DEVELOPMENT AND STANDARDISATION OF LOW FAT FROZEN DESSERT

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DECLARATION

I hereby declare that this thesis, entitled **"DEVELOPMENT AND STANDARDISATION OF LOW FAT FROZEN DESSERT"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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CERTIFICATE

Certified that this thesis, entitled **"DEVELOPMENT AND STANDARDISATION OF LOW FAT FROZEN DESSERT"** is a record of research work done independently by **M.B. Rajesh,** under my guidance and supervision and it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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Introduction

1. INTRODUCTION

Frozen desserts include ice cream and related products. Specific products include ice cream and its low fat varieties, frozen custard, frozen yogurts, mellorine (vegetable fat frozen dessert), sherbet, water ice and frozen confections (Marshall *et al.,* 2003). In India popularity of ice cream and frozen desserts are increasing day by day and is attributed to its refreshingly cool, delightfully sweet characteristics besides as a source of nutrients. India is the world leader in milk production and is still showing an increasing trend in production, which is expected to touch a record of 91 million tonnes in 2004-05. Out of 84.6 million tonnes of milk produced in India during the year 2001, the conversion of milk into various products (in per cent) was ghee 27.5, makhan 6.5, dahi 6.9, khoa and condensed milk 6.5, milk powder 37, paneer, channa and cheese 1.9, ice cream and kulfi 0.6, cream 0.2 and other products 0.5 (Gupta, 2001). In India annual production of ice cream is 150 million litres (Aneja *et al.,* 2002) and per capita consumption is 0.1 litres per year (Kumar, 2004). Even though milk production is increasing annually, the consumption pattern of milk and milk products has not changed much in India.

Frozen desserts are foams with air cells dispersed in a continuous liquid phase that contain ice crystals, emulsified fat globules, proteins, sugars, salts and stabilizers (Flack, 1989). According to the Prevention of Food Adulteration Act, 1954 (PFA) ice cream should contain minimum 10 per cent fat and 36 per cent total solids. The fat in ice cream contribute to the high-energy value, mouth feel, richness and serves as reservoir of flavours. The consumption of high fat ice cream can lead to high blood cholesterol levels. Ice cream with 12.5 per cent milk fat contains approximately 45 mg of cholesterol per 100 g (Moorthy and Balachandran, 1993). Cholesterol, which is considered to be a coronary threat to modern civilization, is effectively reduced by about 52 per cent and 68 per cent in low fat ice cream having 6 per cent and 4 per cent fat respectively. Since the frozen dessert does not have any compositional standard, we can reduce the fat content by replacing other ingredients.

Unfortunately the high cost of ice cream has made it a luxury item, which cannot be afforded by lower income group people of the developing countries including India. The major reason for prohibitive cost of the product is the short supply of ingredients and their high cost. Looking at the tremendous increase in human population as against the rather stagnant milk production it is difficult to expect any substantial reduction in the cost of milk in foreseeable future. Considering the above facts great interest is being shown all over the world for the development of low fat frozen dessert. Efforts have long been made to develop low cost ice cream by substituting costlier milk based ingredients such as butter fat with inexpensive materials. This would not only make frozen desserts a common man's food item but also would divert a large portion of milk for fluid consumption. Since frozen desserts are most popular amongst children, its popularization can be a tool for combating the protein calorie malnutrition amongst the preschool and school going children, which is prevalent in many parts of the country. More over economic pressures are constantly forcing ice cream manufacturers to modify their formulation by substituting various ingredients. The food industry has developed many dairy products incorporating materials of plant origin. Such developments are intended to reduce the cost, together with the advantages offered by the plant nutrients, in terms of economics and availability. Hence the development of frozen desserts, in which the milk fat is partially replaced by mango pulp is worth mentioning.

Mango (*Mangifera indica)* is a tropical fruit relished for its succulence, exotic flavour and delicious taste throughout the world. India is the leading mango growing country of the world with an annual production of 9.2 million tonnes (Gujaral and Khanna, 2002). Chemical and nutritional composition of Neelum variety showed that it contained 16.5 per cent total soluble solids (Nandini and Oommen, 2002) and 2 per cent dietary fibre. Dietary fibre plays an important role in decreasing the risks of many disorders such as constipation, diabetes, cardio vascular diseases, diverticulosis and obesity (Ramulu and Rao, 2003).

The present study is aimed at the use of mango pulp at different levels replacing milk cream in ice cream, thereby making low fat ice cream. This helps in incorporating the nutritional benefits of mangoes such as higher carotenoids and fibre in the frozen product thus developed. More over if the milk fat can be spared it can be used in the manufacture of baby foods and other vital food items. Development of low fat frozen dessert incorporating mango pulp would certainly provide an alternative product which is expected to be of low cost accessible by lower income group.

The present study was aimed at the preparation of low fat frozen dessert incorporating mango pulp with the following objectives.

1. To assess the feasibility of incorporating mango pulp, at different levels in the preparation of low fat frozen dessert.
2. To compare the physico-chemical properties, microbiological, organoleptic qualities and nutritional attributes of low fat frozen dessert with that of standard ice cream.

Review of Literature

2. REVIEW OF LITERATURE

Literature on frozen desserts incorporating mango pulp is limited. But a review is attempted here with available literature regarding the physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes of various types of ice cream and frozen desserts.

2.1 EXTRACTION AND ANALYSIS OF MANGO PULP

Mango is the most popular and choicest commercial fruit produced in tropical regions. Acharya and Shah (1999) reported that mangoes are consumed in very large quantities in different forms viz, fruit as such, pulp, milk shake and ice cream. Joyce *et al.* (2001) reported that mango occupies a prominent position in the world market, because processed products incorporating it such as ice cream, juice and jelly have great commercial importance. Gujral and Khanna (2002) reported that mango is a very important fruit crop of India with an annual production of 9.2 million tonnes. In India, mango ranks first in both cultivated area and production among fruits and occupies 40 per cent of total area under fruits (Gowda and Huddar, 2004).

According to Bose (1985) sugars in mango comprises of sucrose, glucose, fructose, maltose, arabinose, sedoheptulose, and mannoheptulose. Inegite *et al.* (1998) reported that mango pulp contained (per 100 g dry wt) 0.22 mg thiamine, 0.17 mg riboflavin and 1.26 mg niacin. Barwal (1999) reported that mango fruits are rich in vitamins, minerals, organic acids and dietary fibre and hence considered as protective food.

Acharya and Shah (1999) analysed mango pulp for chemical analysis and reported that it contained 20.38 per cent total solids (TS), 18.88 per cent carbohydrate with an acidity of 0.26 percentage. Nandini and Oommen (2002) reported that Neelum variety of mango contained (per cent) acidity 0.21, total soluble solids (TSS) 16.5, total sugar 14.95 and reducing sugar 6.25. It also contained vitamin C 24.65 mg, β carotene 1186 μg, iron 0.9 to 3.2 mg, calcium

10 to 20 mg and phosphorus 10 to 30 mg per 100g. The pH of mango pulp was 4.06. Ramulu and Rao (2003) reported that dietary fibre plays an important role in decreasing the risks of many disorders such as constipation, diabetes, cardiovascular diseases, diverticulosis and obesity in humans and mango pulp had two per cent total dietary fibre.

Hymavathi and Khader (2004) opined that mango imparts a pleasant yellow colour when added to any food there by avoiding the necessity of adding synthetic colour. Gowda and Huddar (2004) reported that mango pulp contained (in per cent) TSS 18.95, reducing sugar 7.63, non reducing sugar 1.75, total sugar 9.38, vitamin C 58.25 mg, carotenoids 2680 μg per100g and pH 4.49 with an acidity of 0.47 per cent. They also reported that pulp per cent obtained from Neelum variety mango was 63.6.

2.2 COMPOSITION OF DAIRY INGREDIENTS

According to PFA Act (1954) specification, cow milk should contain minimum 3.5 per cent fat and 8.5 per cent SNF (solids not fat) where as skim milk should contain not less than 0.5 per cent fat and minimum 8.7 per cent SNF. De (1980) reported that skim milk contained (per cent) 90.6 water, 0.1 fat, 3.6 protein and 5.0 lactose. Webb *et al.* (1987) reported that skim milk contained (per cent) 90.5 moisture, 0.1 fat, 3.6 protein and 5.1 lactose.

According to PFA Act (1954) skim milk powder should contain less than 5 per cent moisture and less than 1.5 per cent fat. According to Bureau of Indian Standards (BIS) specification (IS: 1165,1967) skim milk powder should contain 95.3 per cent total solids and less than 1.5 per cent fat. Hall and Hedrick (1971) reported that skim milk power contained (per cent) 0.8 fat and 3.0 moisture.

According to PFA Act (1954) butter should contain not less than 80 per cent fat. De (1980) reported that butter contained (per cent) 80.2 fat and 16.3 moisture.

2.3 ADDITION OF NON-DAIRY INGREDIENTS IN ICE CREAM AND FROZEN DESSERTS AND ITS PHYSICO-CHEMICAL PROPERTIES

Elhami *et al.* (1977) studied the substitution of butter fat with margarine in ice cream and observed its physico-chemical and organoleptic properties. El-Safty *et al.* (1978) studied the use of hydrogenated oil in ice cream making. Youssef *et al.* (1981) studied substitution of fresh cream fat by butter oil, cottonseed oil and corn oil. Rothwell (1984) observed that potato starch maltodextrin could replace a high proportion of fat and some sugar to produce calorie reduced frozen desserts. Naidu *et al.* (1986) conducted a study to find out the effect of utilization of whey in ice cream. Nair and Geevarghese (1988) prepared a dairy analogue by replacing butter fat up to 80 per cent in ice cream with fat from freshly prepared coconut cream, without any noticeable change in the quality of the product and named it as kera cream.

Rao *et al.* (1988) conducted a study on soft serve frozen dessert made with sweetened fermented milk and plain ice cream mix. Das *et al.* (1989) prepared ice cream made by incorporation of different levels of potato pulp and studied the physico-chemical and organoleptic properties. Pinto *et al.* (2004) conducted a study on ginger juice based herbal ice cream and its physico-chemical and sensory characteristics.

2.3.1 Specific gravity

Arbuckle (1966) reported that specific gravity of ice cream mixes vary from 1.054 to 1.123. Elhami *et al.* (1977) found that replacing butterfat with margarine had a negligible effect on specific gravity of ice cream mix but specific gravity of ice cream increased by the addition of margarine. El-Safety *et al.* (1978) reported that replacing butterfat by hydrogenated oil up to 50 per cent had negligible effect on specific gravity of mix.

Naidu *et al.* (1986) studied the effect of utilization of whey in ice cream and observed that specific gravity of mix ranged from 1.054 to 1.123. Nair and

Geevarghese (1988) found that incorporation of coconut cream in ice cream does not produce any significant difference in the specific gravity.

Rao *et al.* (1988) prepared frozen dessert using sweetened fermented milk and compared its physico-chemical properties with standard ice cream. Specific gravity of control and treatment mixes ranged from 1.092 to 1.102. They also found that the specific gravity of the frozen dessert mixes increased with increasing levels of fermented milk.

Das *et al.* (1989) observed that mean specific gravity decreased with increase in potato pulp contents in the ice cream mixes and it ranged from 1.104 to 1.091. The decrease in specific gravity might be due to the difference in density of milk solids and boiled potato pulp solids, as the former is denser than latter. Geevarghese (1996) found that replacement of milk fat with coconut fat at any level does not influence the specific gravity of ice cream mix.

2.3.2 Viscosity

Viscosity has been considered as an important property of ice cream mix and it is essential for proper whipping and retention of air cells (De, 1980). A lower viscosity seems to be desirable for fast freezing and rapid whipping (Marshall *et al.*, 2003).

Arbuckle (1966) reported that the viscosity of ice cream mix ranged from 50 to 300 centipoise (cp). It was also reported that as the viscosity increases, the resistance to melting and smoothness increases. Elhami *et al.* (1977) reported that replacing butterfat with margarine increased the mix viscosity compared with that of control mix and the increase was proportional with the increase of margarine and values ranged from 343.57 to 581.43 cp. El-Safty *et al.* (1978) found that viscosity of ice cream mixes increased by adding the hydrogenated oils. This increase was proportional with the amount of hydrogenated oil added and the values ranged from 371.6 to 569.8 cp. Rajor (1980) found that the relative viscosity of ice cream mix increased significantly with an increase in stabilizer level when buttermilk and soya solids were incorporated.

Youssef *et al.* (1981) found that butter oil substitution in ice cream resulted in increase in viscosity of the mixes where as cottonseed and corn oil substitute resulted in reduction in viscosity of the mixes. Naidu *et al.* (1986) studied the effect of utilization of whey in ice cream and observed that the viscosity ranged from 57.1 to 85.4 cp and it decreased as the whey solids increased. Rao *et al.* (1988) found that the viscosity values progressively increased with the addition of fermented milk in ice cream and value ranged from 115.6 to 154.3 cp.

El-Neshawy *et al.* (1988) reported that ice cream mixes containing hydrolyzed lactose reconstituted milk showed higher viscosity. Das *et al.* (1989) found that the relative viscosity increased significantly with increasing levels of boiled potato pulp solids and values ranged from 85.2 to 149.1 cp. Schmidt *et al.* (1993) found that the use of carbohydrate based fat replacers in reduced fat ice creams resulted in mixes with higher viscosities. Geevarghese (1996) found that the relative viscosity of kera ice cream mix increased as fat substitution level increased and the values ranged from 45.2 to 79.5 cp. Tirumalesha *et al.* (1998) observed a decrease in viscosity of ice cream mix when skim milk solids were replaced by whey protein concentrate.

Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix have higher viscosity values ranging from 201.6 to 241.6 cp. Alvarez *et al.* (2005) reported that incorporation of milk protein concentrates resulted in higher viscosity of ice cream mix.

2.3.3 Titratable acidity

The apparent or natural acidity of ice cream mix is caused by milk proteins, mineral salts and dissolved gases. A high acidity is undesirable as it contributes to excess mix viscosity, decreased whipping rate, inferior flavor and a less stable mix (Arbuckle, 1966). If fresh milk components of excellent quality are used, the mix can be expected to have a normal acidity (Marshall *et al.*, 2003).

