TECHNOLOGICAL EVALUATION OF KERA ICE CREAM

BY

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THESIS

Submitted in partial fulfilment of the requirement for the degree

Doctor of Philosophy

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

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COLLEGE OF VETERINARY AND ANIMAL SCIENCES
Mannuthy, Thrissur

1996

DECLARATION

I hereby declare that the thesis entitled **"TECHNOLOGICAL EVALUATION OF KERA ICE CREAM"** 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 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 **"TECHNOLOGICAL EVALUATION OF KERA ICE CREAM"** is a record of research work done independently by Dr. P.I. Geevarghese, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENTS

I wish to place on record my profound sense of gratitude and indebtedness to:

Dr. U.T. Francis, Professor, Department of Dairy Science and Chairman of the Advisory Committee, for his sustained and valuable guidance, critical suggestions, constant support and encouragement throughout the course of this work and preparation of the thesis.

Dr. K. Pavithran, Professor and Head, Department of Dairy Science, Dr. C.S. James, Professor, Department of Animal Nutrition, Dr. P.K. Ismail, Associate Professor (Bio chemistry), Centre of Excellence in Pathology, and Dr. M. Mukundan Associate Professor, Department of Dairy Science for their valuable advice, encouragement, constructive criticisms and timely help given to me as members of the Advisory Committee.

Dr. A. Rajan, Dean, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, for providing facilities to undertake the study.

Dr. K.C. George, Professor and Head, Mr. Mathew Sebastian, Asst. Professor, Smt. K.P. Santha Bai, Junior Programmer and Mr. K.V. Prasadan, Technical Assistant, Department of

Statistics for their valuable services rendered in the statistical analysis of the data and preparation of charts.

Dr. M. Krishnan Nair, Former Dean, College of Veterinary and Animal Sciences and Dr. K.I. Mariamma, Former Professor, Department of Pathology, for the interpretation of the electron micrographs and photographs.

Dr. K.M. Ramachandran, Professor and Head, Dr. K.V. Valsala, Associate Professor, Dr. T. Sreekumaran, Associate Professor, and Technicians, Centre of Excellence in Pathology for the preparation of slides, photographs and electron microscopy required for the study.

Mr. R. Rajendrakumar, Associate Professor, Dr. C.T. Sathyan, Mr. P.J. Boniface, Mr. K. Ajithkumar, Sri. S.N. Rajkumar, Sri. P. Sudheer Babu and the other staff members of the Department of Dairy Science for their sincere co-operation and timely help during the period of investigation.

Dr. K.N. Aravinda Ghosh, Associate Professor and Dr. B. Nandakumar, Associate Professor for the splendid co-operation and help to carry out this study.

Dr. Leo Joseph, Associate Professor, Department of Poultry Science in developing the computer programme used in the figuring of the mix.

All the staff members in the Dairy Plant for sincere co-operation and timely help.

M/S Bush Boake Allen (India) Ltd., Madras and M/S Devars M.P. Organics, Gwalior, for supplying the flavour and stabilizer free of cost.

My beloved wife and children Emil and Ann for their constant inspiration and encouragement against all odds they had to face.

The Kerala Agricultural University for granting the Study leave.

P.I. GEEVARGHESE

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LIST OF ABBREVIATIONS

A°	Angstrong
APD	Average particle density
BOPP	Bi axially oriented polypropylene
BD	Bulk density
BHA	Butylated hydroxyanisole
cp	Centipoise
CD	Critical difference
FE	Feed efficiency
FF	Free fat
GMS	Glyceryl monosterate
HDL	High density lipoproteins
HDPE	High density polyethylene
HMHDPE	High molecular high density polyethylene
LD-LLD	Low density linear low density
LDL	Low density lipoproteins
LDPE	Low density polyethylene
MDT	Meltdown time
MET/PEST/PE	Metallised polyester polyethylene
µl	Microlitre
µm	Micrometer
MSNF	Milk solids not fat
Meq	Milli equivalents
NPN	Non protein nitrogen
NS	Not significant
OTR	Oxygen transmission rate
PD	Particle density
PVPP	Percent volume occupied by powder particle
PV	Peroxide value
PUFA	Poly unsaturated fatty acid
PER	Protein efficiency ratio
PEV	Protein efficiency value
RV	Relative viscosity
SEM	Scanning electron microscopy
SA	Sodium alginate
SSI	Soft serve ice cream
SNF	Solids not fat
SI	Solubility index
SG	Specific gravity
SE	Standard error
ST	Surface tension
TBA	Thiobarbituric acid
TS	Total solids
VLDL	Very low density lipoproteins
WVTR	Water vapour transmission rate

INTRODUCTION

1. INTRODUCTION

Milk and milk products form an important part of the average Indian diet. The milk production in India is growing at the rate of 5.5 per cent per annum and our country is likely to emerge as the largest milk producer in the world by 2000 AD (Poonawalla, 1995). Eventhough the milk production is increasing annually the consumption pattern of milk and milk products has not changed much. Nearly 50 per cent of the total milk produced in our country is being utilised to prepare milk products.

The major milk products being produced in the country are clarified butter (28 per cent), khoa (7 per cent), curd (7 per cent), butter (6 per cent), milk powder (3.5 to 4 per cent), ice cream (0.1 per cent) and other products (accounting for roughly 2 to 3 per cent) Prakash, 1995). Ice cream, as a modern frozen dairy product, is gaining momentum in India. The product has occupied a unique place in the western diet since it is delicious, wholesome and nutritious.

