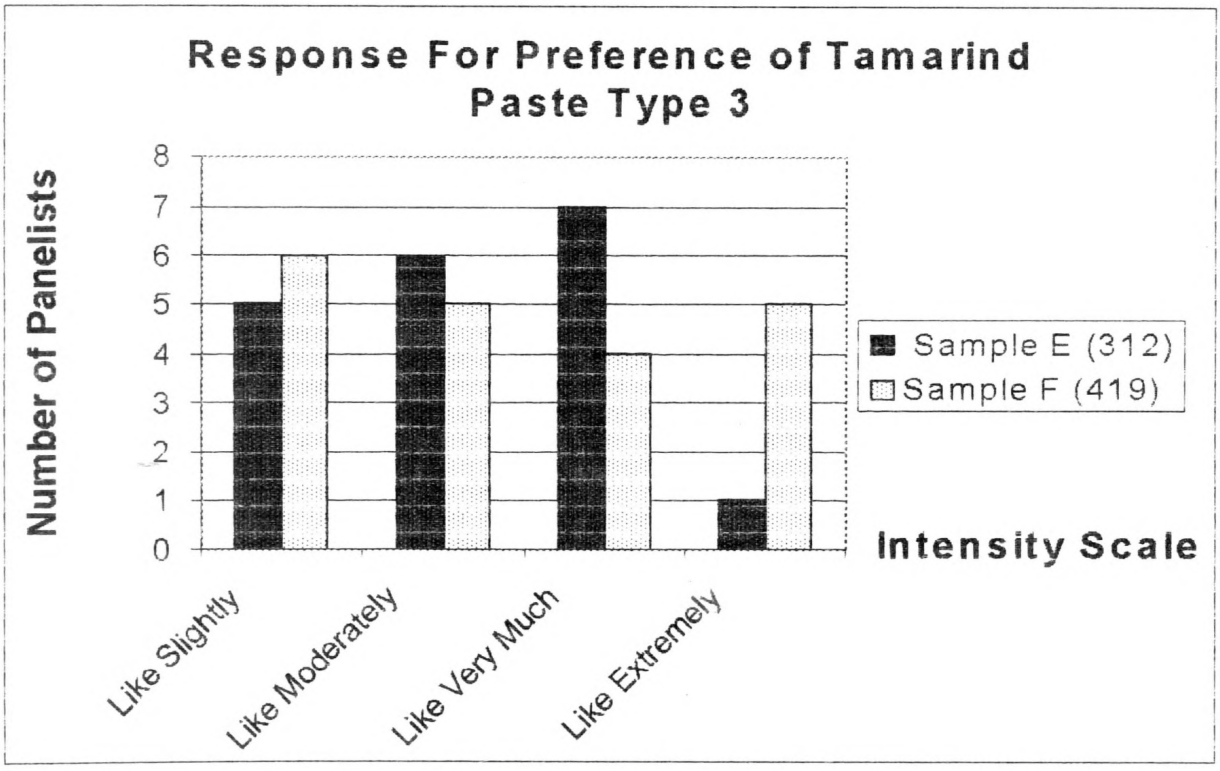
When comparing tamarind paste samples E (312), F (419), figure 4.7 was used.

Where

E(312) - Tamarind paste just prepared in which raw tamarind was get from local market and packed in Jam bottle.

F(419) - tamarind paste ,which was prepared and packed in the same way of above but, 3 months before prepared one.

Figure 4.7: Response for preference of tamarind paste type 3



By using the number of responses were concentrated on the intensity scale, It was not possible to conclude a clear idea about changing sensory parameters. So that results of hedonic test were subjected to T – test (Appendix 11) and it was found that there was no significant difference in the preference of panelists for tamarind sample E(312) and sample F(419).