Frandsen and Arbuckle (1961) reported that the normal ice cream mix containing 11 per cent milk solids not fat (MSNF) have a normal acidity of 0.198 per cent. According to BIS specification (IS: 2802-1964) maximum titratable acidity of ice cream mix is 0.25 per cent. El-Safty *et al.* (1978) concluded that incorporation of hydrogenated oils up to 50 per cent increased the acidity of ice cream as compared to control.

Naidu *et al.* (1986) studied the effect of utilization of whey in ice cream and observed that the titratable acidity ranged from 0.19 to 0.20 per cent. They also found that the titratable acidity increased as the whey solids increased. Das *et al.* (1989) observed that incorporation of potato pulp at 15, 25 and 35 per cent of MSNF resulted in an increase in titratable acidity and the values ranged from 0.19 to 0.21.

Baer *et al.* (1999) reported that titratable acidity of non-fat ice cream ranged from 0.21 to 0.22 per cent. Geevarghese (1996) found that replacement of milk fat with coconut fat at any level did not influence the acidity. Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant product had higher acidity ranging from 0.199 to 0.205 per cent.

2.3.4 pH

Arbuckle (1966) reported that the normal pH of ice cream mix is about 6.3. Elhami *et al.* (1977) observed that the p^H values of the ice cream mix decreased by increasing the per cent of margarine and the value ranged from 6.1 to 6.4. El-Safty *et al.* (1978) studied the use of hydrogenated oils in ice cream and the results indicated that control samples showed higher pH values than treatments with a range from 6.0 to 6.2. This might be due to the higher acidity of hydrogenated oils. Naidu *et al.* (1986) studied the effect of utilization of whey in ice cream and mean pH values ranged from 6.27 to 6.38 in the resultant ice cream.

Nair and Geevarghese (1988) found that 80 per cent substitution of coconut fat in kera ice cream did not produce any appreciable difference in pH. Rao *et al.* (1988) prepared frozen dessert using sweetened fermented milk and compared its physico-chemical properties with ice cream of standard composition and found that the mean pH of different frozen dessert mixes decreased as the level of sweetened fermented milk was increased and values ranged from 5.8 to 6.4.

Das *et al.* (1989) observed that the mean pH of different ice cream mixes decreased as the level of substitution with boiled potato pulp increased and the resultant values ranged from 6.1 to 6.3, which is attributed to low protein content and slightly acidic nature of boiled potato pulp. Geevarghese (1996) found that replacement of milk fat with coconut fat at any level did not influence the pH. Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix had lower pH of 6.32 when compared to control, which was 6.34.

2.3.5 Fat

Milk fat is an important component of ice cream, which is essential to balance the mix and to satisfy legal standards. The fat component of frozen dairy dessert mixes increases the richness of flavour, is a good synergist for added flavour compounds, produces a characteristic smooth texture by lubricating the palate, helps to give body and aids in producing desirable melting properties (Marshall *et al.*, 2003). Limitations on excessive use of fat in a mix include cost, a decreased whipping ability, decreased consumption due to excessive richness and high caloric value.

According to PFA Act (1954) and BIS specification (IS: 2802-1964) ice cream should contain minimum10 per cent fat. Guinard *et al.* (1996) reported that ice cream with higher fat content had better flavour and texture ratings as determined by a sensory panel. Adapa *et al.* (2000) found that structure development in ice cream is often attributed to the macromolecules present in ice cream mix such as milk fat, protein and complex carbohydrates. Koxhold *et al.* (2001) found that meltdown of ice cream is influenced by its composition and by fat globule size.

2.3.6 Protein

The proteins in ice cream are mostly derived from milk, and small amount from stabilizers (Arbuckle, 1966). According to PFA Act (1954) ice cream should contain not less than 3.5 per cent protein. Naidu *et al.* (1986) studied replacement of MSNF in ice cream with whey solids at 10, 20 and 30 per cent resulted in 4.04, 3.84 and 3.61 per cent protein respectively.

Rao *et al.* (1988) found that soft serve frozen dessert made with sweetened milk resulted in decrease in protein content and the value ranged from 4.1 to 4.2 per cent. Das *et al.* (1989) conducted a study on ice cream made by incorporation of different levels of potato pulp and observed that 15, 25 and 35 per cent replacement of MSNF with boiled potato pulp resulted in 3.7, 3.6 and 3.3 per cent protein respectively. Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix had lower protein content as compared to that of control and values ranged from 3.88 to 3.95 per cent.

2.3.7 Sucrose

According to the BIS specification (IS: 2802-1964) ice cream should contain maximum of 15 per cent sugar by weight. Sucrose commonly known as granulated sugar is made from sugarcane or sugar beets. It is crystalline in nature and contained 99.9 per cent solids (Marshall *et al.*, 2003).

2.3.8 Total solids

According to PFA Act (1954) ice cream should contain not less than 36 per cent total solids. According to the BIS specification (IS: 2802-1964) ice cream should contain minimum of 36 per cent total solids by weight. Rao *et al.* (1988) found that soft serve frozen dessert made with sweetened milk resulted in decreased total solid content and the values ranged from 35.5 to 35.9 per cent.

Flores and Goff (1999) found that ice crystal size distributions of frozen ice cream were directly related to total solids in the formulation. Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix had lower total solid content as compared to control and values ranged from 37.25 to 37.56 per cent.

2.4 PHYSICO-CHEMICAL PROPERTIES OF ICE CREAM AND FROZEN DESSERT

2.4.1 Whipping ability

El-Neshawy *et al.* (1988) reported that ice cream mixes containing hydrolyzed lactose reconstituted milk showed higher whipping ability. Schimdt *et al.* (1993) found that the use of carbohydrate based fat replacers in reduced fat ice cream resulted in mixes, which incorporated less air than a control mix or protein based fat replacer mix.

Geevarghese (1996) found that whipping ability was lowest for ice cream as compared to kera ice cream containing coconut cream during the first five minutes of freezing but it significantly increased during the second five minutes of freezing. Baer (1997) reported that emulsifiers increased the viscosity of low fat ice cream mix and reduced whipping time. Tirumalesha *et al.* (1998)

observed that substitution of skim milk solids with whey protein concentrate resulted in significant improvements in the whipping rate of ice cream.

Moorthy and Balachandran (2000) reported that the whipping properties of the ice cream mixes determined ease with which the air is incorporated into the ice cream and fineness of dispersion of air cells. They also observed that the whipping properties are affected by process variables such as fat, MSNF, stabilizer and emulsifier including homogenization and ageing. Pinto *et al.* (2004) reported that the acidity of the mix influences the viscosity, which in turn affects the whipping ability of the mix. They also studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix had lower whipping ability when compared to control and values ranged from 1.037 to 1.127 (cm3/g).

2.4.2 Overrun

Overrun is defined as the volume of ice cream obtained in excess of volume of mix and is expressed as per cent. The increased volume is due to incorporation of air into ice cream during freezing process. Frandsen and Arbuckle (1961) and Arbuckle (1966) reported that the overrun for packed ice cream ranged from 70 to 80 and soft ice cream 30 to 50 per cent. Elhami *et al.* (1977) observed that the overrun of ice cream decreased with increase in margarine and the values ranged from 54.46 to 62.61 per cent.

El-Safty *et al.* (1978) observed that the use of hydrogenated oils at varying levels in ice cream resulted in decreased overrun and values ranged from 56.3 to 59.9 per cent. Youssef *et al.* (1981) reported that slight decrease in overrun was proportional to the level of substitution of butter oil with milk fat increased and values ranged from 32 to 33.1 per cent. They attributed that as substitution rate increased specific gravity also increased and this might be the reason for reduction in overrun.

El-Neshawy *et al.* (1988) observed that ice cream mixes containing hydrolyzed lactose reconstituted milk showed higher overrun. Das *et al.* (1989) observed that overrun percentage decreased significantly as the levels of substitution of MSNF with boiled potato pulp solids increased and the values ranged from 32.3 to 35.8 per cent. Geilman and Schmidt (1992) reported that replacement of milk fat with ultra filtered retentate resulted in lower overrun. Similarly, Schimdt *et al.* (1993) found that the use of carbohydrate based fat replacers in reduced fat ice cream resulted in low overrun.

Geevarghese (1996) observed that the overrun percentage increased as replacement with coconut fat increased in kera ice cream and values ranged from 51.6 to 61.5 per cent. Substitution of skim milk solids with whey protein concentrate resulted in significant improvements in overrun of ice cream (Tirumalesha *et al.*, 1998). Pinto *et al.* (2004) studied the effect of ginger juice in ice cream and observed that an increase in the level of ginger juice led to decrease in the overrun of ice cream. They also found that incorporation of ginger juice beyond 4 per cent level in ice cream mix led to significant decline in over run and the values ranged 37.13 to 39.29 per cent.

2.4.3 Specific gravity

Elhami *et al.* (1977) found that replacing butterfat with margarine in ice cream resulted in increased specific gravity. Reddy *et al.* (1987) reported that replacement of milk solids not fat (MSNF) by chhana whey solids increased specific gravity of ice cream. Geevarghese (1996) observed a decreasing trend in specific gravity as replacement with coconut fat increased in kera ice cream.

2.4.4 Weight per litre

AS per BIS specification (IS: 2802-1964) minimum weight in g per litre for plain and fruit ice cream are 525 and 540 respectively. Elhami *et al.* (1977) observed that substitution of butterfat with margarine resulted in increase in weight per gallon of ice cream. El-Safety *et al.* (1978) reported that replacing butterfat by hydrogenated oil up to 50 per cent had negligible effect on weight per gallon of ice cream mix. They also found that the weight per gallon of the ice cream made by replacing hydrogenated oil at the rate of 20 and 50 per cent were 5.70 and 5.90 pound and was proportional to the specific gravity values in all treatments.

2.4.5 Meltdown time

Meltdown is also an important property of ice cream affecting its sensory quality. Deviation in the melting property from ideal condition can make the ice cream defective. The ideal body is produced by the correct proportion of solids (both butter fat and MSNF) and proper overrun. In general, as the viscosity increases the resistance to melting and smoothness of body increases (Arbuckle, 1966).

Elhami *et al.* (1977) found that replacing butter fat with margarine decreased the melting rate. Youssef *et al.* (1981) studied the effect of partial substitution of cream with butter oil, cottonseed oil and corn oil in ice cream and reported that a pronounced decrease in the meltdown properties was detected in case of cottonseed oil and a slight for the corn oil.

Rao *et al.* (1988) prepared frozen dessert using sweetened fermented milk and found that the melting resistance increased due to its addition and meltdown values ranged from 50.7 to 57.8 minutes. Das *et al.* (1989) proved that addition of potato pulp in ice cream resulted in an increase in melting time with positive correlation with the levels of the substitution and the values ranged from 58.4 to 63.7 minutes.

Conforti (1993) incorporated corn sweetener blend in place of sucrose in ice cream, which resulted in similar melting rates as compared to 100 per cent sucrose ice cream. Geevarghese (1996) observed a decreasing trend in meltdown time as replacement with coconut fat increased in kera ice cream. Tirumalesha *et* *al.* (1998) concluded that substitution of skim milk solids with whey protein concentrate resulted in decreased melting resistance of ice cream.

Pinto *et al.* (2004) studied the effect of ginger juice in ice cream and observed that the melting resistance of ice cream samples increased progressively with increasing levels of ginger juice addition. Ginger contained some hydrocolloids (starch), which might be responsible for increased viscosity and hence the melting resistance.

2.5 MICROBIOLOGY OF ICE CREAM AND FROZEN DESSERT

According to BIS specification (IS: 2802-1964) ice cream should contain not more than 2,50,000 and 90 per g for standard plate count and coliform count respectively. Arora and Sudarsanam (1986) found that the bacteria in ice cream come from two sources (i) ingredients used (ii) contamination during manufacturing and handling.

Ramakrishnan *et al.* (1986) observed that conditions during manufacture, handling, storage, and transportation are the major chances of contamination. Shrestha and Sinha (1987) studied the occurrence of coliform bacteria in dairy products and found that 77 per cent of ice cream contained unsatisfactory levels of coliforms on the basis of Indian standards.

Staphylococcus spp. which can survive for four to seven months at –28°C was isolated from ice cream of poor quality that was prepared with contaminated ingredients, kept in improperly packed containers and stored in unsanitary conditions (Yadav *et al.*, 1993). Patwari (1995) detected coliforms, lactic acid bacteria and micrococci in ice cream and he also attributed it due to unclean equipment and utensils used for the production of ice cream.

Kumari *et al.* (1996) detected organisms such as *Staphylococcus aureus, Staphylococcus epidemidis, Streptococcus pyogenes, Klebsiella aerogenes and Enterobacter aerogenes* as well as coliforms and fungi such as Aspergillus spp.

Pencillium spp and Mucor spp in ice cream samples, which was due to imperfect sanitary conditions followed during handling, production and storage of ice cream in Mumbai region. Arslan *et al.* (1996) studied the microbial quality of ice cream samples marketed in Elazig region and detected Listeria, Salmonella, E.coli type 1, and *Klebsiella pneumonia* indicating that above samples do not meet microbiological quality standards required for consumer health.

Erol *et al.* (1998) found that the pathogenic microorganism in ice cream predisposed it to a poor hygienic quality, which was responsible for food infections and intoxications and thereby posed the potential risk to public health. This can be evaded by following hygienic precautions by the producers. Bostan *et al.* (2002) conducted a study on the microbiological quality of industrial ice cream and the product was of acceptable microbial quality, since the quality of the raw material and plant was good.

2.6 ENERGY VALUE AND NUTRIENTS

The energy value and nutrients of ice cream depend upon the food value of the ingredients from which it was made. Marshall *et al.* (2003) reported that on a weight basis ice cream contains three to four times as much fat, 12 to16 per cent as much protein, four times as much carbohydrate as milk and they also reported that the total caloric value of ice cream depends on the percentage of carbohydrates, protein and fat and 100 g of ice cream contained 212 k cal of energy.