The popularity of ice cream is increasing day by day in India also and it is estimated that the growth rate of ice cream production by value is at the rate of 25 to 35 per cent per year (Bharat Bhushan, 1992). It is estimated that the present market reach of ice cream is conservatively estimated

at five million cups equivalent per day (Bharat Bhushan, 1992). In short, the size of the Indian ice cream market is estimated to be, at anywhere, between Rupees 200 to 300 crores excluding the unorganized sector (Anon, 1994).

Eventhough the growth rate in ice cream production is encouraging, the per capita consumption of the product remains very low, when compared to developed countries. This is mainly attributed to the high cost of ice cream which has made it a luxury item and people of low income group cannot afford it. The major reason for the high cost of the product is due to the costly ingredients such as milk fat and solids not fat (SNF) used in the preparation of ice cream. Short supply of the ingredients, mainly milk, aggravates the situation. Moreover, it is worth mentioning that the existing rules and regulations of the country make it obligatory that, ice cream should contain a minimum of 10 per cent milk fat.

Ice cream being relished by all and particularly by children, it is necessary that the product cost has to be reduced, to make it available to all. The development of dairy analogues especially ice cream should be viewed in this context. The food industry has developed many dairy food products utilising 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. So the development of non-dairy

ice creams, in which milk fat and protein are partially or completely replaced by plant proteins and vegetable fats is worth mentioning. Miekle *et al.* (1955) studied incorporation of other fats and found that there was little or no difference between the physical and chemical characteristics of ice cream made from different vegetable fats. Moreover, the use of vegetable fat gives a product comparable to traditional ice cream in sensory qualities also (Gupta *et al.*, 1987).

Unfortunately the existing rules and regulations (IS:2802-1964) as well as Prevention of Food Adulteration Act (1954) in India, permit the use of only milk fat in the preparation of ice cream. On the contrary, in U.K., ice cream industry produces both milk fat based (dairy) and vegetable fat based (non-dairy) ice creams (Anon, 1990). The European Communities Umbrella Organisation for the Dairy and Margarine Industries is actively considering the possibility of the use of vegetable fat in the manufacture of ice cream (Kuhn, 1990).

It is well known that the state of Kerala has derived its name from "Kera" (coconut tree). The people of the state by and large has got developed an affinity for coconut and it enters into the diet of people in many ways. The total area under coconut production in India (1993-94) is 15.32 lakh hectares and out of this 8,81,600 (54.63%) hectares are in Kerala (Aravindakshan, 1995a). Total production per year in India is 1236 crores of nuts and Kerala's share is 558.64

crores (Aravindakshan, 1995b). It is worth mentioning that coconut contributes 15 per cent of Kerala's annual income which amounts to 35 per cent of the income from their whole agriculture sector. Moreover, coconut and coconut based industries give employment to 10 lakhs of people in India (Aravindakshan, 1995b).

It is estimated that 55 per cent of coconut produced in the country is used for culinary preparation and 36 per cent is converted into oil. The oil which is utilised for industrial purposes, determines the price of coconut in Kerala and neighbouring states. More often the price of coconut oil depends on the price of other edible oils, their internal production and also on their import to the country. The liberalised import policy announced by the government has aggravated the situation. The above factors had resulted in the lowering of the price of coconut, which affected the economy of the State very adversely. The only way to solve the problem is by finding diversified uses for the coconut especially the production of value added products. Mass production of dairy analogues incorporating coconut fractions should be of prime necessity in this connection.

The possibility of using coconut fractions in various dairy foods were discussed by Escueta (1981), Escueta *et al.* (1985), Thampan (1987), Markose (1991) and Pavithran (1994). Of the different fractions, coconut cream is of much value in

the preparation of dairy like foods. The term coconut cream unless otherwise modified shall refer exclusively to the aqueous coconut product expressed from disintegrated moist solid coconut endosperm (Asian and Pacific coconut community, 1992). The possibility of using coconut cream replacing milk fat at 80 per cent level in the manufacture of ice cream was tried by Nair and Geevarghese (1988). They could successfully incorporate coconut fat replacing milk fat in the production of ice cream with a saving of 33 per cent in the material cost. The product named as Kera cream was having physico-chemical and organoleptic properties comparable to milk based ice cream. Besides being a low cost frozen product the diversified uses of coconut will have a direct bearing on the socio economic situation of the southern states of India, especially Kerala.

The development of convenience foods is gaining momentum in recent years. Ice cream is one of the important nutritious, attractive and appealing dairy product involving a number of processing steps such as heat treatment, cooling, ageing, freezing, hardening and low temperature storage. The development of dry ice cream mixes will help to avoid few steps in the preparation of ice cream. The development of the product has made it easy for the house wives and the small scale ice cream manufacturers to prepare ice cream at a short notice. The other advantages include proper utilization of the excess milk, easiness in packing and handling, longer

durability of the product at room temperature, low transportation cost and storage space saving.

There appears to be some controversy on the relation between the consumption of coconut oil as well as coconut kernel and the incidence of cardiovascular diseases. Coconut oil identified as a highly saturated fat has probably been maligned for decades as hypercholesterolemic. Many people including some of the medical fraternity are of the view that consumption of coconut oil and kernel predisposes an individual to cardiovascular diseases. On the other hand practitioners of Ayurveda (Warrier, 1994). Homeopathy (Vidya Prakash, 1994) and nature cure (Ulpalakshan, 1994) attribute several beneficial properties for coconut oil and kernel as far as human health is concerned.