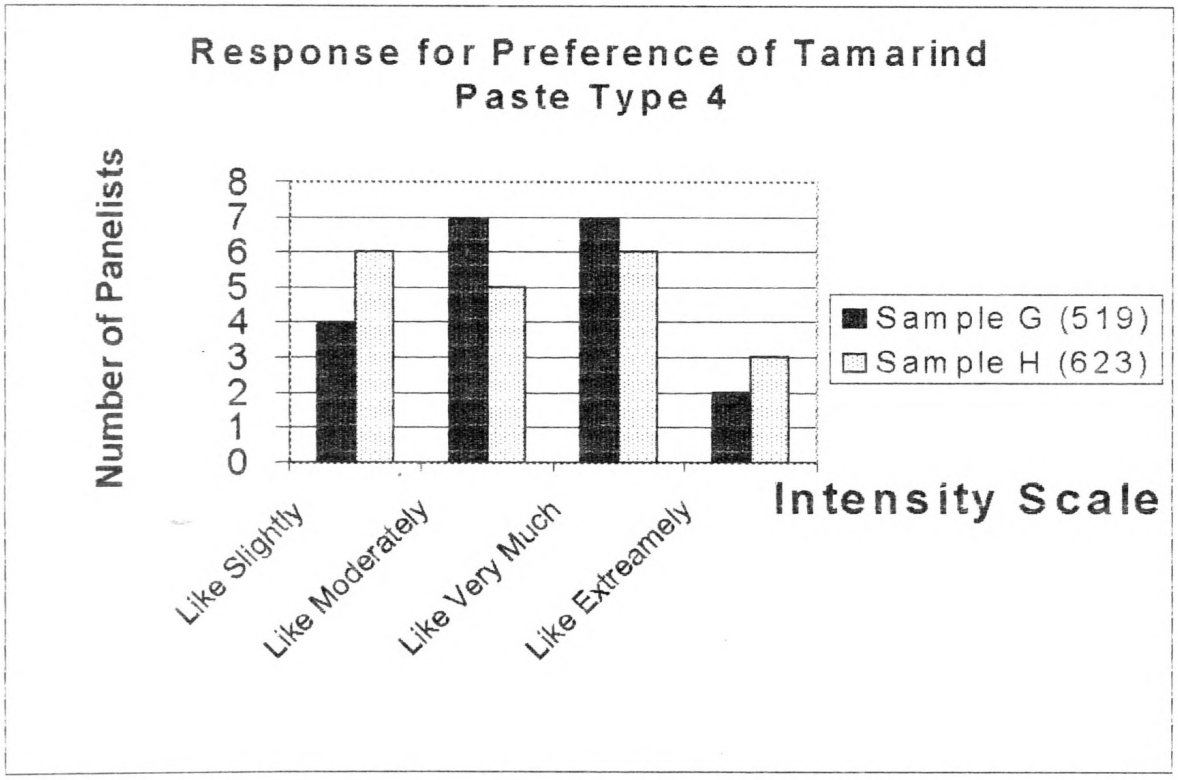
When comparing tamarind paste samples G(519), H(623), figure 4.8 was used.

Where

G(519) - Tamarind paste just prepared in which raw tamarind was get from tree (decontaminated) and packed in Yoghurt cups.

H(623) - tamarind paste ,which was prepared and packed in the same way of above but, 3 months before prepared one.

Figure 4.8 Respose for preference of tamarind paste type 4



Use of the number of responses were concentrated on the intensity scale, did not give a clear idea about changing sensory parameters. So the results of hedonic test were subjected to T – test (Appendix 12) and It was found that there was no significant difference in the preference of panelists for tamarind sample G(519) and sample H(623).

4.4 Cost Analysis

4.4.1 Cost of production of 100 kg Tamarind paste

1 kg of tamarind paste is produced from	= 1.5 kg of market sample
100 kg of tamarind paste is produced from	= 1.5 X 100
	= 150 kg
Price of 1 kg tamarind	=Rs. 50.00
Price of 150 kg tamarind	= 50 X 150
	= Rs. 7500