They also reported that 70 g servings of ice cream contributed 58 to 135 mg of calcium 75 to175 µg of riboflavin in diet, which was directly proportional to non-fat milk solids (NMS) in ice cream. They also stated that ice cream is a good source of vitamin A, thiamin, pyridoxine and pantothenic acid.

Kumar (2004) reported that the calcium and phosphorus content of ice cream were derived almost entirely from the NMS. He also reported that a standard 10 per cent fat ice cream contained approximately 200 kcal per 100g and a reduction in the caloric content could be achieved by reducing or replacing either fat or sugar or both.

2.7 SENSORY CHARACTERESTICS

Arbuckle (1966) reported that texture of ice cream is attributed to the grain or fine structure, which is dependent upon the size, shape and arrangement of the ice crystals. Ice cream with ideal texture will have crystals too small to be detected in the mouth. He also reported that the ideal body is produced by the correct proportion of solids (both butter fat and milk solids not fat) and the proper overrun.

Elhami *et al.* (1977) found that margarine up to 50 per cent had negligible effect on body and texture of ice cream. El-Safty *et al.* (1978) studied use of hydrogenated oils in ice cream making and found that adding 20 per cent hydrogenated oil had a slight tallowy flavour. They also observed that hydrogenated oil upto 20 per cent had a slight greasy texture and 10 per cent hydrogenated oil yielded a firm, smooth and velvety body and texture comparable to the control samples.

Youssef *et al.* (1981) studied the effect of partial substitution of cream by butter oil, cotton seed oil and corn oil and results indicated the possibility of using butter oil as a substitute for milk fat up to 50 per cent without affecting the flavour as well as body and texture. If cotton seed oil or corn oil is used as substitute, 25 per cent is recommended as maximum without noticeable effect on the qualities of the finished product and substitution of milk fat with above oils at a rate higher than 25 and 35 per cent respectively imparted off flavour to the ice cream mix.

Naidu *et al.* (1986) studied the effect of utilization of whey and observed that the mean organoleptic scores for ice cream of different treatments such as 10, 20, 30 per cent replacement with whey solids ranged from 89.13 to 94.2. The ice cream prepared by replacing a maximum of 20 per cent MSNF with whey solids was most acceptable where as 30 per cent replacement was not or less acceptable.

Nair and Geevarghese (1988) prepared a dairy analogue by replacing butter fat up to 80 per cent in ice cream with fat from freshly prepared coconut cream, without any noticeable change in the sensory quality of the product. Rao *et al.* (1988) prepared soft serve frozen dessert using varied amounts of sweetened fermented milk and standard plain ice cream mix and compared its physico-chemical properties with ice cream of standard composition. Results indicated that the frozen dessert prepared by the combination of two parts of ice cream mix and one part of fermented milk was found to be superior to plain ice cream and it scored 93 out of 100.

El-Neshawy *et al.* (1988) studied the organoleptic and physical properties of ice cream made from hydrolyzed lactose reconstituted milk and observed that the product showed better organoleptic properties than the control. Das *et al.* (1989) prepared ice cream by replacing 15 and 25 per cent MSNF with boiled potato pulp and its organoleptic evaluation indicated that it was equally acceptable as control.

Donhowe *et al.* (1991) reported that ice crystal size is a critical attribute governing the texture of ice cream and other frozen desserts. They also reported that larger ice crystals could result in coarse or grainy texture if present in sufficient number. Geilman and Schmidt (1992) observed that frozen dessert incorporating ultra filtered milk resulted in harder body, but smoother texture than that of normal ice cream.

Conforti (1994) reported that replacement of sucrose with corn sweetener blend resulted in smooth texture as compared to 100 per cent sucrose ice cream. Specter and Setser (1994) reported that replacement of milk fat with tapioca or potato maltodextrin increased coarseness and wateriness and decreased creaminess relative to control. Geevarghese (1996) studied the technological evaluation of kera ice cream and found that organoleptic quality of kera ice cream was comparable to that of normal ice cream and the values ranged from 93 to 95.

Guinord *et al.* (1996) reported that ice cream with higher fat content had better flavour and texture ratings as determined by a sensory panel. Li *et al.* (1997) studied the effect of milk fat content in flavor perception of vanilla ice cream and found that as fat content was increased, sensory quality improved and overall preference increased.

Tirumalesha *et al.* (1998) studied the effect of substitution of skim milk solids with whey protein concentrates and found that hardness of ice cream decreased with increase in whey protein concentrate level. Ronald *et al.* (1999) observed that the addition of fat replacers to fat free ice cream resulted in a decrease in the amount of ice in the product. These fat replacers gave the appearance and texture of the ice cream but did not match the attributes imparted by 10 per cent fat.

Aime *et al.* (2001) reported that low fat and fat free ice creams prepared using a modified pea starch have lower smoothness and mouth coating. Hyvonen *et al.* (2003) observed that polydextrose and maltodextrin as bodying agents in the fat free ice cream significantly increased flavour release and melting rate of ice cream. Maltodextrin and polydextrose increased perceived fattiness and creaminess of fat free ice cream. Clarke (2004) found that as ice crystal size increases the texture of ice cream become less smooth.

2.8 COST ANALYSIS OF FROZEN DESSERT

Reddy *et al.* (1987) proved that when SNF was replaced by chhana whey solids at 15, 25 and 35 per cent in ice cream making the reduction in cost was 5.3, 8.9 and 12.5 per cent respectively. Rao *et al.* (1988) prepared soft serve frozen dessert using varied amounts of sweetened fermented milk and standard plain ice cream mix and estimated the cost of the product based on the existing market prices of ingredients which indicated that a cost reduction of 9.6, 13.0 and 19.3 per cent was possible when different ratios were used.

Nair and Geevarghese (1988) achieved a reduction of 33 per cent in the material cost of the ice cream by substituting 80 per cent of butterfat with fat from coconut cream. Das *et al.* (1989) reported that when 25 per cent of milk SNF was replaced by potato pulp 8.5 per cent reduction in production cost could be achieved. Cheema and Arora (1991) calculated the cost of 100 ml of ice cream where milk fat was replaced by groundnut oil, soybean oil, and corn oil, which were (in rupees) 1.12, 1.07, and 1.12 respectively against 1.29 for control ice cream. The savings in cost of production for kera ice cream with 100 per cent replacement of milk fat was calculated as 40.57 per cent compared to control (Geevarghese, 1996).

Materials and Methods

3. MATERIALS AND METHODS

The main objective of the study was to assess the feasibility of incorporating mango pulp, at different levels in the preparation of low fat frozen dessert. The work was carried out in the department of Dairy Science, College of Veterinary and Animal Sciences, Mannuthy utilizing the facilities of Kerala Agricultural University (KAU) Dairy Plant. The products prepared were analyzed for physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes. Analytical grade reagents were used throughout the study. Six replications were done and the data were analysed by statistical methods (Snedecor and Cochran, 1989).

3.1 MATERIALS

These are divided in to dairy ingredients and non-dairy ingredients.

3.1.1 Dairy ingredients

3.1.1.1 Milk

Pasteurized cow milk was procured from the KAU Dairy Plant, Mannuthy.

3.1.1.2 Skim milk

Fresh-pooled cow milk was collected from the KAU Dairy Plant, Mannuthy, which was skimmed using cream separator to obtain the skim milk.

3.1.1.3 Skim milk power

Spray dried skim milk power (Anikspray, Anik Industries Pvt. Ltd. Mumbai-400 021) was used in the preparation of ice cream as source of MSNF.

3.1.1.4 ***Butter***

Unsalted butter purchased from the local market (Amul, Nambisans) was used in the preparation of ice cream.

3.1.2 Non dairy ingredients

3.1.2.1 ***Mango Pulp***

Ripened mangoes of Neelum variety was collected from KAU mango orchard.

3.1.2.2 ***Sugar***

Cane sugar purchased from local market was used in the experiment.

3.1.2.3 ***Stabilizer***

Carrageenan manufactured by Davars M.P. Organics, Tansen Road, Gwalior-474 002 (M.P. India) was used for the experiment.

3.1.2.4 ***Emulsifier***

Glyceryl mono stearate manufactured by Davars M.P. Organics, Tansen Road, Gwalior-474 002 (M.P. India) was used.

3.1.2.5 ***Flavour***

Liquid synthetic mango flavour manufactured by Dawn Foods and Flavours, R.T. Nagar, Bangalore was used.

3.1.2.6 ***Colour***

Synthetic food colour (Lemon yellow) containing sodium chloride and tartrazine manufactured by Bush Boake Allen (India) Ltd, Chennai-600 016 was used. The colour solution was prepared by mixing 4 g of powder in 100 ml of distilled water.

3.1.2.7 Plate count agar

Plate Count Agar (Sisco Research Laboratories, Mumbai-400 049, India) was used for standard plate count in ice cream.

3.1.2.8 Violet red bile agar

Violet Red Bile Agar (Himedia Laboratories Ltd. Mumbai-400 086 India.) was used for the enumeration of coliforms in ice cream

3.1.2.9 Peptone water

Peptone Water (Sisco Research Laboratories, Mumbai-400 049, India) was used for diluting the samples.

3.2 METHODS

3.2.1 Preparation of mango pulp

Collected mangoes were rinsed initially with chlorine water (10 ppm) and then thoroughly washed with clean water and peeled. Fleshy portion from peeled mangoes were cut into pieces, and made into pulp in a domestic liquidizer.

3.2.2 Estimation of total solids of mango pulp

The total solids in mango pulp were estimated by gravimetric method.

(IS: SP (Part I) 1980).

3.2.3 Analysis of fat in milk, skim milk, skim milk powder and butter

The fat content of milk, skim milk, skim milk powder and butter were estimated by the procedure laid out in IS: SP 18 (Part XI), 1981.

3.2.4 Analysis of total solids in milk, skim milk, skim milk powder and butter

The procedure described in IS: SP: 18 (Part XI) 1981 was followed for estimating total solids of milk, skim milk powder and butter. Total solids of skim milk was estimated following the procedure described in Atherton and Newlander (1987).

3.3 PROCEDURE FOR THE PREPARATION OF ICE CREAM AND LOW FAT FROZEN DESSERT

The method described by De (1980) was followed in the preparation of ice cream. Flow chart of procedure is given in Fig 1.

3.3.1 Selection of ingredients

The ingredients such as skim milk powder, butter, sugar, stabilizer, emulsifier, flavour and colour were selected for different treatments according to need.

3.3.2 Figuring the mix

The proportionate quantity of different ingredients to meet the minimum standard for fat and total solids as per PFA Act (1954) for the preparation of ice cream and frozen desserts were derived by computer aided linear programming model.

3.3.3 Making the mix

Ingredients used for the preparation of ice cream were weighed and taken in a milk cooker and heated with frequent agitation. The sequence of addition was liquid ingredients first followed by solid ingredients.

3.3.4 Pasteurizing the mix

The mix was pasteurized at a temperature of 68.5°C for 30 minutes.

3.3.5 Homogenizing the mix

Homogenization of the mix was done at a temperature of 65°C at a pressure of 150 kg/cm^2 at first stage and 30 kg/cm^2 at the second stage.

3.3.6 Cooling and ageing the mix

After cooling and before ageing the mix, required quantity of the pasteurized mango pulp was added and mixed well to get uniform distribution of mango pulp. The mix after homogenization was immediately cooled to room temperature and later transferred to a cold storage maintained at a temperature of 4 ± 1°C for 4 hours.

3.3.7 Freezing the mix

Flavour at the rate of 4 ml per litre and required quantity of colour was added to the mix and mixed well. The mix was then frozen using a softy ice cream freezer.

3.3.8 Packaging of ice cream

The frozen product was collected in 50 ml ice cream cups and were subjected to sensory evaluation and analysis.

3.3.9 Hardening and storage of ice cream

The frozen ice cream was placed in deep freezer at a temperature of –25 to –29°C for hardening and subsequent storage.

3.4 PREPARATION OF LOW FAT FROZEN DESSERT INCORPORATING MANGO PULP.

The procedure outlined in 3.3 was followed in the preparation of frozen dessert. The quantities of different ingredients required were arrived by chemical analysis and subsequent figuring of mix as described in 3.3.2.

In treatment I frozen dessert was prepared replacing 50 per cent milk fat with mango pulp to maintain the total solids as per PFA Act for ice cream.

In treatment II frozen dessert was prepared replacing 100 per cent milk fat with mango pulp to maintain the total solids as per PFA act for ice cream. The mango pulp was added to the mix after cooling. Flavour and colour were not added to treatment samples. All other processing steps were same for control and treatment samples. Six replications were carried out for each treatment. The proportion of ingredients used in the preparation of control and low fat frozen desserts are given in Table 1.

The physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes of frozen dessert incorporating mango pulp with different levels were studied and compared with control ice cream containing 10 per cent fat.

3.5 PHYSICO-CHEMICAL PROPERTIES OF CONTROL AND TREATMENT MIXES

3.5.1 *Titratable acidity*

The titratable acidity of control and treatment mixes were determined as per the procedure outlined by Arbuckle (1966).

3.5.2 pH

The pH of control and treatment mixes were determined by pH Scan 2 (MERCK) pH meter.

3.5.3 Viscosity

The apparent viscosity values of the samples were measured with a Brooke Field Viscometer Model DV-1 using 500 ml of samples refrigerated over night. After standardizing the equipment the spindle was allowed to rotate and the spindle was immersed into the sample slowly. Readings were taken at 20^0C.

3.5.4 Total solids

Total solids of ice cream and treatment mixes were determined as per the procedure outlined by Arbuckle (1966).

3.5.5 Fat

The fat percentage in ice cream and treatment mixes were determined using the procedure outlined by Arbuckle (1966).

3.5.6 Protein

The percentage of protein in the ice cream and treatment mixes were estimated using the procedure outlined by Arbuckle (1966).

3.5.7 Sucrose

Percentage of sucrose in ice cream and frozen dessert mixes were determined using the procedure outlined in IS: 2802 (1964).