The present study was aimed at the preparation of ice cream and ice cream mix powder incorporating coconut fat with the following objectives:

1. To study the physico-chemical, biological and organoleptic qualities of "Kera ice cream" wherein milk fat and Solids Not Fat (SNF) was partially or fully replaced by coconut solids.

2. To explore the feasibility of preparing Kera ice cream mix powder and to study its physico-chemical and storage characteristics.

3. To study the physical and organoleptic properties of reconstituted Kera ice cream.

4. To compare the nutritional qualities of Kera ice cream mix powder with that of ice cream mix powder.

5. To study the comparative merits and cost of production of Kera ice cream with that of the ice cream.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 Use of coconut fractions in dairy foods

Incorporation of coconut fractions in dairy products with a view to reduce the cost of such products has attracted the attention of various scientists in different parts of the world. Literature on ice cream incorporating coconut fat are limited. But a review is attempted here with available literature regarding the physico-chemical properties of various filled products, including ice cream.

2.1.1 Filled milk

Bhandari *et al.* (1976) prepared flavoured filled milk having 3.5 per cent fat and 8.5 per cent Solids Not Fat (SNF) using coconut oil and dried skim milk powder. The products showed resemblance with natural flavoured milk in terms of homogeneity and body. Filled milk was prepared by Jensen and Nielsen (1982) using coconut oil. They observed that the use of vegetable oil may result in unwanted changes in both organoleptic properties and/or nutritive value due to the composition of fatty acids.

Davide *et al.* (1987) have shown that coconut milk could be blended with reconstituted skim milk to formulate a new type of low fat fresh filled milk even without the use of stabilizer

and emulsifier. The product had mild coconut flavour and smooth homogeneous texture that remain good and organoleptically unchanged for seven days at 5-7°C. Agrawal *et al.* (1991) prepared recombined milk from non fat milk solids either of liquid or of powder origin in which vegetable fats or oils have been incorporated in approximately the same proportion as in the butter fat of fresh milk. The product could be used as a coconut flavoured milk in food preparations.

2.1.2 Low fat dairy spreads

Prajapathi *et al.* (1987) studied the use of vegetable oils including coconut oil up to a level of 10 to 30 per cent for partial replacement of butter fat in the manufacture of low fat dairy spreads. Incorporation of vegetable oils raised the level of polyunsaturated fat and also improved the spreadability at refrigerated temperature.

2.1.3 Yoghurt

Sanchez and Rasco (1984) used coconut milk in the manufacture of yoghurt. Combination of 50 per cent coconut milk and 50 per cent dried skim milk had the desired pH and viscosity for high quality yoghurt.

2.1.4 Cheese

Havarti and Danish Blue cheese with acceptable quality and reduced costs were prepared with a mixture of oils such as coconut, palm and rape seed replacing milk fat (Nielsen and Pihl, 1985). Sanchez and Rasco (1986) utilised coconut in white soft cheese production. Coconut milk percentage increased the cheese fat content while moisture, protein and salt contents were decreased. Johnson (1994) studied the possibility of using coconut fat filled milk for the preparation of Mozzarella cheese and whey drinks. It was concluded that cow milk in which the fat was replaced to the extent of 50 per cent and 100 per cent with coconut fat can be effectively utilised for the preparation of Mozzerella cheese. The quality of cheese and whey drinks were comparable with that made from cow milk.

2.1.5 Ice cream

Bray (1983) mixed palm oil and coconut oil with cocoa butter to give chocolate coating of ice cream which gave a good consistency at low temperature. Pitz (1987) patented a lactose-free-synthetic ice cream comprising of coconut oil, and the product had all the characteristics of milk based ice cream such as taste, palatability, aroma, appearance and keeping quality. 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.

2.1.6 Paneer and rasogolla

Mini (1992) prepared paneer, rasogolla and whey drink using filled milk containing coconut fat. The chemical and sensory evaluation of the products did not reveal any significant difference between the treatments and control prepared from cows milk.

2.2 Yield and composition of coconut cream

2.2.1 Yield

Arumughan (1991) reported that a mature husked coconut yielded 50 per cent kernel, 17 per cent coconut water and 33 per cent shell.

2.2.2 Composition

The composition of coconut cream reported by Walker (1906) was water-56.3 per cent, total solids (TS)-43.7 per cent, ash-1.2 per cent, fat-33.4 per cent, protein-4.1 per cent and total sugar as invert sugar-5.0 per cent. The percentages reported by Jaganathan (1970) were 50, 40, 3, 1.5 and 5.5 for moisture, fat, protein, ash and carbohydrate respectively. Analysis of Philippine coconut milk showed that it contained

46.5 per cent water, 53.5 per cent TS and 10.1 per cent SNF (Banzon, 1978). The analysis of coconut cream at Central Food Technological Research Institute revealed a composition of water-41 per cent, protein-5.8 per cent, fat-38.40 per cent, minerals 6.2 per cent, and carbohydrates-9.11 per cent (Thampan, 1984).

2.3 Flavour for ice cream

Aqueous solutions of colour and flavour are added to ice cream which impart extra palatability and appeal. Jain and Verma (1969) stated that, flavour of ice cream contributes to the extent of 40 per cent of the quality of the finished product and therefore its acceptability to the consumer is of vital importance. Jain and Verma (1973) reported that, Indian consumers mostly prefer vanilla flavour followed by orange, lemon, chocolate, pineapple and strawberry. Rajor (1980) studied the suitability of different flavours for ice cream incorporating soya solids and butter milk solids. It was observed that pineapple flavour was preferred by the majority of consumers followed by strawberry, orange and vanilla. Nair and Geevarghese (1988) reported that the best flavour for Kera cream incorporating coconut fat was chocolate followed by pineapple. Both these flavours could effectively mask the characteristic coconut aroma.