For producing 1 kg tamarind paste, cost of spices and other ingredients

	Sugar (30 g)	= Rs. 1.110
	Salt (15 g)	= Rs. 0.525
	SMS (0.75 g)	= Rs. 1.500
Spices		
	Pepper (6 g)	= Rs. 1.800
	Cloves (6 g)	= Rs. 5.100
	Cinnamon (6 g)	= Rs. 5.000
	Cardamom (12 g)	= Rs. 23.520
	Total	**= Rs 39.005**

Cost of ingredient for 100 kg tamarind paste	= 39.005 X 100
	= Rs. 3900.50
Cost for sterilization of bottles	= Rs. 21.04
Cost for pasturerization of tamarind paste	= Rs. 21.04
Labour cost	= 10 X 150
	= Rs. 1500
Total cost of production of 100 kg tamarind paste	= 7500+3900.50+21.04+21.04 + 1500
	= Rs. 12942.58
Total cost of production of 1 kg tamarind paste	=12942.58 /100
	= Rs. **129.4258**

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The findings of preliminary marketing survey revealed that the following :

- Most of consumers use tamarind once a week in their day today meals.
- The most preferable form of tamarind for there is spice incorporated tamarind paste.
- The packaging mostly acceptable for the consumers are glass bottles.

According to the sensory evaluation for selecting the best tamarind paste formula, the samples showed no significant difference in preference at $p< 0.05$. Formula number 4 was selected as the best formulation due to its high means scores compared with other tree. However, all four formulae can be developed for tamarind paste preparation, because there is no significant difference among them.

Tamarind paste traditionally have relied on a combination of its acidity, salt and sugar for their preservation. In addition to these, in here the product was prepared by using the thermal processing (pasteuritration), preservatives (SMS) and other functional ingredients (spices). These product was resulted in less salty and less sweetly, which are increasingly being demanded by the consumers.

According to the results of microbiological, chemical and sensory analyses intended to study the shelf – life, all four types of tamarind pastes remained acceptable for over 3 months. No significant effect was found of raw materials on the shelf life of the tamarind paste prepared. At the same time, no significant effect was found of packaging materials on the shelf life of the product.

CHAPTER 5

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5.2 Recommendations

- Further shelf-life study should be done to study the shelf life of the product.

- Further research should be carried out to check whether the method of extraction effect on the sensory parameters of the product.

- Formula 1 is economically suitable to tamarind paste preparation since, cost of production is very less than other three formulae. Cheapest spice ratio incorporated with this formula 1 at the same time most expensive spice was incorporated with other three.

- Spoilage may not a problem of an opened product at room temperature. It may be controlled to ascertain extent by limiting the shelf life of opened product at room temperature and or recommending refrigerated storage once the product has been opened.

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APPENDIX 1

Market Survey on Introduction of Tamarind Paste to The Market

1. Occupation of father or mother?
2. Monthly income :

   Less than Rs 2000.00

   Rs 2000.00 – 5000.00

   Rs 5000.00 – 10000.00

   More than Rs 10000.00
3. Do you use tamarind in your meals?
4. In which form do you buy them?
   (i) Pods
   (ii) Paste
   (iii) Shelled tamarind (raw materials from local market)
   (iv) Any other form
5. Do you like to have tamarind as a paste?
6. In which type of package do you like to buy?
   (i) Bottle
   (ii) Polyethylene bags
   (iii) Plastic containers
   (iv) Any other package
7. At what price do you buy tamarind now?
8. Do you prefer to buy tamarind paste by paying more money than now paying for tamarind?
9. Do you like :
   (i) Pure tamarind paste
   (ii) Tamarind paste with spices
   (iii) Any other way
10. How often do you use it?
    (i) In every meal
    (ii) Once a week
    (iii) Occasionally
    (iv) Other response
11. How many members in your family like to have tamarind in your meal?

APPENDIX 2

Questionnaire for hedonic scale

Name :..... Date:.....

Taste the "Rasam" preparation made of various tamarind and check how much you like or dislike each one.