3.5.8 Specific Gravity

The specific gravity of the ice cream mixes after ageing for four hours was determined using standard specific gravity bottle. The mix was weighed at a temperature of 20°C. Weight of equivalent amount of water was recorded at the same temperature. Specific gravity was calculated using the formula (Rajor, 1980).

$$\text{Specific Gravity} = \frac{\text{Weight in gram of the sample}}{\text{Weight in gram of water}}$$

3.6 ANALYSIS OF ICE CREAM AND TREATMENT SAMPLES

The frozen products were analyzed for the following parameters.

3.6.1 Weight per litre

Weight per litre of ice cream and frozen dessert was estimated using the procedure outlined in IS: 2802 (1964).

3.6.2 Specific Gravity

The specific gravity of the ice cream was determined using standard specific gravity bottle (Rajor, 1980) as per the procedure mentioned in 3.5.8.

3.6.3 Overrun

The over run percentage obtained in the control and experimental treatments I and II were calculated using the formula suggested by De (1980).

$$\text{Percentage overrun} = \frac{\left[\begin{array}{c}\text{Weight of unit}\\ \text{volume of mix}\end{array}\right] - \left[\begin{array}{c}\text{Weight of unit}\\ \text{volume of ice cream}\end{array}\right]}{\text{Weight of unit volume of ice cream}} \times 100$$

3.6.4 Meltdown Time

The meltdown time (MDT) was estimated following the procedure outlined by Rajor (1980). Hundred gram of frozen dessert was carefully placed on a four square inch glass plate rested on the brim of five inches glass funnel, fitted on a metal stand with its tail end leading into a 100 ml graduated cylinder. The time taken for complete meltdown was recorded.

3.6.5 Whipping ability

The whipping ability of the product was determined by the procedure outlined by Rajor (1980) while the mix was being frozen in a softy ice cream freezer, a certain volume of the mix was drawn at 5 minutes after the commencement of freezing and weighted. The loss of weight of the mix due to air incorporation was recorded.

3.6.6 Microbiological analysis

3.6.6.1 Preparation of diluents

Peptone water was used for serial dilution of samples. 11 gram of ice cream and frozen dessert sample were transferred aseptically into 99 ml of peptone water. 1 ml of apparent dilution (10^1) was used for coliform count and standard plate count.

3.6.6.2 Total colony count

Total colony count of ice cream and frozen desserts was estimated using the procedure outlined in IS: 2802 (1964).

3.6.6.3 Coliform count

Coliform count of ice cream and frozen dessert was enumerated using the procedure outlined in IS: 2802 (1964).

3.6.7 Sensory evaluation

A panel of selected judges conducted sensory evaluation of ice cream. The evaluation was done using the scorecard adopted by the American Dairy Science Association (Arbuckle, 1966). The scorecard is appended as Appendix I.

According to Nelson and Trout (1964) there was a general practice to allot full ratings of 15 points, under the item of bacteria as it is impossible to judge the bacterial population by organoleptic test.

3.6.7 Cost analysis

The cost of preparation of 1 kg of ice cream mix was calculated based on the cost of individual ingredients. The prevailing market rate of ingredients was taken into account for calculating the cost of ice cream (Table 1).

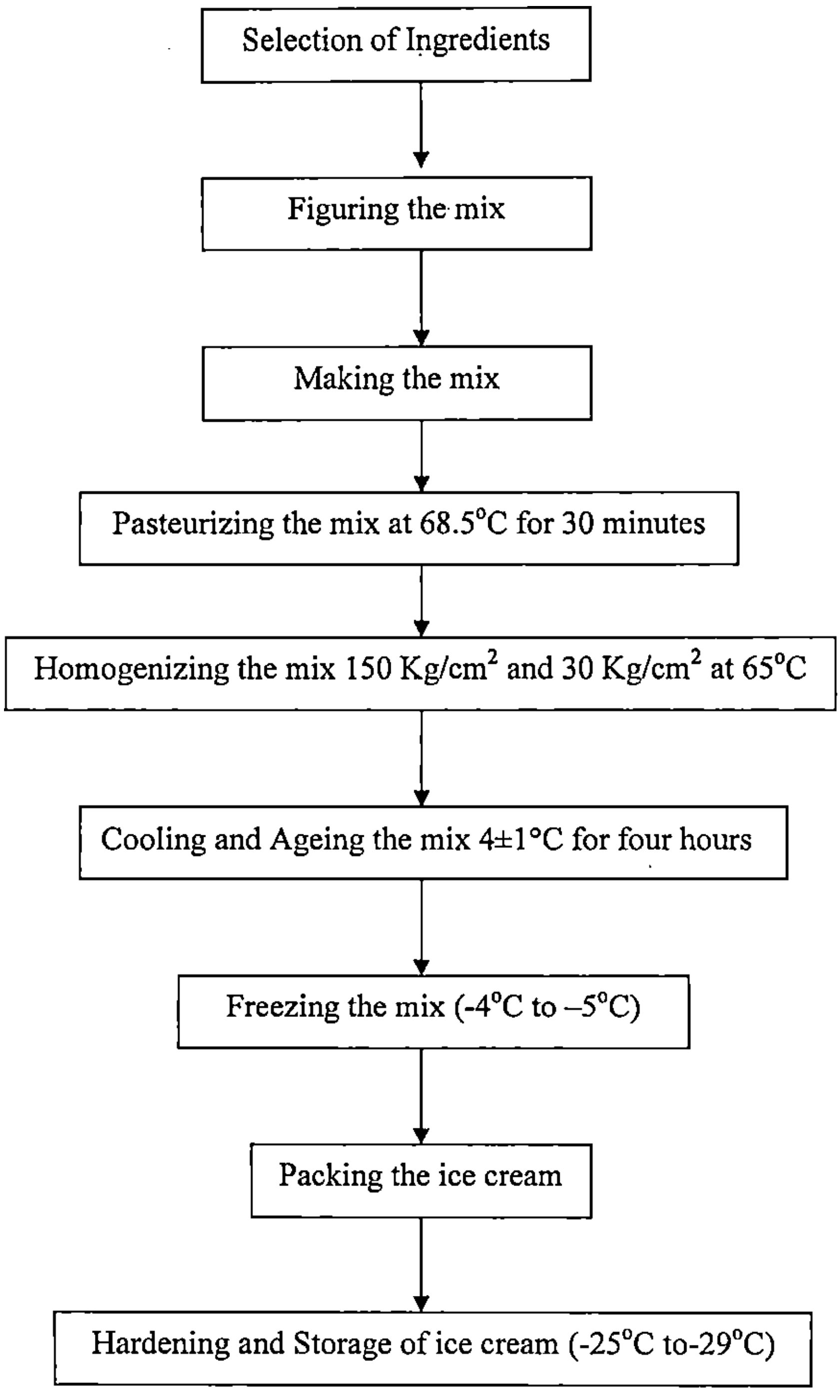
3.6.9 Energy value

Energy value of the product was determined from the chemical composition as per the procedure out lined in Mc Donald *et al.* (2002).

3.7 STATISTICAL ANALYSIS

The experiment was carried out with 6 replications. The data obtained were subjected to statistical analysis (Snedecor and Cochran, 1989).

Fig. 1 Flow chart for the preparation of ice cream



Results

4. RESULTS

A study was conducted in detail to assess the feasibility of incorporating mango pulp at different levels in the preparation of low fat frozen dessert and to compare its qualities. The results of the experiments in six replications for each group are presented in the following section.

4.1 EXTRACTION AND ANALYSIS OF MANGO PULP

The edible portion of ripe mangoes excluding the nuts and peels ranged from 55.42 to 59.62 per cent with a mean of 58.73. The edible portion was made into pulp and its total solids ranged from18.71 to 20.30 per cent with a mean of 19.04. The data with respect to yield and composition are presented in Table.2

4.2 ANALYSIS OF DAIRY INGREDIENTS

The dairy ingredients used in the preparation were analysed for fat and total solids. The mean fat and total solids (per cent) presented in Table 3 were 3.90 and 12.52 for milk, 0.11 and 8.72 for skim milk, 0.53 and 97.21 for skim milk powder and 81.06 and 82.31 for butter respectively.

4.3 PHYSICO-CHEMICAL PROPERTIES OF CONTROL AND TREATMENT MIXES

4.3.1 Specific gravity

Analyses of the data with regard to specific gravity of control and treatment mixes are presented in Table 4 and Fig. 2. The mean for control and treatment mixes T_1 and T_2 were 1.078, 1.128 and 1.156 respectively. Statistical analysis of the data revealed that there is significant difference ($P<0.01$) between control and treatments and among treatments indicating that there is linear increase in specific gravity, as the replacement level was higher.

4.3.2 Viscosity

Viscosity (cp) for control and treatment mixes are presented in Table 4 and Fig. 3. The mean for control and treatments were 88.35, 161.48 and 272.98 respectively. Analysis of variance showed significant difference ($P<0.01$) between control and treatment mixes as well as among the treatments, indicating that as the level of incorporation increased it resulted in higher viscosity.

4.3.3 Titratable acidity.

Analysis of the data with regard to titratable acidity (per cent lactic acid) of ice cream and treatment mixes are presented in Table 5 and Fig. 4. The mean for control and treatment mixes were 0.184, 0.238 and 0.250 respectively for control and treatments. Results indicated that as the replacement level with mango pulp increased, the acidity also increased and statistical analysis of the data indicated a significant difference ($P<0.01$) in titratable acidity between control and treatments and among treatments.

4.3.4 pH.

Analysis of the data presented in Table. 5 and Fig. 4. With regard to pH of control and treatment mixes revealed significant difference ($P<0.01$) between control and treatment samples. The mean for control and treatment samples were 6.33, 6.04 and 6.01 respectively. Between the treatments there was no significant difference ($P>0.05$) indicating that the level of replacement have no influence on the pH.

4.3.5 Fat

Data with respect to fat per cent of control and treatment mixes are presented in Table 6 and Fig. 6. The mean for control and treatment mixes were 10.05, 5.04 and 0.33 respectively. The data when statistically analysed revealed significant difference ($P<0.01$) between control and treatments, and this difference was expected, since figuring of the mixes was done accordingly.

4.3.6 Protein

The statistics with respect to protein per cent of control and treatment mixes are presented in Table 6 and Fig. 7. The protein per cent (mean) for control and treatments were 4.20, 3.59 and 3.35 respectively. Analysis of variance showed significant difference ($P<0.01$) between control and treatment mixes where as no significant difference ($P>0.05$) existed between treatments, indicating that level of replacement does not influence protein percentage of mix.

4.3.7 Sucrose

Data with regard to sucrose per cent of control and treatment mixes are presented in Table 7 and Fig. 8. The mean for T_0, T_1, and T_2 mixes were 15.00, 18.18 and 19.21 respectively. Mean sucrose per cent increased as the replacement level was higher and the statistical analysis of the data indicated a significant difference ($P<0.01$) between control and treatments and among treatments.

4.3.8 Total solids

The total solids per cent of control and treatment mixes T_1 and T_2 are presented in Table 7. The mean values were 37.21, 37.37 and 37.35 respectively. Statistical analysis revealed no significant difference ($P>0.05$) between control and treatments.

4.4 PHYSICO-CHEMICAL PROPERTIES OF ICE CREAM AND FROZEN DESSERTS

4.4.1 Whipping ability

The whipping ability of ice cream and frozen dessert (mean) in percentage five minutes after the commencement of freezing are presented in Table 10 and Fig. 3. The values were 33.16, 31.15 and 26.61 for T_0, T_1 and T_2 respectively. Statistical analysis revealed that there is no significant difference ($P>0.05$)

between T_0 and T_1 where as T_2 showed a decrease in whipping ability and was significant ($P<0.01$). This indicated that replacement of milk fat with mango pulp at 100 per cent level resulted in lower whipping ability.

4.4.2 Overrun

The results with respect to overrun per cent for control and treatments are depicted in Table 9 and Fig. 5. The mean were 48.53, 46.32 and 37.10 for control and treatments T_1 and T_2 respectively. Statistical analysis of the data revealed that, there is significant difference ($P<0.01$) between control and treatments and among the treatments. The overrun was higher for control and it decreased as the level of replacement with mango pulp increased.

4.4.3 Specific gravity

Data with respect to specific gravity of ice cream and treatments are presented in Table 8. Mean values were 1.016, 1.054 and 1.099 respectively for control and treatments T_1 and T_2. Mean specific gravity values showed an increasing trend as the replacement level of mango pulp increased as compared to control. Statistical analysis of the values indicated that there is significant difference ($P<0.01$) between control and treatments and among treatments.

4.4.4 Weight per litre

The data with regard to weight per litre in grams are depicted in Table 8 and Fig. 2. The mean were 757.41, 800.23 and 826.11 for control and treatments T_1 and T_2 respectively. The mean weight per litre showed an increasing trend as the replacement level with mango pulp increased. The control had the lowest weight per litre of 757.41 as compared to a value of 826.11 for T_2. When the data was subjected to statistical analysis there was a significant difference ($P<0.01$) between control and treatments and among the treatments.

4.4.5 Meltdown time.

The mean meltdown time (min.) for ice cream was 52.78 where as treatments T_1 and T_2 had meltdown time of 66.96 and 69.78 respectively (Table. 9 and Fig. 5). It is obvious that the meltdown time was lowest for control where as the time was more in treatments T_1 and T_2. Data on statistical analysis revealed a significant increase between control and treatments and among treatments.

4.5 MICROBIOLOGICAL QUALITY OF ICE CREAM AND FROZEN DESSERTS

The microbiological quality of the products were assessed by enumerating standard plate count and the respective data are presented in Table 11. The mean $\log_{10}$ cfu per g for the control and treatments were 5.41, 5.43 and 5.51 respectively. Statistical analysis of the data revealed no significant difference ($P>0.05$) between control and treatments and among treatments indicating that incorporation of mango pulp does not produce any significant difference in standard plate count as compared to control.