2.4 Stabilizers in ice cream

Stabilizers are used in ice cream to produce smoothness in body and texture. Baer (1916) and Mortenson (1918) showed that gelatin did not increase the whipping ability of the ice cream mix. Williams (1922) and Sommer (1951) noted that the whipping ability decreased as the gelatin content increased. Although other stabilizers also have a limiting effect on the whipping ability, sodium alginate (SA) was found to improve the whipping ability due to the decrease in calcium ion concentration of the mix through the formation of calcium alginate.

Rajor (1980) found that the relative viscosity (RV) of ice cream mix containing soya and butter milk solids increased significantly with an increase in stabilizer level when buttermilk solids and soya solids were incorporated. Minhas and Bains (1984) studied the suitability of different stabilizers in the preparation of ice cream mix from buffalo milk and concluded that the body, texture and flavour of ice cream were highly inter-related. Gelatin and gum accacia showed better stabilizing effect on body and texture of ice cream during storage of the product.

Ice cream was made using traditional mix containing 8.5 per cent milk SNF, 3.1 per cent fat, 21.9 per cent sucrose and 0.78 per cent stabilizer, and modified mix containing 10.4

per cent SNF, 8 per cent fat, 18 per cent sucrose, 0.7 per cent stabilizer and 0.3 per cent emulsifier (Tekinsen and Karacabey, 1984). The modified mixes gave higher flavour, body and texture scores than the traditional mix. Thyagarajan (1987) reported that the protein of coconut is a good natural emulsifier and the proportion of the protein in coconut milk would probably be sufficient for emulsification in the colloid milk.

2.5 Emulsifiers in ice cream

The emulsifiers are substances which tend to concentrate in the interphase between the fat and the plasma and reduce the surface tension of the system. Emulsifiers as such or emulsifiers with stabilizers had been generally acknowledged for their enhancing influence on the whipping ability of the mix (Defew and Dyers, 1925; Sommer, 1927 and Leighton, 1941). Mann (1968) studied the efficiency of different emulsifiers on fat destabilization. The level of 0.01 per cent Tween 80-A was found to be equivalent to 0.2 per cent glyceryl monostearate (GMS) in causing fat destabilization. The structure of the internal layers of the fat globules in ice cream mixes immediately after homogenization and during ageing was studied by Buchheim *et al.* (1988). It was observed that during ageing gradual desorption of coherent interfacial protein layers occurred in mixes containing emulsifiers. Barfod *et al.*

(1991) reported that in the presence of emulsifiers fat crystallization and protein desorption were distinctly enhanced resulting in increased agglomeration of fat globules during ice cream manufacture which is important for the formation and stability of ice cream. The role of milk proteins in the emulsification properties, whipping properties and to the water holding capacity of ice cream was discussed by Goff (1992). Sayed and Aly (1992) prepared saturated and unsaturated monoglyceride from coconut oil and used in ice cream preparation. It was observed that saturated monoglyceride gave organoleptically comparable products as that of the commercial emulsifier.

2.6 Physico chemical properties of filled ice cream

2.6.1 Acidity

Arbuckle (1966) reported that the normal ice cream mix containing 11 per cent milk solids not fat (MSNF) would have a normal acidity of 0.198 per cent. El Safty *et al.* (1978) concluded that incorporation of hydrogenated oils increased the acidity of ice cream mixes as compared to the control. Titratable acidity of ice cream mixes made by incorporating whey solids increased from 0.18 to 0.20 per cent of lactic acid (Naidu *et al.*, 1986). Gonc *et al.* (1988) prepared ice cream by substituting milk fat at various levels with margarine. It was observed that increasing proportions of margarine increased lactic acid

content. 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. Venkateswarlu *et al.* (1990) observed that titratable acidity of ice cream mixes decreased due to incorporation of arrowroot powder at any level. Acidity of ice cream mixes got reduced when milk fat was replaced by sunflower and maize oils at levels of 50, 75 and 100 per cent (Al Saleh and Hammad, 1992).

2.6.2 pH

Arbuckle (1966) reported that the normal pH of the ice cream mix is about 6.3. Elhami *et al.* (1977) prepared ice cream by substituting milk fat with margarine and observed that the pH values of the mix decreased by increasing the percentage of margarine. Naidu *et al.* (1986) concluded that replacement of MSNF with whey solids decreased pH from 6.43 to 6.27 at 30 per cent replacement level. Gabriel *et al.* (1986) proved that ice cream made of buffalo milk with groundnut protein isolate at 30, 40 and 50 per cent replacement of milk SNF resulted in an increase in pH and it was correlated with the level of replacement.

Nair and Geevarghese (1988) could prove that 80 per cent substitution of coconut fat in Kera cream does not produce any appreciable difference in pH. Addition of potato pulp in the preparation of ice cream to replace milk SNF at 15, 25 and 35

per cent resulted in a decrease in pH (Das *et al.*, 1989). Umesh *et al.* (1989) concluded that replacement of milk fat at 40, 50 and 60 per cent with vanaspathi decreased the pH of the filled soft serve ice cream (SSI). Replacement of milk SNF with arrowroot powder at 20, 40 or 60 per cent in SSI increased the pH as the replacement of the powder increased (Venkateswarlu *et al.*, 1990). Cheema and Arora (1991a) found no statistical difference in the pH between the filled ice cream incorporating groundnut, soyabean and corn oil with that of the control. Jayaprakasha and Venkateshaiah (1995) reported that replacement of milk fat with palmolein oil did not affect the pH of ice cream.