Degree of like	208	318	415	523
....like extremely	.....	.....	.....	.....
....like very much	.....	.....	.....	.....
. like moderately	.....	.....	.....	.....
....like slightly	.....	.....	.....	.....
....neither like or dislike	.....	.....	.....	.....
....dislike slightly	.....	.....	.....	.....
....dislike moderately	.....	.....	.....	.....
.. .dislike very much	.....	.....	.....	.....
...dislike extremely	.....	.....	.....	.....

If the above commodities are available in the market which commodity you prefer to purchase and give reasons for that.

APPENDIX 3

Sas program to check if there any significant differences among four different tamarind paste formulae

```
Data Tamarind;
Input Score Product$;
Cards;
5 A
3 A
5 A
8 A
4 A
7 A
9 A
9 A
8 A
8 A
7 A
8 A
7 A
8 A
7 A
7 A
7 A
3 A
7 A
2 A
5 A
6 A
6 A
7 A
5 A
6 A
8 A
6 B
4 B
2 B
8 B
6 B
8 B
9 B
8 B
7 B
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4 B
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1 B
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4 B
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6 C
3 C
3 C
7 C
6 C
7 C
6 C
8 C
8 C
4 C
6 C
7 C
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9 C
7 C
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9 C
8 C
6 C
5 C
6 C
7 C
5 C
8 D
7 D
7 D
9 D
8 D
4 D
1 D
4 D
9 D
5 D
6 D
9 D
9 D
9 D
6 D
3 D
9 D
8 D
9 D
6 D
8 D
8 D
6 D
4 D
6 D
4 D
6 D
9 D
8 D
9 D
run;
proc anova;
class product;
model Score=Product;
means product;
run;
Proc Anova;
Class Product;
Model     Score=Product
Means Product/LSD;
Run;

Means Product/LSD;
Run;
```

APPENDIX 4

Analysis of Variance Procedure
Class Level Information
Class Levels Values
PRODUCT 4 A B C D
Number of observations in data set = 120

Analysis of Variance Procedure
Dependent Variable: SCORE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	5.09166667	1.69722222	0.49	0.6924
Error	116	404.83333333	3.48994253		
Corrected Total	119	409.92500000			

R-Square	C.V.	Root MSE	SCORE Mean
0.012421	28.85156	1.86813879	6.47500000

Source	DF	Anova SS	Mean Square	F Value	Pr > F
PRODUCT	3	5.09166667	1.69722222	0.49	0.6924

Analysis of Variance Procedure

Level of PRODUCT	N	SCORE Mean	SCORE SD
A	30	6.23333333	1.81342376
B	30	6.40000000	1.86806188
C	30	6.46666667	1.54770873
D	30	6.80000000	2.18774013

Analysis of Variance Procedure

T tests (LSD) for variable: SCORE
NOTE: This test controls the type I comparisonwise error rate not the experimentwise error rate.
Alpha= 0.05 df= 116 MSE= 3.489943
Critical Value of T= 1.98
Least Significant Difference= 0.9554
Means with the same letter are not significantly different.

T Grouping	Mean	N	PRODUCT
A	6.8000	30	D
A	6.4667	30	C
A	6.4000	30	B
A	6.2333	30	A

Appendix 5 **Tabulated data of sample preparation and testing**

Year	2001															
Month	October				November				December				January			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Sample 1 Preparation			P_{12} P_{10} P_8 P_6	P_4 P_2	P_0											
Sample 1 Testing					T_0	T_2		T_4	T_6		T_8		T_{10}		T_{12}	
Sample 2 Preparation			P_{12} P_{10}	P_8 P_6 P_6 P_4	P_0											
Sample 2 Testing					T_0	T_2		T_4		T_6		T_8	T_{10}		T_{12}	

P denotes prepared tamarind paste samples.
In each time tamarind paste was prepared in 6 jam bottles and 6 yoghurt cups
T denotes testing tamarind paste samples
For each sample 3 replication was carried out.
Sample 1denotes tamarind paste prepared by using tamarind as raw material purchased from local market.
Sample 2 denotes tamarind paste prepared by using tamarind as raw material picked from tree and decontaminated.
Numerical with P symbol denotes after which week, analyses will be carried out.
Numerical with T symbol denotes after which week, analyses were carried out.