The mean with respect to coliform count per g for control and treatments T_1 and T_2 were 45.7, 48.9 and 51.2 respectively (Table 11). Statistical analysis revealed no significant difference ($P>0.05$) between control and treatments and among treatments indicating that level of replacement of milk fat with mango pulp had no influence on coliform count as compared to control.

4.6 ENERGY VALUE OF THE PRODUCTS

Energy value (kcal) per100 g of the ice cream and frozen dessert samples with mean are presented in Table 10 and Fig. 6. The values were 207.55, 164.41 and 134.75 respectively for control and treatments. Statistical analysis showed a significant difference ($P<0.01$) between control and treatments indicating that the energy value decreased as the level of replacement of mango pulp increased.

4.7 SENSORY EVALUATION OF ICE CREAM AND FROZEN DESSERT

Analysis of data presented in Table 12 with regard to flavor score of control and treatments revealed no significant difference (P>0.05) between them. The mean score for the control (T_0) was 39.52 and for treatments T_1 and T_2 were 40.24 and 38.37 respectively. Even though T_1 had a highest mean score of 40.24 statistically it was not significant (P>0.05). This indicated that addition of mango pulp does not produce any significant difference in the flavor score as compared to control.

Data with respect to body and texture score of ice cream and treatments T_1 and T_2 presented in Table 12 were (mean) 27.60, 27.68 and 26.90 respectively. Data when statistically analysed revealed no significant difference (P>0.05) between control and treatments and among treatments indicating that the organoleptic quality with respect to body and texture of control and treatments were identical.

The mean melting quality scores for control and treatments T_1 and T_2 were 4.5, 4.3 and 4.3 respectively (Table 12). The statistical analysis of the data revealed that the addition of mango pulp had no significant influence on the melting quality of the product and was comparable to control. Analysis of data presented in Table 12 with regard to colour and packaging revealed no significance difference (P>0.05) between control and treatments and among treatments. The mean score for control and treatments were 4.6, 4.5 and 4.4 respectively.

The total score obtained by sensory evaluation considering the parameters mentioned as above are presented in Table 12 and Fig. 9. The mean for control and treatments T_1 and T_2 were 91.29, 91.55, and 89.40 respectively. Even though the treatment T_2 had a lowest score of 89.40 statistical analysis of the data revealed that no significant difference (P>0.05) existed between control and treatments and among treatments. The results indicated that the organoleptic quality of frozen dessert incorporating mango pulp at 50 and 100 per cent levels replacing milk fat are equally acceptable as normal ice cream.

4.8 COST ANALYSIS

The cost of one kg of control and treatment mixes were calculated based on the ingredient cost (Table 1 and Fig. 10). The cost of ingredients for one kg control (rupees) was 33.24, where as for treatment T_1 and T_2 were 30.53 and 29.63 respectively. The savings in cost was 8.15 and 10.86 per cent for treatments T_1 and T_2 respectively as compared to control indicating that incorporation of mango pulp in frozen dessert replacing fat will be economical.

Table 1. Quantity of ingredients and cost of 1 kg ice cream and frozen dessert mixes

Treatments		QUANTITY OF INGREDIENTS PER 1kg.						
		Milk	Skim Milk	Skim Milk Powder	Butter	Stabilizer & Emulsifier	Sugar	Mango Pulp
Control	Qty (g)	710.5	-	47.2	89.3	3	150	-
	Cost (Rs)	9.94	-	6.60	12.50	1.50	2.70	-
T_1	Qty	483.9	-	75.2	37.9	3	150	250
	Cost	6.77	-	10.51	5.30	1.50	2.70	3.75
T_2	Qty	-	409.5	118.1	-	3	150	319.4
	Cost	-	4.11	16.53	-	1.50	2.70	4.79

Table 2. Yield per mango fruit and total solids of mango pulp

Property	Range	Mean±SE
Yield (per cent)	55.42 to 59.62	58.73±0.37
Total solids (per cent)	18.71 to 20.30	19.04±0.26

Table 3. Mean fat and total solids of dairy ingredients

Ingredients	Fat (per cent)	Total solids (per cent)
Milk	3.90	12.52
Skim milk	0.11	8.72
Skim milk powder	0.53	97.21
Butter	81.06	82.31

Table 4. Specific gravity and viscosity of control and treatments

Property	Mean and Range	T_0	T_1	T_2
Specific gravity	Mean ± SE	1.078 ± 0.008^{A}	1.128 ± 0.005^{B}	1.156 ± 0.004^{C}
	Range	1.055-1.106	1.104-1.141	1.141-1.172
Viscosity (cp)	Mean ± SE	88.35 ± 0.38^{A}	161.48 ± 2.85^{B}	272.98 ± 1.03^{C}
	Range	87.25-89.37	153.32-174.26	208.04-314.35

(Means bearing different superscripts differ significantly at $P<0.01$)

Table 5. Titratable acidity and pH of control and treatment mixes

Property	Mean and Range	T_0	T_1	T_2
Titratable Acidity (%)	Mean ± SE	0.184 ± 0.003^{A}	0.238 ± 0.004^{B}	0.250 ± 0.005^{C}
	Range	0.174-0.196	0.223-0.250	0.245-0.259
pH	Mean ± SE	6.33 ± 0.02^{A}	6.04 ± 0.01^{B}	6.01 ± 0.004^{B}
	Range	6.29-6.42	6.01-6.10	6.00-6.03

(Means bearing different superscripts differ significantly at $P<0.01$)

Table 6. Fat and protein content of control and treatment mixes

Property	Mean and Range	T_0	T_1	T_2
Fat (%)	Mean ± SE	10.05 ± 0.01^{A}	5.04 ± 0.02^{B}	0.33 ± 0.05^{C}
	Range	10.01-10.12	4.97-5.10	0.25-0.50
Protein (%)	Mean ± SE	4.20 ± 0.15^{A}	3.59 ± 0.09^{B}	3.35 ± 0.09^{B}
	Range	3.84-4.86	3.16-3.79	3.17-3.82

(Means bearing different superscripts differ significantly at $P<0.01$)

Table 7. Sucrose and total solids of control and treatment mixes

Property	Mean and Range	T_0	T_1	T_2
Sucrose (%)	Mean ± SE	15.00± 0.24^A	18.18±0.15^B	19.21± 0.14^C
	Range	13.98-15.59	17.79-18.82	18.68-19.73
Total solids (%)	Mean ± SE	37.21±0.22	37.37±0.38	37.35±0.43
	Range	36.32-38.04	36.41-38.97	35.91-38.78

(Means bearing different superscripts differ significantly at P<0.01)

Table 8. Specific gravity and weight per litre of control and treatments

Property	Mean and Range	T_0	T_1	T_2
Specific gravity	Mean ± SE	1.016±0.00^A	1.054±0.008^B	1.099±0.008^C
	Range	1.011-1.02	1.034-1.084	1.084-1.098
Weight/litre (g)	Mean ± SE	757.41±3.60^A	800.23±1.59^B	826.11±4.56^C
	Range	744.9-768.4	792.8-804.3	825.1-836.6

(Means bearing different superscripts differ significantly at P<0.01)

Table 9. Overrun and Meltdown time of control and treatments

Property	Mean and Range	T_0	T_1	T_2
Overrun (%)	Mean ± SE	48.53 ± 0.18^A	46.32 ± 0.28^B	37.10 ± 0.31^C
	Range	48.04-49.19	46.12-47.70	36.10-38.00
Meltdown time (min)	Mean ± SE	52.78 ± 0.33^A	66.96 ± 0.17^B	69.78 ± 0.26^C
	Range	51.6-53.7	66.3-67.5	68.9-70.3

(Means bearing different superscripts differ significantly at P<0.01)

Table 10. Whipping ability and Energy value of control and treatments

Property	Mean and Range	T_0	T_1	T_2
Whipping ability (%)	Mean ± SE	33.16 ± 0.66^A	31.15 ± 0.72^A	26.61 ± 0.72^B
	Range	32.1-34.0	30.3-32.1	25.8-27.5
Energy value (kcal /100 g)	Mean ± SE	207.55 ± 1.76^A	164.41 ± 1.75^B	134.75 ± 1.32^C
	Range	202.7-214.2	160.8-168.7	130.6-138.2

(Means bearing different superscripts differ significantly at P<0.01)

Table 11. Standard plate count and coliform count of control and treatments

Property	Mean and Range	T_0	T_1	T_2
Std. plate count (log_{10} cfu / g)	Mean ± SE	5.41±0.20	5.43±0.15	5.51±0.21
	Range	5.11-5.65	5.26-5.72	5.29-5.81
Coliform count / g	Mean ± SE	45.7±0.01	48.9±0.01	51.2±0.08
	Range	38.0-48.9	44.6-52.4	47.8-58.8

Table 12. Sensory evaluation of control and treatments

Property	Max. score	Mean and Range	T_0	T_1	T_2
Flavour	45	Mean ± SE	39.52±0.68	40.24± 0.55	38.37 ± 0.43
		Range	37.00-41.60	36.35-41.60	37.14-40.00
Body and texture	30	Mean ± SE	27.60± 0.31	27.68 ± 0.24	26.90± 0.28
		Range	26.57-28.80	27.00-28.40	26.14-27.00
Melting quality	5	Mean ± SE	4.5± 0.11	4.3 ± 0.006	4.3± 0.05
		Range	4.2-4.8	4.2-4.6	4.1-4.5
Colour and package	5	Mean ± SE	4.6±0.08	4.5±0.08	4.4±0.11
		Range	4.4-5.0	4.3-4.9	4.1-4.8
Bacteria	15	Mean ± SE	15.00±0.00	15.00±0.00	15.00±0.00
		Range	--------	--------	--------
Total	100	Mean ± SE	91.29±1.00	91.55±0.85	89.40±0.65
		Range	88.07-94.70	87.66-93.53	86.86-91.11