2.6.3 Viscosity

Turnbow and Raffetto (1928) stated that the viscosity of ice cream mix is important and a liquid without appreciable viscosity possess no power to retain air when whipped. Arbuckle (1966) observed that a lower viscosity seems desirable with the advent of fast freezing using modern equipments. It was also stated that as the viscosity increases the resistance to melting and smoothness of the body increases but the rate of whipping decreases. It was also reported that the basic viscosity of the ice cream mix may range from 50 to 300 centipoise (cp). SSI made by hydrogenated sunflower or coconut oil or margarine was prepared by Kozin and Rebrina (1976) and found that the viscosity of the product ranged from 17.4 to

27.8 cp. El Safty *et al.* (1978) noticed that the viscosity of ice cream mixes could be increased by adding hydrogenated oils and the increase was proportional with the amount of hydrogenated oil added. The viscosity values were 415.4 cp and 569.8 cp after a period of four hours of ageing, when replacement levels were 20 and 50 per cent respectively. Youssef *et al.* (1981) showed that the substitution of milk fat in ice cream with cotton seed or corn oil reduced the viscosity of ice cream mixes and was proportional to the rate of substitution. It was also shown that ageing of ice cream mixes with cotton seed oil or corn oil increased their viscosity. Rajor and Gupta (1982) observed that addition of SA resulted in an increase in viscosity and specific gravity of ice cream with soy and butter milk solids. The use of cottonseed, soyabean and faba bean flour in ice cream making, resulted in an increase in viscosity of ice cream mixes before and after ageing (El Deeb *et al.*, 1984). Naidu *et al.* (1986) confirmed that the relative viscosity (RV) of ice cream mixes incorporating whey solids ranged from 57.1 to 85.4 cp and showed a decreasing trend when the proportion of whey solids increased.

Incorporation of groundnut protein isolate on the physico-chemical properties of filled ice cream was studied by Gabriel *et al.* (1986). It was concluded that viscosity of ice cream mix increased with the incorporation of groundnut protein isolate. On the contrary, Reddy *et al.* (1987) observed that

incorporation of chhana whey solids in ice cream resulted in a decrease in relative viscosity. Gonc (1988) proved that use of margarine instead of milk fat in ice cream increased viscosity. Nair and Geevarghese (1988) found that viscosity of Kera cream mix was found to be higher than the control ice cream.

Das *et al.* (1989) observed that addition of potato pulp in partial replacement of MSNF resulted in an increase in RV. Venkateswarlu *et al.* (1990) concluded that replacement of MSNF with arrowroot powder resulted in an increase in RV. Al Saleh and Hammad (1992) reported that substitution of milk fat by maize and sunflower oil at levels of 50, 75 and 100 per cent reduced the viscosity of the mix and the reduction was proportional to the level of replacement. Sivakumar *et al.* (1992) reported that the mean RV values of different categories of ice cream made by incorporating soya oil and soya flour ranged from 86.124 to 88.784 cp.

2.6.4 Surface tension

The normal surface tension (ST) values for ice cream mix ranged from 48 to 53 dynes/cm. The surface tension of ice cream mixes were studied by Reid and Mossley (1926), Gebhardt (1928) and Turnbow and Reffetto (1928). The results failed to show any definite relationship between surface tension and the whipping ability of the mix.

Rajor (1980) proved that there was a substantial increase in the ST with the increase in the stabilizer level in SSI prepared by incorporating butter milk and soya solids, and the ST ranged from 46.59 to 59.54 (dynes per cm). Cheema and Arora (1991a) proved that the ST values of filled ice cream made by using groundnut, soyabean and corn oils were similar to the control.

2.6.5 Specific gravity

Arbuckle (1966) reported that specific gravity of ice cream mix vary from 1.0544 to 1.1232. El Safty *et al.* (1978) reported that replacing butter fat by hydrogenated oil up to 50 per cent had negligible effect on specific gravity and weight per gallon of the ice cream mix. Specific gravity of the resultant ice cream increased as the level of replacement increased from 10 to 50 per cent. The use of vegetable proteins in partial replacement of MSNF in vanilla and chocolate ice cream was studied by El Deeb *et al.* (1984). Substitution of vegetable proteins had only very little effect on specific gravity. Specific gravity of ice cream mixes made by incorporating whey solids in partial replacement of MSNF ranged from 1.083 to 1.092 (Naidu *et al.*, 1986). Reddy *et al.* (1987) concluded that replacement of milk SNF by chhana whey solids increased specific gravity of ice cream. Nair and Geevarghese (1988) could prove that incorporation of coconut cream in ice

cream does not produce any significant difference in the specific gravity.

In an experiment conducted by Umesh *et al.* (1989), wherein milk fat was replaced by vanaspathi at various levels ranging from 40 to 60 per cent resulted in a decrease in specific gravity of ice cream mix. Similarly Das *et al.* (1989) observed that addition of potato pulp for replacing milk SNF decreased specific gravity . Replacement of MSNF with arrow root powder in SSI manufacture could produce a reduction in specific gravity (Venkateswarlu *et al.*, 1990). Specific gravity of ice cream mixes incorporating sunflower and maize oils decreased by increasing the level of replacement (Al Saleh and Hammad, 1992). Decrease in specific gravity was observed when palmolein oil was substituted for milk fat in ice cream making (Jayaprakasha and Venkateshaiah, 1995).