APPENDIX 6

Questionnaire for hedonic scale

Name :..... Date:.....

Taste the " **Thambum hodi** " preparation made of various tamarind paste and check how much you like or dislike each one.

Degree of like	A(472)	B(523)
... like extremely	.....	.....
.. .like very much	.....	.....
. like moderately	.....	.....
... like slightly	.....	.....
....neither like or dislike	.....	.....
....dislike slightly	.....	.....
. . dislike moderately	.....	.....
...dislike very much	.....	.....
...dislike extremely	.....	.....

If the above commodities are available in the market which commodity you prefer to purchase and give reasons for that.

APPENDIX 7

Questionnaire for hedonic scale

Name :..... Date:.....

Taste the "**Thambum hodi** " preparation made of various tamarind paste and check how much you like or dislike each one

Degree of like	C(712)	D(631)
... like extremely	.....	.....
.. like very much	.....	.....
.. .like moderately	.....	.....
....like slightly	.. ..	.....
....neither like or dislike	.....	.....
....dislike slightly	.....	.....
... dislike moderately	.....	.....
... dislike very much	.....	.....
....dislike extremely	.....	.....

If the above commodities are available in the market which commodity you prefer to purchase and give reasons for that.

APPENDIX 8

Questionnaire for hedonic scale

Name :..... Date:.....

Taste the **"Thambum hodi "** preparation made of various tamarind paste and check how much you like or dislike each one.

Degree of like	E(312)	F(419)
....like extremely	.....	.....
....like very much	.....	.....
....like moderately	.....	.....
....like slightly	.....	.....
....neither like or dislike	.....	.....
...dislike slightly	.....	.....
...dislike moderately	.....	.....
...dislike very much	.....	.....
....dislike extremely	.....	.....

If the above commodities are available in the market which commodity you prefer to purchase and give reasons for that.

APPENDIX 9

Questionnaire for hedonic scale

Name :..... Date:.....

Taste the " **Thambum hodi** " preparation made of various tamarind paste and check how much you like or dislike each one.

Degree of like	G(519)	H(623)
....like extremely	.....	.....
....like very much	.....	.....
....like moderately	.....	.....
....like slightly	.....	.....
.. .neither like or dislike	.....	.....
....dislike slightly	.....	.....
....dislike moderately	.....	.....
....dislike very much	.....	.....
....dislike extremely	.....	.....

If the above commodities are available in the market which commodity you prefer to purchase and give reasons for that

Appendix 10

Converted descriptive scores for type 1 tamarind paste from hedonic test results

Processed Tamarind Paste Type 1			
Panelists	Sample A (472)	Sample B (523)	Panelists Difference
1	6	9	-3
2	9	7	2
3	8	6	2
4	7	8	-1
5	9	7	2
6	7	8	1
7	9	7	2
8	6	7	-1
9	9	6	3
10	8	9	-1
11	8	9	-1
12	6	8	-2
13	8	7	1
14	7	6	1
15	9	8	1
16	6	9	-3
17	7	8	-1
18	8	6	2
19	7	9	-2
20	8	8	0
Total	152	152	2
Mean	7.6	7.6	0.15

APPENDIX 11

Converted descriptive scores for type 2 tamarind paste from hedonic test results

Processed Tamarind Paste Type 2			
Panelists	Sample C (712)	Sample D (631)	Panelists Difference
1	8	6	2
2	7	6	1
3	6	7	-1
4	6	8	-2
5	9	8	1
6	7	9	-2
7	9	7	2
8	8	6	2
9	6	9	-3
10	6	7	-1
11	8	9	-1
12	7	6	1
13	6	7	-1
14	8	9	-1
15	7	6	1
16	6	8	-2
17	9	6	3
18	9	8	1
19	7	6	1
20	6	7	-1
Total	143	141	0
Mean	7.15	7.00	0