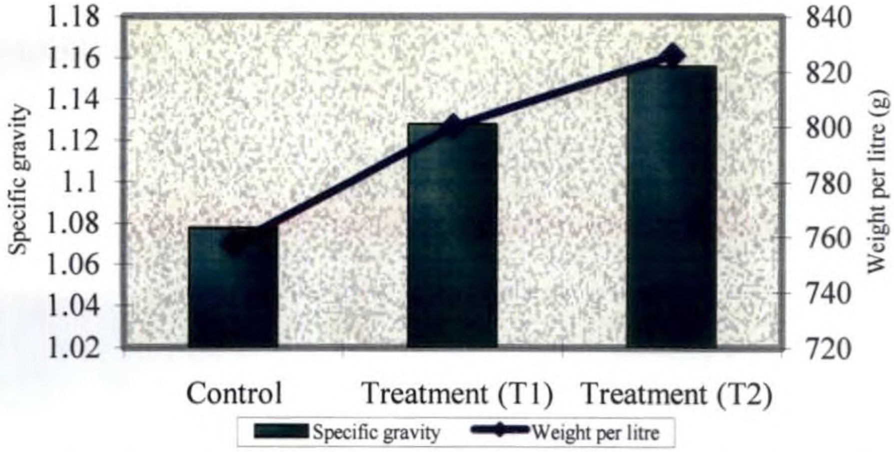


Fig. 2. Specific gravity and weight per litre of control and treatments

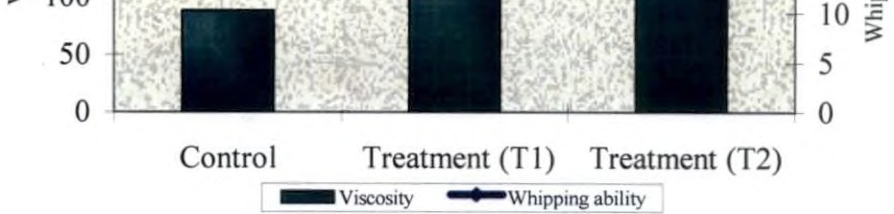


Fig. 3. Viscosity and whipping ability of control and treatments

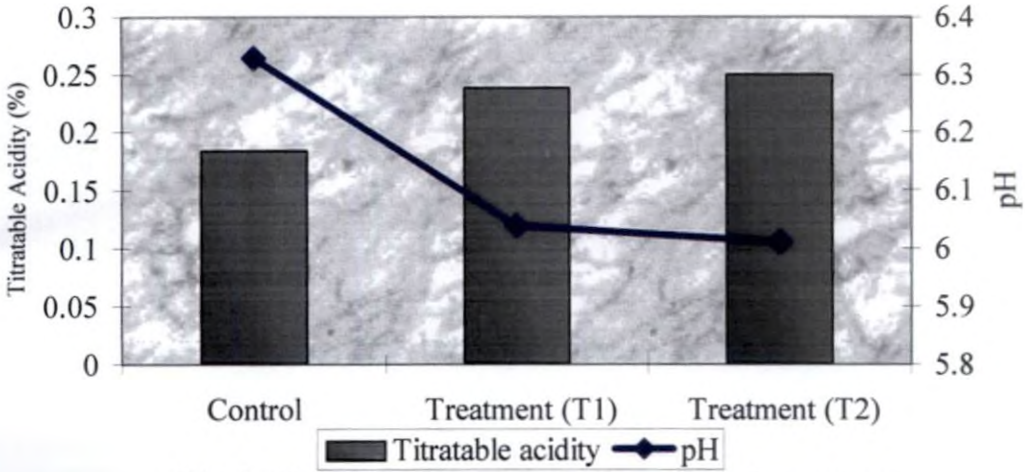


Fig. 4. Titratable acidity and pH of control and treatments

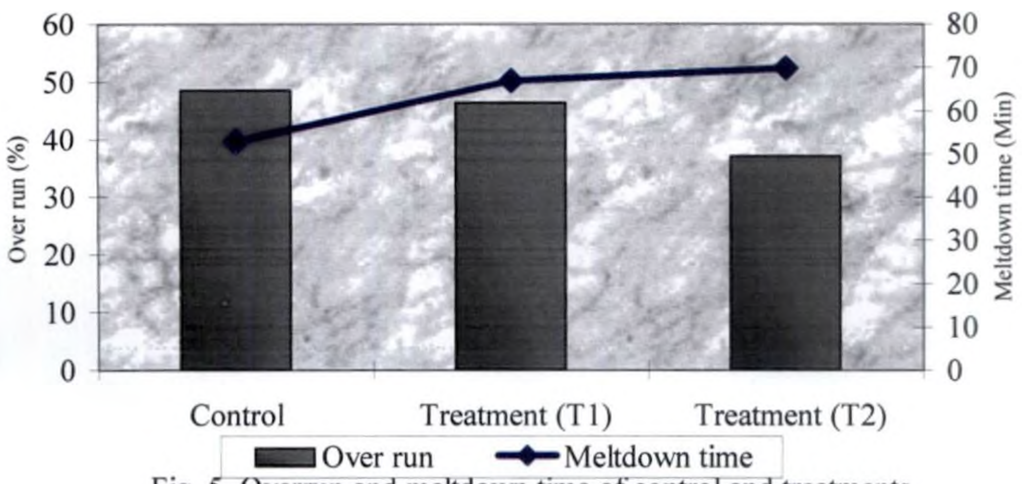


Fig. 5. Overrun and meltdown time of control and treatments

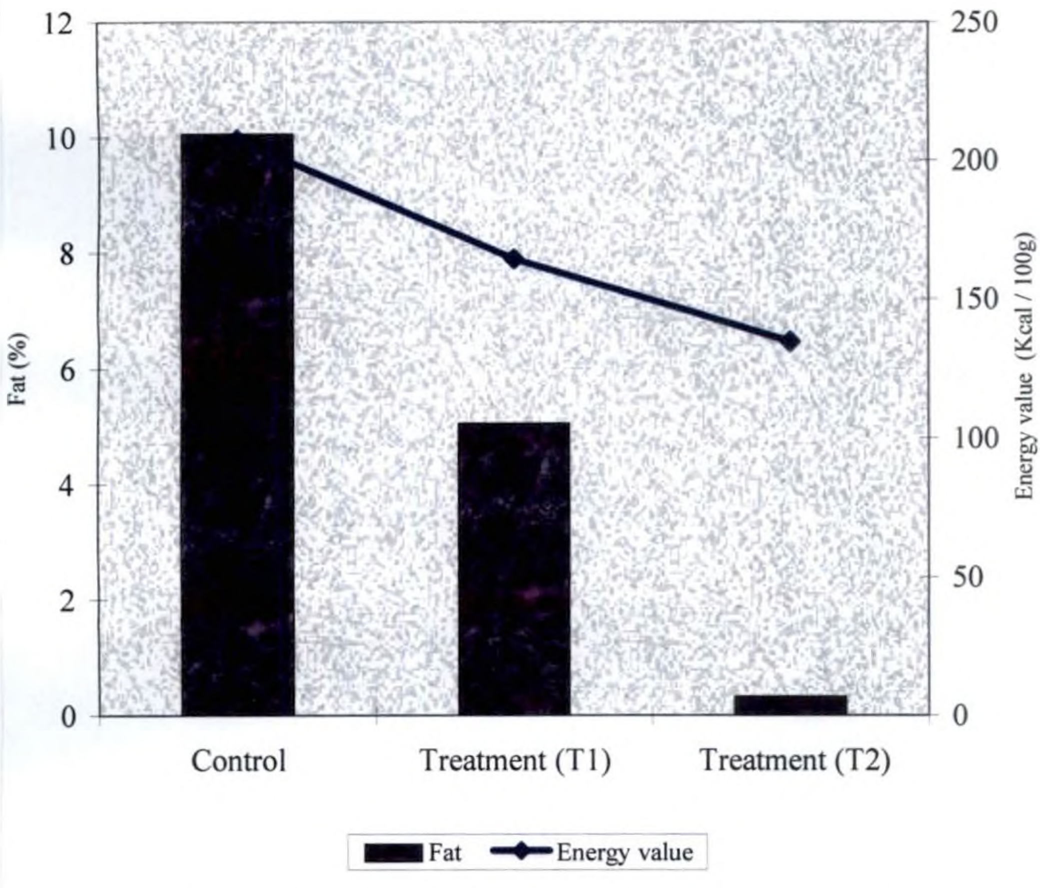


Fig. 6. Fat and energy value of control and treatments

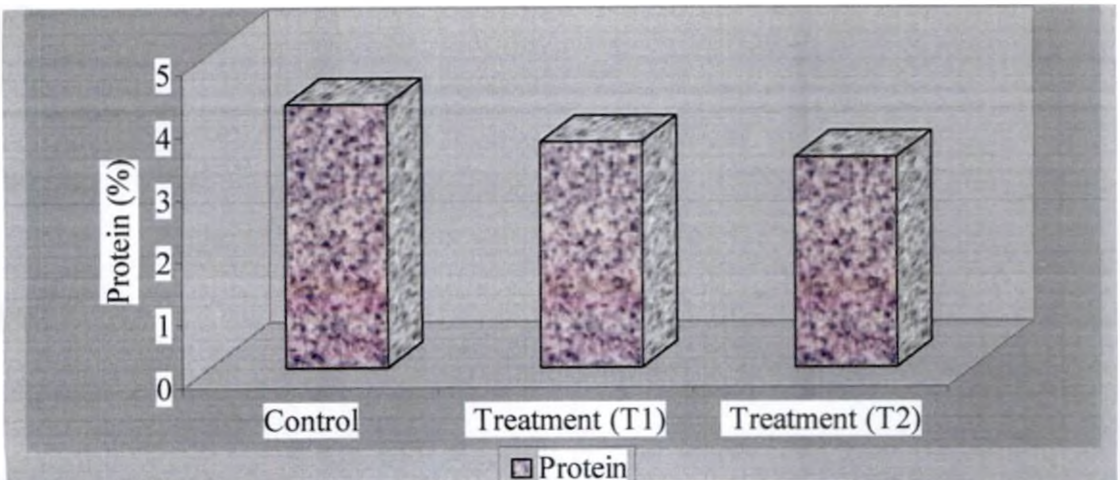


Fig. 7. Protein content of control and treatments

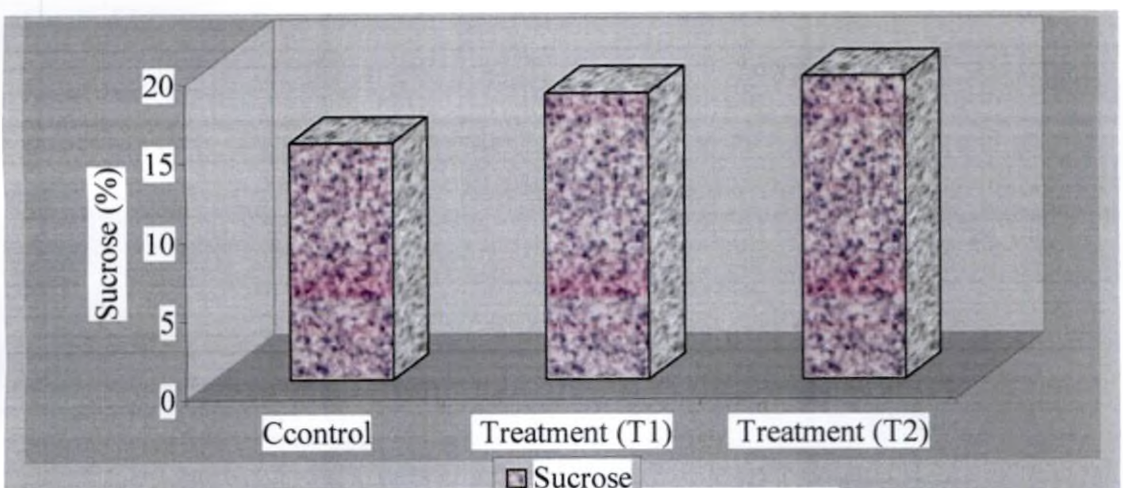


Fig. 8. Sucrose content of control and treatments

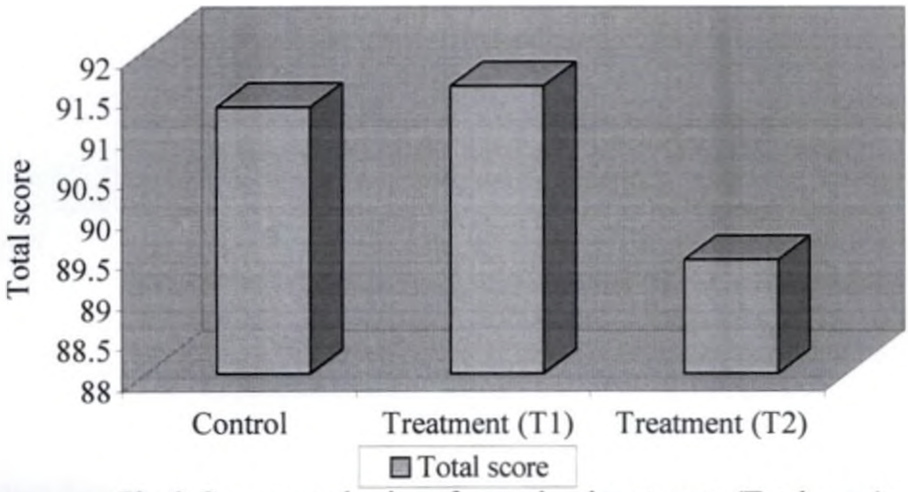


Fig. 9. Sensory evaluation of control and treatments (Total score)

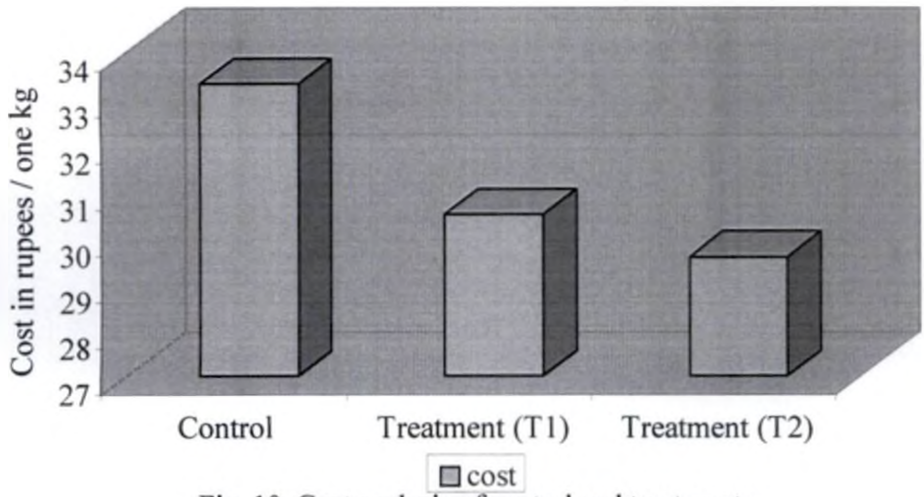


Fig. 10. Cost analysis of control and treatments

Discussion

5. DISCUSSION

This study was undertaken to explore the feasibility of using mango pulp at various levels for the manufacture of low fat frozen desserts. The products prepared were analysed for various physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes and were compared to standard ice cream. The results of the experimental findings are discussed in this chapter.

5.1 EXTRACTION AND ANALYSIS OF MANGO PULP

The mean yield of mango pulp was 58.73 per cent, which was comparable to the value of 63.6 per cent reported by Gowda and Huddar (2004). The mean total solids content in mango pulp for various replications were 19.04 per cent (Table 2). This value was comparable to the value of 20.38 per cent reported by Acharya and Shah (1999), 16.5 per cent reported by Nandini and Oommen (2002) and 18.95 per cent reported by Gowda & Huddar (2004).

5.2 ANALYSIS OF DAIRY INGREDIENTS

The dairy ingredients such as milk, skim milk, skim milk powder and butter used in the preparation of ice cream and treatments were analysed for fat and total solids (Table 3). The values obtained for milk and skim milk were with in the minimum limit prescribed by PFA Act (1954). The fat and total solids recorded for the skim milk were closer to the report of De (1980) and Webb *et al.* (1987).

The values for skim milk powder were with in the limit prescribed by BIS specification (IS: 1165, 1967) and PFA Act and closer to the values reported by Hall and Hedrick (1971). The obtained values for butter were with in the limit prescribed by PFA Act and also in close agreement with the report of De (1980).

5.3 PHYSICO-CHEMICAL PROPERTIES OF CONTROL AND TREATMENT MIXES

5.3.1 Specific gravity

Data with regard to specific gravity presented in Table 4 and Fig. 2 revealed that there is a linear increase in specific gravity as the replacement level was higher. The value for control was in accordance with the reports by Arbuckle (1966). Similar result was reported by Rao *et al.* (1988) when they used fermented milk in frozen dessert mixes.

But there are reports of non significant effect on specific gravity when replacing butterfat by hydrogenated oil up to 50 per cent (El-Safety *et al.*, 1978) and coconut fat (Geevarghese, 1996). Das *et al.* (1989) observed that mean specific gravity decreased with increase in potato pulp content in the ice cream mixes. Elhami *et al.* (1977) reported that replacing butterfat with margarine had a negligible effect on the specific gravity of ice cream mix.

The increase or decrease in the specific gravity of ice cream mixes can be attributed to the specific gravity of the components used in the mix preparation. In the present investigation mainly milk fat was replaced by mango pulp having higher specific gravity, which might have resulted in higher value.

5.3.2 Viscosity

The data with respect to viscosity presented in Table 4 and Fig. 3 indicated that viscosity values (cp) increased as percentage replacement of milk fat increased. The mean value for control and treatments T_1 and T_2 were 88.35, 161.48 and 272.98 respectively. According to Arbuckle (1966) normal viscosity values ranged from 50 to 300 cp for ice cream mixes and factors such as composition, kind and quality of ingredients, total solids concentration, processing and handling of the mix were influencing viscosity of ice cream mix.