2.6.6 Overrun

Overrun is usually defined as the volume of ice cream obtained in excess of the volume of the mix. Fat in the mix had retarding rate on both the rate of increase in overrun and the maximum overrun attained (Williams, 1922; Gregory and Manhart, 1924). Lucas *et al.* (1930) showed that increasing the fat content decreased the maximum overrun and increased the time required to reach an overrun of 90 per cent. Arbuckle

(1966) reported that the overrun for packaged ice cream ranged from 70 to 80 and soft ice cream 30 to 50 per cent.

Kozin and Rebrina (1976) prepared SSI using 20 per cent synthetic cream containing hydrogenated sunflower or coconut oil or margarine. The overrun in the product was between 37.7 and 50.6 per cent. Elhami *et al.* (1977) proved that substitution of milk fat with margarine in ice cream decreased overrun. El Safty *et al.* (1978) showed that the overrun decreased as the amount of hydrogenated oil increased. The decrease was proportional to the amount of hydrogenated oil in the mix. Reddy *et al.* (1987) could not record any difference in overrun when chhana whey solids are used in the preparation of ice cream. A decrease in overrun was observed when milk fat is replaced by vanaspathi in ice cream making at levels of 40, 50 and 60 per cent (Umesh *et al.*, 1989). Similarly, incorporation of potato pulp in ice cream also decreased overrun. Jayaprakasha and Venkateshaiah (1995) observed that replacement of palmolein oil in ice cream decreased the overrun.

2.6.7 Whipping time

Earlier investigations (Washburn, 1910, Brown, 1913; Baer, 1916) indicated that high viscosity was conducive to good whipping quality of ice cream mix. However, subsequent findings (Davis,1916; Lucas and Roberts, 1927) conclusively proved that the difference in whipping ability could not be explained on

the basis of viscosity. Further observations made by Hening and Dahlberg (1929) and Dahle (1930) established that whipping ability was not dependent on viscosity.

It appeared that an increase in viscosity retards the rate of whipping without necessarily decreasing the maximum overrun that can finally be attained (Dahle, 1926). However this does not hold true for aged mix which has increased viscosity and better whipping characteristics (Washburn, 1910). Miglani *et al.* (1988) proved that whipping time of filled ice cream containing Dalda, groundnut oil and sunflower oil in order to replace 10 per cent of milk fat with the incorporation of sodium caseinate could considerably decrease the whipping time. Whipping ability of the ice cream mixes incorporating groundnut, soyabean and corn oil was much lower than the milk based SSI (Cheema and Arora, 1991a).

2.6.8 Melting resistance and meltdown time

Gabriel *et al.* (1986) incorporated different levels of groundnut protein isolate in partial replacement of MSNF. They found that as groundnut protein isolate content increased the melt down time (MDT) decreased. Replacement of milk SNF by chhana whey in ice cream preparation was studied by Reddy *et al.* (1987). It was observed that melting resistance decreased with increased SNF replacement. Nair and Geevarghese (1988) observed that the lower MDT and the oily taste of ice cream

could be appreciably improved by making use of freshly prepared coconut cream instead of coconut oil in the ice cream preparation. Gonc *et al.* (1988) confirmed that increasing proportions of margarine increases melting resistance.

Umesh *et al.* (1989) concluded that replacement of milk fat with vanaspathi in the preparation of filled SSI resulted in an increase in melting resistance. Das *et al.* (1989) proved that addition of potato pulp in ice cream resulted in an increase in melting time.

Trials using arrowroot powder in partial replacement of milk SNF in ice cream manufacture, resulted in an increase in MDT (Venkateswarlu, 1990). Cheema and Arora (1991a) proved similarity in melting rate between filled ice cream made by incorporating groundnut, soyabean and corn oil, and the control ice cream. The meltdown characteristics of ice cream made by incorporating soya oil and soya flour was studied by Sivakumar *et al.* (1992). The mean meltdown values of different categories of ice cream ranged from 28.9 to 49.1 minutes. On analysis of variance the mean meltdown values of different categories of ice cream was found to be decreasing significantly as percentage replacement of MSNF with soya flour and milk fat with soya oil were increased. Jayaprakasha and Venkateshaiah (1995) reported that replacement of milk fat with palmolein oil

in ice cream increased the melting resistance significantly with increase in level of replacement.

2.6.9 Weight per gallon

El Safty *et al.* (1978) found that the weight per gallon of ice cream made by replacing hydrogenated oil at the rate of 20 and 50 per cent were 5.70 and 5.94 pounds in one gallon. Weight per gallon of ice cream mixes got reduced when milk fat was replaced at 50, 75 and 100 per cent level with sunflower and maize oil (Al Saleh and Hammad, 1992).

2.6.10 Structure of ice cream

Mohar and Peters (1955) described a technique for determining the size and distribution of air cells. King (1962) made valuable studies on the physical structure of Ice Cream and discussed the effect of mix composition, homogenization, freezing, whipping and hardening on the physical structure of ice cream. It was also observed that the air cell size ranged from 5 to 10 microns. Walker (1963) studied the different factors influencing the structure of ice cream and found that it was affected by milk fat, milk protein, emulsifier and air content. Air had its maximum effect at 110 to 120 per cent overrun and gave a palatable product when the air cells were fine and well distributed.

Arbuckle (1966) conducted microscopic examination of ice cream and found that texture and structure was affected by composition and homogenization. He reported that the average size of air cells will be in between 110 and 185 microns. Nearly 70 to 80 per cent of the water in ice cream was frozen to form the ice crystals whose size and shape influences the structure. The remainder was present as bound water and in liquid form in concentrated syrup. The distribution of air also influences the texture, and a uniform distribution of small air cells gave a smooth texture (Nielsen, 1973).