APPENDIX 12

Converted descriptive scores for type 3 tamarind paste from hedonic test results

Processed Tamarind Paste Type 3			
Panelists	Sample E (312)	Sample F (419)	Panelists Difference
1	8	6	2
2	6	8	-2
3	7	9	-2
4	9	8	1
5	6	9	-3
6	7	6	1
7	8	7	1
8	8	7	1
9	7	7	0
10	9	8	1
11	5	8	-3
12	6	7	-1
13	7	9	-2
14	8	6	2
15	6	9	-3
16	7	6	1
17	8	7	1
18	8	6	2
19	7	9	-2
20	8	6	2
Total	142	145	3
Mean	7.1	7.25	0.15

Average difference (d) =0.15

Standard Deviation (S) =2.093

Number of pairs (n) =20

Degrees of freedom (d.f) =19

Calculated t value =0.320

$t_{0.05} = 2.093$

APPENDIX 13

Converted descriptive scores for type 3 tamarind paste from hedonic test results

Processed Tamarind Paste Type 4			
Panelists	Sample G(519)	Sample H (623)	Panelists Difference
1	8	7	1
2	7	6	1
3	6	7	-1
4	8	9	-1
5	7	6	1
6	9	8	1
7	6	7	-1
8	8	6	2
9	7	8	-1
10	7	6	1
11	6	9	-3
12	8	7	1
13	7	8	1
14	9	8	1
15	8	6	2
16	7	8	-1
17	8	9	-1
18	7	8	-1
19	6	7	-1
20	8	6	2
Total	147	146	3
Mean	7.35	7.3	0.15

Average difference (d) =0.15

Standard Deviation (S) =1.548

Number of pairs (n) =20

Degrees of freedom (d.f) =19

Calculated t value =0.4332

$t_{0.05} = 2.093$

APPENDIX 14

STATISTICAL CHART

Two-sample test

Number of judgments	Two-tail tests: Minimum agreeing judgments necessary to establish significant differentiation			One-tail tests: Minimum correct answers necessary to establish significant differentiation		
	Probability level			Probability level		
	5%	1%	0.1%	5%	1%	0.1%
5	....	....	....	5	....	....
6	....	....	....	6	....	....
7	7	....	....	7	7	....
8	8	8	....	7	8	....
9	8	9	....	8	9	....
10	9	10	....	9	10	10
11	10	11	11	9	10	11
12	10	11	12	10	11	12
13	11	12	13	10	12	13
14	12	13	14	11	12	13
15	12	13	14	12	13	14
16	13	14	15	12	14	15
17	13	15	16	13	14	16
18	14	15	17	13	15	16
19	15	16	17	14	15	17
20	15	17	18	15	16	18
21	16	17	19	15	17	18
22	17	18	19	16	17	19
23	17	19	20	16	18	20
24	18	19	21	17	19	20
25	18	20	21	18	19	21
26	19	20	22	18	20	22
27	20	21	23	19	20	22
28	20	22	23	19	21	23
29	21	22	24	20	22	24
30	21	23	25	20	22	24
31	22	24	25	21	23	25
32	23	24	26	22	24	26
33	23	25	27	22	24	26
34	24	25	27	23	25	27
35	24	26	28	23	25	27
36	25	27	29	24	26	28
37	25	27	29	24	27	29
38	26	28	30	25	27	29
39	27	28	31	26	28	30
40	27	29	31	26	28	31
41	28	30	32	27	29	31
42	28	30	32	27	29	32
43	29	31	33	28	30	32
44	29	31	34	28	31	33
45	30	32	34	29	31	34
46	31	33	35	30	32	34
47	31	33	36	30	32	35
48	32	34	36	31	33	36
49	32	34	37	31	34	36
50	33	35	37	32	34	37
60	39	41	44	37	40	43
70	44	47	50	43	46	49
80	50	52	56	48	51	55
90	55	58	61	54	57	61
100						