Following reports by various scientists also agree with the present study. Viscosity values of different categories of ice cream made by incorporating margarine (Elhami *et al.*, 1977), hydrogenated oil (El-Safty *et al.*, 1978), fermented milk (Rao *et al.*, 1988), butter oil (Youssef *et al.*, 1981), coconut cream (Geevarghese, 1996), hydrolysed lactose reconstituted milk (El-Neshawy *et al.*, 1988), boiled potato pulp (Das *et al.*, 1989) and ginger juice (Pinto *et al.*, 2004) had resulted in increased viscosity as compared to control.

Decrease in viscosity values were reported in ice cream incorporating cottonseed and corn oil (Youssef *et al.*, 1981), whey solids (Naidu *et al.*, 1986) and whey protein concentrate (Tirumalesha *et al.*, 1998). The increase in viscosity values noted for the treatments in this experiment was attributed to the composition and quality of ingredients.

5.3.3 Titratable acidity

Analysis of the data with regard to titratable acidity (per cent lactic acid) of ice cream and treatment mixes presented in Table 5 and Fig. 4 revealed that as the replacement level with mango pulp increased, titratable acidity increased significantly ($P<0.01$). The mean for control and treatment mixes were 0.184, 0.238 and 0.250 respectively.

De (1980) suggested that normal acidity of the ice cream mixes should not be more than 0.25 per cent and in the present investigation all the samples had an acidity of less than or equal to 0.25 per cent. The results are in agreement with the reports of Elsafty *et al.* (1978), Naidu *et al.* (1986), Das *et al.* (1989) and Pinto *et al.* (2004) that, the acidity of ice cream mixes increased by incorporating hydrogenated oil, whey solids, potato pulp and ginger juice. Geevarghese (1996) found that replacement of milk fat with coconut fat at any level does not influence the acidity. It is generally accepted that the acidity of the ingredients used in the mix preparation will have a direct bearing on mix acidity. In the present investigation mango pulp, which had high acidity of 0.26, 0.21 and 0.47 per cent reported by Acharya and Shah (1999), Nandini and Oommen (2002), Hymavathi and Khader (2004) might have resulted in higher acidity of ice cream mixes. However the values obtained for acidity were with in the limits prescribed by BIS (IS: 2802 –1964) specification and De (1980).

5.3.4 pH

Data presented in Table 5 and Fig. 4 with respect to pH of control and treatment mixes revealed significant difference ($P<0.01$) between control and treatments. The mean pH for control and treatment samples were 6.33, 6.04 and 6.01 respectively. Frandsen and Arbuckle (1961), Arbuckle (1966), De (1985) and Marshall *et al.* (2003) reported that the normal pH of an ice cream mix is about 6.3. Nair and Geevarghese (1988) found that 80 per cent substitution of milk fat with coconut fat in kera cream did not produce any appreciable difference in pH. The experimental findings are in agreement with the reports of Elhami *et al.* (1977), Naidu *et al.* (1986), Rao *et al.* (1988) and Das *et al.* (1989) that ice cream incorporating margarine, whey solids, sweetened fermented milk, and potato pulp could decrease the pH. In the present investigation the pH of the control mix was in concurrence with the values reported by the above researchers. In the present experiment milk fat was replaced by mango pulp, which had a pH of 4.06 and 4.49 reported by Nandini and Oommen (2002) and Gowda and Huddar (2004). De (1985) reported that acidity and pH are related to the composition of mix and an increase in MSNF raises the percentage acidity and lowers the pH. Decrease in pH obtained in the present experiment for treatments was due to higher acidity of the mixes, increase in MSNF and low pH of the mango pulp.

5.3.5 Fat

Analysis of the data with respect to fat per cent of control and treatments are presented in Table 6 and Fig. 6. The mean value for control and treatment mixes were 10.05, 5.04 and 0.33 respectively. Statistically analysed data revealed significant difference ($P<0.01$) between control and treatments, and this difference was expected, since figuring of the mixes was done accordingly.

According to PFA Act and BIS specification ice cream should contain minimum 10 per cent fat. In the present study, the experiment was designed to have a control meeting legal standards and this aim was satisfied. Treatments T_1 and T_2 were figured in such a way to replace 50 and 100 per cent fat with mango pulp. Even though 100 per cent replacement was aimed in T_2 it could not be materialized since skim milk used in the trial, which had a mean fat percentage of 0.11.

5.3.6 Protein

The data with respect to protein per cent of control and treatment mixes are presented in Table 6 and Fig. 7. The mean protein per cent for control and treatments were 4.20, 3.59 and 3.35 respectively. Analysis of the data indicated that the protein content was less in treatments as compared to control and there is a statistical difference ($P<0.01$) between control and treatments and no difference ($P>0.05$) among treatments. According to PFA Act ice cream should contain a minimum of 3.5 per cent protein and control and treatment T_1 met the legal standards where as T_2 had lower protein content. Naidu *et al.* (1986) studied the effect of replacement of MSNF with whey solids in ice cream at 10, 20 and 30 per cent levels, which resulted in protein content of 4.04, 3.84 and 3.61 per cent protein respectively.

The results are similar to the reports of Das *et al.* (1989) that 15, 25 and 35 per cent replacement of MSNF with boiled potato pulp resulted in protein percentage 3.7, 3.6 and 3.3 respectively. Rao *et al.* (1988) opined that frozen dessert made with sweetened fermented milk resulted in decrease in protein content and the value ranged from 4.2 to 4.1 per cent. Pinto *et al.* (2004) found that ice cream mix incorporating ginger juice had lower protein content when compared to control and value ranged from 3.95 to 3.88 per cent. In the present experiment the protein content in treatment T_2 was low since higher quantity of mango pulp was incorporated and it contained a very low level of protein (0.58 per cent) as reported by Acharya and Shah (1999).

5.3.7 Sucrose

Analysis of the data with regard to sucrose per cent of control and treatment mixes are presented in Table 7 and Fig. 9. The mean values for T_0, T_1, and T_2 mixes were 15.00, 18.18 and 19.21 respectively. Statistical analysis of the data indicated a significant difference ($P<0.01$) between control and treatments and among treatments and mean sucrose per cent increased proportional to the higher level of replacement with mango pulp.

Bose (1985) reported that sugars in mango comprises of sucrose, glucose, fructose, maltose, arabinose, sedoheptulose and mannoheptulose. Gujral and Khanna (2002) reported that Neelum variety mango contained 14.95 per cent total sugar out of which 6.25 is reducing sugar. Gowda and Huddar (2004) reported that mango pulp contained 9.38 per cent total sugar out of which 7.63 per cent is reducing sugar and 1.75 per cent was non-reducing sugar. In the present investigation high sucrose content was obtained for treatments T_1 and T_2. This has resulted from the addition of mango pulp in the treatments where as in control only 15 per cent sugar has been added. Treatment T_2 had a higher sucrose content as compared to T_1 since the quantity of mango pulp added was higher.

5.3.8 Total solids

Analysis of the data with respect to total solids per cent of control and treatment mixes T_1 and T_2 are presented in Table 7. Statistical analysis revealed no significant difference (P>0.05) between control and treatments and among treatments since the mean values were 37.21, 37.37 and 37.35 respectively. According to PFA Act and BIS specification ice cream should contain minimum of 36 per cent total solids by weight. Rao *et al.* reported that soft serve frozen dessert made with sweetened fermented milk resulted in decrease in total solid content and the values ranged from 35.5 to 35.9 per cent as percentage replacement increased.

Pinto *et al.* (2004) studied the physico-chemical and sensory characteristics of ginger juice based herbal ice cream and found that the resultant ice cream mix have lower total solids content as compared to control and value ranged from 37.25 to 37.56 per cent. In the present investigation the total solid content of control and treatments were more than what is prescribed under PFA Act and BIS specification. This was achieved by proper figuring of mixes taking in to consideration the composition of ingredients used in ice cream making.

5.4 PHYSICO-CHEMICAL PROPERTIES OF ICE CREAM AND FROZEN DESSERT

5.4.1 Whipping ability

Data with regard to whipping ability of ice cream and frozen dessert (mean) five minutes after the commencement of freezing are presented in Table 10 Fig. 3. The values were 33.16, 31.15 and 26.61 per cent for T_0, T_1 and T_2 respectively. Statistical analysis revealed that there is no significant difference (P>0.05) between T_0 and T_1 where as T_2 showed a decrease in whipping ability and was significant. This indicated that replacement of milk fat with mango pulp at 100 per cent level resulted in lower whipping ability. The results are in agreement with the reports of Schimdt *et al.* (1993) that the use of carbohydrate based fat replacers in reduced fat ice creams resulted in mixes, which incorporated less air than a control mix or protein based fat replacer mix. Pinto *et al.* (2004) reported that the acidity of the mix influences the viscosity, which in turn affects the whipping ability of the mix. They also found that the resultant ice cream mix containing ginger juice had lower whipping ability which is due to higher acidity of the mixes as compared to control.

Cheema and Arora (1991) proved that replacement of milk fat with various vegetable fat considerably decreased the whipping time of ice cream. Tirumalesha *et al.* (1998) reported that substitution of skim milk solids with whey protein concentrate resulted in significant improvements in the whipping rate of ice cream. Geevarghese (1996) found that whipping ability was lowest for the control than kera ice cream containing coconut cream during the first 5 min. of freezing but it significantly increased during the second five min. of freezing. El-Neshawy *et al.* (1988) reported that ice cream mixes containing hydrolyzed lactose reconstituted milk showed higher whipping ability.

In the present investigation the lower whipping ability observed in treatments is due to higher acidity of treatment mixes as compared to control. Marshall *et al.* (2003) reported that a lower viscosity seems to be desirable for fast freezing and rapid whipping. In the present investigation viscosity values of treatments were significantly higher than the control.

5.4.2 Overrun

Data with respect to overrun per cent for control and treatments are presented in Table 9 and Fig. 5. The mean values were 48.53, 46.32 and 37.10 for control and treatments T_1 and T_2 respectively. Statistical analysis of the data revealed that, there was significant difference ($P<0.01$) between control and treatments and among treatments. The overrun was higher for control and it decreased as the level of replacement with mango pulp increased.

The experimental findings are in agreement with the results of Elhami *et al.* (1977) that the overrun decreased with increase in margarine and the value ranged from 54.46 to 62.61 per cent. El-Safty *et al.* (1978) observed that use of hydrogenated oils in ice cream resulted in decreased overrun and value ranged from 56.3 to 59.9 per cent. Youssef *et al.* (1981) observed that slight decrease in overrun was proportional to the percentage of substitution of butter oil and values ranged from 32.0 to 33.1 per cent. They attributed that as substitution level increased specific gravity also increased resulting in lower overrun. Das *et al.* (1989) observed that the overrun percentage decreased significantly as the levels of substitution of MSNF with boiled potato pulp solids increased and values ranged from 32.3 to 35.8 per cent.

Similar to this Geilman and Schmidt (1992) reported that when milk SNF was replaced with ultra filtered retentate resulted in lower overrun. Similarly, Schimdt *et al.* (1993) found that the use of carbohydrate based fat replacers in reduced fat ice creams resulted in mixes with higher viscosities and lower overrun. Pinto *et al.* (2004) observed that an increase in the level of ginger juice led to decrease in the overrun of ice cream. They also found that incorporation of ginger juice beyond 4 per cent level in ice cream mix led to significant decline in over run and values ranged from 37.13 to 39.29 per cent.

Contrary to this, Geevarghese (1996) observed that the overrun percentage increased as replacement with coconut fat increased and values ranged from 51.6 to 61.5 per cent. Tirumalesha *et al.* (1998) reported that substitution of skim milk solids with whey protein concentrate resulted in significant improvements in overrun of ice cream. El-Neshawy *et al.* (1988) observed that ice cream mixes containing hydrolyzed lactose reconstituted milk showed higher overrun. In the present experiment the overrun obtained was in agreement with the values reported by Arbuckle (1966) for soft ice cream. The values reported by Youssef *et al.* (1981), Das *et al.* (1989), Pinto *et al.* (2004) were also in agreement with the values recorded in the present experiment.

A higher overrun could not be expected in this experiment since a softy ice cream freezer was used which does not have a provision to incorporate air at higher levels. However, there was a significant reduction in the overrun for the treatments as compared to control. The different factors which have influenced the whipping ability as discussed in 5.4.1 above have also influenced the overrun of the final product.

5.4.3 Specific gravity

Specific gravity values of ice cream and treatments are presented in Table 8. Mean values were 1.016, 1.054 and 1.099 respectively for control and treatments T_1 and T_2. Statistical analysis of the values indicated that there was significant difference (P<0.01) between control and treatments and among treatments. Mean specific gravity values showed an increasing trend as the replacement level of mango pulp increased as compared to control.

Similar results are reported by Elhami *et al.* (1977) that replacing butterfat with margarine resulted in increased specific gravity. Reddy *et al.* (1987) reported that replacement of milk SNF by chhana whey solids increased specific gravity of ice cream. Contrary to this Geevarghese (1996) found that replacement of milk fat with coconut fat resulted in decreased specific gravity of ice cream and the values ranged from 0.851 to 0.857.

The increase in specific gravity in treatment T_1 and T2 compared to control can be attributed to the lesser overrun in treatments. Control ice cream incorporated more air during freezing process that resulted in higher overrun and less specific gravity.

5.4.4 Weight per litre

The mean weight per litre in g are presented in Table 8 and Fig. 2. The mean values were 757.41, 800.23 and 826.11 for control and treatments T_1 and T_2 respectively. The mean weight per litre showed an increasing trend as the replacement level with mango pulp increased. The control had the lowest weight per litre of 757.41 as compared to a value of 826.11 for T_2. When the data was analysed statistically there was a significant difference ($P<0.01$) between control and treatments and among the treatments.

As per BIS specification minimum weight in g per litre for plain ice cream and fruit ice cream are 525 and 540 respectively. In the present investigation a significantly higher weight per litre was observed in treatments T_1 and T_2. This can be correlated with the overrun for treatments T_1 and T_2. Overrun percentage was lowest for T2. As the overrun decreased the weight per litre increased. The substitution of milk ingredients resulting in higher weight per litre was reported by Elhami *et al.* (1977). It is worth mentioning that all samples had higher weight than recommended by BIS specification.