Rajor (1980) studied the effect of addition of stabilizers on the size and number of air cells in the SSI made by incorporation of buttermilk solids and soya solids. The influence of stabilizers and emulsifiers on the ultra structure of spray dried ice cream mix was studied by Bhandari *et al.* (1984). The particles of powder made without additives were spherical in shape and had smooth surface. Caldwell *et al.* (1992) studied the microscopic structure of ice cream using low temperature Scanning Electron Miscroscope (SEM). Air bubbles had a size of 10.0 to 60 micrometers and were lined with fat globules of size 0.15 to 2.5 micrometers in diameter.

2.6.11 Organoleptic properties

Incorporation of hydrogenated oil at 0, 10, 25 or 50 per cent of the milk fat did not make any noticeable changes on

body, flavour or texture of the final product (El Deeb *et al.*, 1983). The organoleptic properties of ice cream made by using different flour vegetables were studied by El Deeb *et al.* (1984). It was concluded that milk SNF could be substituted with defatted cotton seed flour at 10 or 15 per cent in vanilla or chocolate ice cream mixes to give acceptable ice cream.

Naidu *et al.* (1986) reported that ice cream prepared by replacing a maximum of 20 per cent MSNF with whey solids was most acceptable with a score of 94.2 per cent. Gabriel *et al.* (1986) noted that ice cream made from buffalo milk with groundnut protein isolate resulted in a decrease in organoleptic scores. Replacement of MSNF of ice cream by chhana whey solids would result in a product which were acceptable when used at 15, 25 or 35 per cent (Reddy *et al.*, 1987). Use of margarine at increasing proportions (60 per cent or above) impaired organoleptic quality of ice cream (Gonc, 1988).

Rodriguez *et al.* (1991) reported that maize oil upto 20 or 25 per cent replacement of milk fat in ice cream was judged as excellent and 30 per cent substitution as good. Sivakumar *et al.* (1992) prepared ice cream with substitution of 25 per cent milk fat with soya oil and 20 per cent SNF with soya flour. The physico-chemical and organoleptic properties of the product were similar to control ice cream. Sivaramakrishnan *et al.*

(1994) reported that partial substitution of milk fat by cotton seed oil in SSI had identical organoleptic properties to that of standard ice cream.

2.6.12 Low cost ice cream

Ramanna (1975) studied the costing of ice cream and found that the cost of non dairy ice cream was reduced considerably with the use of non milk fat. No major problem in manufacture was encountered and large scale trials in industrial units gave quite acceptable ice cream. El Deeb *et al.* (1984) reported that by replacing MSNF by cotton seed flour, soyabean flour or faba bean flour,the cost of ice cream could be considerably reduced.

Similarly Lautsen (1985) proved that when fractionated palm kernel oil was used in ice cream as an alternative to butter fat, appreciable reduction in price of raw materials could be achieved. Incorporation of groundnut protein isolate reduced 10.53 per cent of production cost of ice cream when replaced at 50 per cent level. This was reported by Gabriel *et al.* (1986).

Reddy *et al.* (1987) proved that when chhana whey solids was replaced at 15, 25 and 35 per cent in ice cream making to replace milk SNF the reduction in cost was 5.3, 8.9 and 12.5 per cent respectively. Gupta *et al.* (1987) reviewed the

fabricated dairy products and the advantages of these products are low cost owing to the utilization of relatively cheap ingredients such as vegetable protein, fat, emulsifiers and stabilizers.

Nair and Geevarghese (1988) proved that a reduction of 33 per cent in the material cost of the ice cream could be achieved by substituting 80 per cent of butter fat with fat from coconut cream. When 25 per cent of milk SNF is replaced by potato pulp 8.5 per cent of reduction in production cost could be achieved (Das *et al.*, 1989). A study was carried out to prepare low cost SSI by replacing milk fat with vegetable fat using vanaspathi at levels of 40, 50 and 60 per cent and was concluded that when replacement is at 60 per cent level the cost of ice cream could be reduced by 15.68 per cent without loss in quality (Umesh *et al.*, 1989).

Cheema and Arora (1991b) estimated the cost (Rs.) of 100 ml of filled ice cream made with three vegetable oils viz., groundnut, soyabean and maize oil as 1.12, 1.07 and 1.12 respectively as compared to 1.29 for control ice cream. The saving in cost is 13 to 17 per cent when compared to normal ice cream. Jana *et al.* (1995) reported that fat substitutes are ingredients intended to be used as a substitute for natural fats with the objective of obtaining a reduction in calorific value. Perceived health risks and economic reasons seem to be

the main driving forces for searching for fat substitutes. Jayaprakasha and Venkateshaiah (1995) reported that by the replacement of 60 per cent of milk fat with palmolein oil, production costs were reduced by 15.68 per cent.

2.7 Packaging materials for storing high fat milk products

Parekh (1983) suggested that high fat containing powder should be packed under conditions designed to minimize fat oiling off and hydration of the solids not fat. The powder should be packed under conditions of low humidity in air tight containers. Storage of these products should be below the melting point of fat, to reduce detrimental effects on the body.

Shah *et al.* (1987) packed spray dried acidophilus malt preparations in pouches of three different packaging materials such as:

1. Polyethylene aluminium foil laminate
2. Polyethylene and
3. Metallised poly paper

The experimental results showed that polyethylene aluminium foil laminated pouches could be suggested as one of the suitable packaging material for dried products containing live lactobacillus cells. Bhandari (1987) reported that dried

ice cream mix when packed in polyethylene bags and stored in cardboard box had a shelf life of six months at 20°C. Studies had also revealed that dried mix packed in laminated polyester packages can keep well without deterioration for more than six months at 30°C. Under similar storage conditions its shelf life was comparable to dried mix, stored in gas packed tins.