APPENDIX 15

STATISTICAL CHART

The distribution of t

Degrees of freedom	Probability of a larger value, sign ignored								
	0.500	0.400	0.200	0.100	0.050	0.025	0.010	0.005	0.001
1	1.000	1.376	3.078	6.314	12.706	25.452	63.657		
2	0.816	1.061	1.886	2.920	4.303	6.205	9.925	14.089	31.598
3	0.765	0.978	1.638	2.353	3.182	4.176	5.841	7.453	12.941
4	0.741	0.941	1.533	2.132	2.776	3.495	4.604	5.598	8.610
5	0.727	0.920	1.476	2.015	2.571	3.163	4.032	4.773	6.859
6	0.718	0.906	1.440	1.943	2.447	2.969	3.707	4.317	5.959
7	0.711	0.896	1.415	1.895	2.365	2.841	3.499	4.029	5.405
8	0.706	0.889	1.397	1.860	2.306	2.752	3.355	3.832	5.041
9	0.703	0.883	1.383	1.833	2.262	2.685	3.250	3.690	4.781
10	0.700	0.879	1.372	1.812	2.228	2.634	3.169	3.581	4.587
11	0.697	0.876	1.363	1.796	2.201	2.593	3.106	3.497	4.437
12	0.695	0.873	1.356	1.782	2.179	2.560	3.055	3.428	4.318
13	0.694	0.870	1.350	1.771	2.160	2.533	3.012	3.372	4.221
14	0.692	0.868	1.345	1.761	2.145	2.510	2.977	3.326	4.140
15	0.691	0.866	1.341	1.753	2.131	2.490	2.947	3.286	4.073
16	0.690	0.865	1.337	1.746	2.120	2.473	2.921	3.252	4.015
17	0.689	0.863	1.333	1.740	2.110	2.458	2.898	3.222	3.965
18	0.688	0.862	1.330	1.734	2.101	2.445	2.878	3.197	3.922
19	0.688	0.861	1.328	1.729	2.093	2.433	2.861	3.174	3.883
20	0.687	0.860	1.325	1.725	2.086	2.423	2.845	3.153	3.850
21	0.686	0.859	1.323	1.721	2.080	2.414	2.831	3.135	3.819
22	0.686	0.858	1.321	1.717	2.074	2.406	2.819	3.119	3.792
23	0.685	0.858	1.319	1.714	2.069	2.398	2.807	3.104	3.767
24	0.685	0.857	1.318	1.711	2.064	2.391	2.797	3.090	3.745
25	0.684	0.856	1.316	1.708	2.060	2.385	2.787	3.078	3.725
26	0.684	0.856	1.315	1.706	2.056	2.379	2.779	3.067	3.707
27	0.684	0.855	1.314	1.703	2.052	2.373	2.771	3.056	3.690
28	0.683	0.855	1.313	1.701	2.048	2.368	2.763	3.047	3.674
29	0.683	0.854	1.311	1.699	2.045	2.364	2.756	3.038	3.659
30	0.683	0.854	1.310	1.697	2.042	2.360	2.750	3.030	3.646
35	0.682	0.852	1.306	1.690	2.030	2.342	2.724	2.996	3.591
40	0.681	0.851	1.303	1.684	2.021	2.329	2.704	2.971	3.551
45	0.680	0.850	1.301	1.680	2.014	2.319	2.690	2.952	3.520
50	0.680	0.849	1.299	1.676	2.008	2.310	2.678	2.937	3.496
55	0.679	0.849	1.297	1.673	2.004	2.304	2.669	2.925	3.476
60	0.679	0.848	1.296	1.671	2.000	2.299	2.660	2.915	3.460
70	0.678	0.847	1.294	1.667	1.994	2.290	2.648	2.899	3.435
80	0.678	0.847	1.293	1.665	1.989	2.284	2.638	2.887	3.416
90	0.678	0.846	1.291	1.662	1.986	2.279	2.631	2.878	3.402
100	0.677	0.846	1.290	1.661	1.982	2.276	2.625	2.871	3.390
120	0.677	0.845	1.289	1.658	1.980	2.270	2.617	2.860	3.373
∞	0.6745	0.8416	1.2816	1.6448	1.9600	2.2414	2.5758	2.8070	3.2905

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