5.4.5 Meltdown time

The data with respect to meltdown time (min.) revealed that the time required for meltdown decreased as percentage replacement of milk fat with mango pulp increased (Table 9 and Fig. 5). Meltdown time (min.) for control ice cream was 52.78 where as treatments T_1 and T_2 had meltdown time of 66.96 and 69.78 respectively. Statistical analysis of the data revealed a significant difference ($P<0.01$) between control and treatments and among treatments.

Rao *et al.* (1988) prepared frozen dessert using sweetened fermented milk and found that the melting resistance increased due to addition of sweetened fermented milk and meltdown values ranged from 50.7 to 57.8 min. Das *et al.* (1989) proved that addition of potato pulp in ice cream resulted in an increase in melting time with positive correlation with the levels of the substitution and the value ranged from 58.4 to 63.7 min. Pinto *et al.* (2004) studied the effect of ginger juice in ice cream and observed that the melting resistance of ice cream samples containing ginger juice increased progressively with increasing level of ginger juice addition. Ginger contain some hydrocolloids (starch), which might be responsible for increased viscosity and hence the melting resistance.

Contrary to this, Geevarghese (1996) observed a decreasing trend in meltdown time as replacement with coconut fat increased in kera ice cream. Tirumalesha *et al.* (1998) opined that substitution of skim milk solids with whey protein concentrate resulted in decrease in melting resistance of ice cream. The reason for the increased meltdown values observed in the present experiment may be due to the decreased overrun observed in the treatment groups as compared to control.

5.5 MICROBIOLOGY OF ICE CREAM AND FROZEN DESSERT

5.5.1 Standard Plate Count and Coliform count

The mean values of standard plate count (SPC) were in $\log_{10}$ cfu per g were 5.41, 5.43 and 5.51 respectively for T_0, T_1 and T_2. Analysis of the data revealed no significant difference (P>0.05) between control and treatments and among treatments indicating that incorporation of mango pulp does not produce any significant difference in standard plate count as compared to control. Both control and treatments T_1 and T_2 had a slightly higher SPC than what is recommended as per BIS specification.

Data with respect to coliform count per g for control and treatments T_1 and T_2 were 45.7, 48.9 and 51.2 respectively (Table 11). Analysis of the data revealed no significant difference (P>0.05) between control and treatments and among treatments indicating that level of replacement of milk fat with mango pulp had no influence on coliform count as compared to control.

Shrestha and Sinha (1987) studied the occurrence of coliform bacteria in dairy products and found that 77 per cent of ice cream contained unsatisfactory levels of coliforms on the basis of Indian standards. Ramakrishnan *et al.* (1986) reported that contamination in ice cream is attributed to manufacturing conditions, handling, storage and transportation of the products. Coliforms were detected by Patwari (1995). The microbial quality of any food product is an index of the hygienic practices followed during the various stages of the processing. BIS specification suggests a maximum of 90 coliform per g. In all the samples the mean coliform count were lower than what is recommended by BIS specification.

5.6 ENERGY VALUE AND NUTRIENTS

Energy value in kcal per100 g of the ice cream and frozen dessert samples with mean are presented in Table 10 and Fig. 6. The values were 207.55, 164.41and 134.75 respectively for control and treatments. Data when statistically analysed showed a significant difference (P<0.01) between control and treatments indicating that the energy value decreased as the level of replacement of mango pulp increased.

The energy value of control ice cream was in accordance with the values of 212 kcal and 200 kcal per 100 g reported by Marshall *et al.* (2003) and Kumar (2004) respectively. Among the food ingredients fat is having highest energy value of 9 kcal per gram as reported by Arbuckle (1966) and Marshall *et al.* (2003). In the treatment the energy value decreased as the percentage replacement increased and is attributed to the lower fat content of 5 percentage in T_1 and nil in T_2.

5.7 SENSORY EVALUATION OF ICE CREAM AND FROZEN DESSERT

The mean flavour score for control and treatments T_1 and T_2 were 39.52, 40.24 and 38.37 respectively (Table 12). The statistical analysis of the data revealed that the addition of mango pulp had no significant influence on the flavour and was comparable to control. Analysis of the data presented in Table 12 with regard to body and texture revealed no significant difference between control and treatments and among treatments. The mean for control and treatments were 27.60, 27.68 and 26.90 respectively.

Data with respect to melting quality score of ice cream and treatments T_1 and T_2 presented in Table 12 were 4.5, 4.3 and 4.3 respectively. Data when statistically analysed revealed no significant difference between control and treatments and among treatments indicating that melting quality of control and treatments were identical. The mean colour and package scores for control and treatments T_1 and T_2 were 4.6, 4.5 and 4,4 respectively (Table 12). The statistical analysis of the data revealed that the addition of mango pulp had no significant influence on the colour and package and was comparable to control.

Analysis of data presented in Table 12 and Fig. 9 with regard to total score of control and treatments revealed no significant difference between them. The mean score for the control (T_0) was 91.29, and for treatments T_1 and T_2 were 91.55 and 89.40 respectively. Even though treatment T_2 had lower mean score of 89.40 statistical analysis revealed no significant difference between control and treatments. This indicated that addition of mango pulp does not produce any significant difference in the total score as compared to control.

From the Table 12 it is understood that all the samples scored more or less uniformly for the characters such as flavour, body and texture, melting quality and colour and package.

Elhami *et al.* (1977) and Geevarghese (1996) studied the effect of replacement of milk fat with margarine and coconut cream on the organoleptic properties. It was concluded that the replacement with the above ingredients had not affected the organoleptic properties of resultant ice cream. Similarly replacement of milk SNF with potato pulp (Das *et al.*, 1989), whey solids (Naidu *et al.*, 1986) and whey protein concentrates (Thirumalasha *et al.*, 1998) also did not produce any change in the organoleptic properties of the resultant product. In the present investigation it was proved that replacement of milk fat with mango pulp at 50 and 100 per cent levels did not produce any change in the sensory attributes of the product as compared to control. Since the products developed are having very good organoleptic characteristics commercialization of the product can be explored.

5.8 COST ANALYSIS OF ICE CREAM AND FROZEN DESSERT

The cost of 1kg each of control and treatment mixes based on ingredient cost presented in Table 1 and Fig. 10 indicated that when replacement level increased the total cost decreased. The savings in cost was 8.15 and 10.86 per cent for treatments T_1 and T_2 respectively as compared to control.

Nair and Geevarghese (1988) reported that 33 per cent reduction in material cost could be achieved by substituting milk fat with fat from coconut cream at 80 per cent level. Reddy *et al.* (1987), Rao *et al.* (1988), and Das *et al.* (1989) reported that replacement of milk SNF with whey solids, sweetened fermented milk respectively reduced the cost of ice cream. The reduction in cost attained in the present investigation was due to lower cost of mango pulp, which was used in place of butter.

Summary

6. SUMMARY

A detailed study was carried out to assess the feasibility of incorporating mango pulp to replace milk fat at 50 and 100 per cent levels in the preparation of low fat frozen dessert. The products prepared were analysed for physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes.

Mango pulp was extracted from ripened mangoes and its analysis revealed 19.04 per cent total solids. Dairy ingredients such as milk, skim milk, skim milk powder and butter were analyzed for fat and total solids and the results were within the normal range. Standard procedure was followed for the preparation of low fat frozen dessert where in milk fat was replaced by mango pulp at 50 and 100 per cent levels and the treatments were designated as T_1 and T_2 respectively and properties were compared with normal ice cream designated as T_0. The proportionate quantity of different ingredients to be used in the mix preparation was derived by the computer aided linear programming model.

The physico-chemical properties of control and treatment mixes and ice cream were analysed for various properties using standard procedures. Specific gravity revealed significant difference ($P<0.01$) between control and treatments. There was linear increase in specific gravity as replacement of mango pulp was higher. Viscosity (cp) of control and treatment mixes revealed an increase, which was statistically significant ($P<0.01$) as fat replacement level increased from 50 to 100 per cent. The values were 88.35, 161.48 and 272.98 cp for control, T_1 and T_2 respectively.

Titratable acidity (per cent lactic acid) revealed significant difference ($P<0.01$) between control and treatments indicating that replacement of milk fat with mango pulp at different levels influenced pH of the ice cream mix. The pH values ranged from 6.01 to 6.33. However all the treatments were having acidity equal to or less than 0.25, which is considered to be normal.

Fat per cent value for control and treatment mixes were 10.05, 5.04 and 0.33 respectively. This significant difference was expected since the figuring of mix was done accordingly. Protein percentage revealed a significant difference ($P<0.01$) between control and treatments and no significant difference ($P>0.05$) among treatments. The values ranged from 3.3 to 4.2. This difference was due to less protein content of mango pulp. Sucrose per cent for control and treatments were 15.00, 18.18 and 19.21 respectively and statistical analysis indicated a significant difference ($P<0.01$) between control and treatments and among treatments due to higher content of sugar in mango pulp. Total solids percentage for control and treatments were 37.21, 37.37 and 37.35 respectively and revealed no significant difference ($P>0.05$) between control and treatments and it was expected since the figuring of the mix was done accordingly.

Whipping ability in per cent calculated based on the overrun per cent 5 minutes after the commencement of freezing revealed that there was no significance ($P>0.05$) between control and treatment T_1. But significant difference ($P<0.01$) was noticed between T_2 and control also T_1 and T_2. On comparing the over run (per cent) obtained for the control and treatments it was found that as the percentage replacement of milk fat with mango pulp increased a significant decrease ($P<0.01$) was noticed in overrun as compared to control. The highest overrun was 48.53 per cent for control and lowest was 37.10 for treatment T_2. Mean specific gravity of control ice cream was 1.016 and it significantly ($P<0.01$) increased as percentage replacement of milk fat with mango pulp increased. Mean values for T_1 and T_2 were1.054 and 1.099 respectively. A similar increase was observed for weight in g per litre of ice cream. Mean weight in g per litre for control, T_1 and T_2 were 757.41, 800.21, 826.11 g respectively which was statistically significant ($P<0.01$). However all the samples were having weight more than that is prescribed under BIS specification of 525 g per litre. With regard to meltdown time an increasing trend was observed as percentage replacement of milk fat with mango pulp increased. Mean meltdown time for the control was 52.78 min. as compared to 69.78 for the treatment T_2 and the difference was statistically significant.

Microbiological quality evaluation by SPC and coliform count of ice cream and frozen dessert revealed that there was no significant difference ($P>0.05$) between control and treatments and among treatments. The mean SPC count ($\log_{10}$ cfu /g) for T_0, T_1 and T_2 were 5.41, 5.43 and 5.51 respectively, which was slightly higher than what is recommended by BIS specification. Coliform count was 48.7, 48.9 and 51.2 for T_0, T_1 and T_2 respectively and these counts were below than the value recommended by BIS specification. Organoleptic quality with regard to characters like flavor, body and texture, melting quality and colour and package of the product was assessed by sensory evaluation. All samples in the control and treatments secured more or less uniform score for the above characters and no significant difference ($P>0.05$) could be noted between control and treatments. The total score obtained for all the samples were in the range of 89 to 91.

The cost of 1 kg of control and experimental ice cream mixes based on the ingredient cost revealed that as replacement level increased the cost decreased considerably. The savings in cost of ingredients (in percentage) were 8.21 and 10.96 per cent for treatment T_1 and T_2. Overall results indicated that the developed frozen dessert is a low calorie, low cost product which is accepted by the consumers.

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Appendix

Appendix- I

ICE CREAM SCORE CARD

Write scores opposite the rating for perfect score. Check criticisms in the space opposite the defects noted and in the proper sample column.

Perfect Score	**Criticisms**	**Sample Number**				
		1	**2**	**3**	**4**	**5**
Flavour 45 Normal range 31 - 40	No. Criticism 40-45					
	Cooked					
	Lacks fine flavor					
	Too high flavor					
	Lacks flavoring					
	Lacks freshness					
	Lacks sweetness					
	Too sweet					
	Metallic					
	Old ingredient					
	Oxidized					
	Rancid					
	Salty					
	Storage					
	Syrup flavor					
	Average*					
Body & Texture 30 Normal range 25 - 30	No criticism 29.5 - 30					
	Coarse or icy					
	Crumbly					
	Fluffy					
	Sandy					
	Soggy					
	Weak					
	Average*					
Melting quality 5 Normal range 4 - 5	No Criticism 5					
	Curdy					
	Does not melt					
	Average*					
Colour & Package 5 Normal range 3 – 5	No criticism 5					
	Colour uneven					
	Colour unnatural					
	Average *					
Bacteria 15	Allowed perfect in contest					
Total 100	Total score of each sample					

Date :

Time :

Signature :

Name :

DEVELOPMENT AND STANDARDISATION OF LOW FAT FROZEN DESSERT

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Abstract of the thesis submitted in partial fulfilment of the requirement for the degree of

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ABSTRACT

An experiment was conducted to assess the feasibility of the incorporating mango pulp to replace milk fat in the preparation of low fat frozen dessert at 50 and 100 per cent levels (treatments) with the objective of developing a low calorie, low cost frozen dessert. The physico-chemical properties, organoleptic qualities, microbiological parameters and nutritional attributes of the low fat frozen dessert were studied and compared with normal ice cream (control). It was found that replacement of milk fat with mango pulp resulted in a mix with increased specific gravity, viscosity, titratable acidity and sucrose.

However, a decreasing trend was observed in pH, fat and protein but normal value was observed in total solids since figuring of mix was done accordingly. It was observed that whipping ability and overrun of treatments decreased as the replacement level of mango pulp increased. But specific gravity, weight per litre and meltdown time increased with increase in replacement level. Replacement of milk fat with mango pulp does not produce any significant difference in microbiological qualities. Energy value was also lower in treatments as compared to control. Organoleptic quality of low fat frozen desserts were comparable to normal ice cream. Cost reduction of low fat frozen dessert mixes with 50 and 100 per cent replacement were 8.15 and 10. 86 per cent respectively as compared to control.