Rancidity of fats is mainly due to unsaturated fatty acids and Kumar (1992) suggested that for packaging of edible oil, packaging materials with low water vapour transmission rate (WVTR) and oxygen transmission rate (OTR) has to be used.

Anon (1989) reported that chocolate milk powder filled in 500 g presterilized tins keep well for one year without perceptible defects and above six months in metallised polyethylene bags. Malhotra and Mann (1989) carried out studies to find out the feasibility on the preparation and storage of ready to reconstitute coffee complete powder and packed in metallised polyester-LDPE laminate and stored at 30 ± 1°C. Physico-chemical and sensory changes were studied and was concluded that the product could be stored for three months in the above packaging material. Punjrath (1995) described the primary role of packaging as to protect the nutritional and sensory properties of any food product.

2.8 Composition of ice cream mix powder

The composition of ice cream mix powder was reported by many authors. Webb and Whittier (1972) suggested the following composition for dried ice cream mix : Milk fat not less than 27 per cent, total milk solids-54.4 per cent, sugar 39.6 per cent, stabilizer not more than 1.25 per cent and water 1.25 per cent. Rajor (1980) studied the composition of soy buttermilk SSI mix powder. The composition in percentage were: moisture-1.67, fat-29.76, protein-16.74, ash-2.03 carbohydrates 41.61 and crude fibre-0.70. While discussing the status of infant milk based foods in India, Bhanumurthy (1986) had discussed the composition of ice cream mix powder. It contained 27 per cent fat, 32 per cent SNF, 38 per cent sugar, 0.8 per cent stabilizer and 2.5 per cent moisture. The composition of dried ice cream mix as suggested by Sachdeva (1986) was moisture-1.5 to 2.0 per cent, milk fat 30 to 31 per cent, MSNF-28 to 29 per cent, stabilizer-1.0 to 1.5 per cent and sugar 35 to 37 per cent. Goyal *et al.* (1987) reported the composition of an ice cream mix powder which contained fat 30-31 per cent, MSNF 28-29 per cent, sugar 35-37 per cent, stabilizer 1.0 to 1.5 per cent and moisture 1.5-2.0 per cent. The values reported by Balachandran (1988) were (in percentage) 29.5 fat, 25.5 MSNF, 40.5 sugar, 1.25 stabilizer and 3.25 moisture respectively.

2.9 Physico-chemical properties of dried milk products

Beckett *et al.* (1962) studied the particle density (PD), bulk density (BD) and percentage volume occupied by particles (PVPP) in 39 commercial spray dried skim milk powder. The mean values were 1.233 g/ml, 0.609 g/ml and 49.4 per cent respectively. Hall and Hedrick (1966) reported that PD of milk powder was influenced mainly by the amount of entrapped air. Extensive reports regarding the various physico-chemical properties of milk powder was also presented by the above author. Buma (1971) defined free fat (FF) in dried milk as, that part of the fat which can be extracted with organic solvents under standardized conditions. It was shown that the FF value of spray dried whole milk depends not only on the contact time and extraction temperature but also on the type of the powder used. Spray powder prepared from homogenised, concentrated milk showed a much smaller increase in FF content with time and temperature than did commercial whole milk powder.

The average FF was 14.2 per cent and solubility 94.2 per cent in the spray dried ice cream mix manufactured by Sood and Srinivasan (1975). Rajor (1980) prepared SSI powder with soy and butter milk solids and stored them under different packaging media. The physico-chemical values reported were moisture-1.29 per cent, Non protein nitrogen (NPN)-0.0894

per cent, FF-38.64 per cent, peroxide value (PV)-0.000 (meq/kg fat), solubility index (SI)-9.00 (ml), BD-0.617 (g/ml), average particle density (APD)-1.1420 (g/ml), PVPP-59.5230.

Bhandari and Balachandran(1984) observed that drying conditions influenced the particle size and BD of spray dried ice cream mix. Infant formula developed by Rao and Mathur (1987) had a loose BD of 0.376 and 0.410 g/ml and packed BD of 0.489 and 0.510 g/ml for two different types of formula. Solubility index for the two were 0.12 and 0.20 ml respectively. Salooja and Balachandran (1988) made an attempt to standardise the processing conditions for the production of malted milk powder. When the TS percentage was 40, the product had a moisture percentage of 2.4, BD (loose) 0.42 (g/ml), mean PD 1.22 (g/ml) and SI 0.54 (ml).

Malhotra and Mann (1989) reported that ready to reconstitute coffee complete powder had 2.28 per cent moisture and 10.86 per cent FF. Bulk density and SI were 0.65 (g/ml) and 0.62 (ml) respectively. Manmohan (1994) reviewed the different factors affecting the BD of milk powder. It was observed that pasteurization temperature, flowability, electrostatic charge etc. influence the BD of milk powder.

2.10 Keeping quality of dry milk products.

The shelf life of dry fat rich products depends upon, factors such as temperature of storage, relative humidity, type of the packing material and the composition of the product. Upon storage the powder undergoes chemical and other changes causing deterioration and reduction in shelf life of the product.

Coconut oil contains certain proportion of free fatty acids and hence has a tendency to become rancid. The first stage of rancidity was due to hydrolysis and the rapidity of which varies with the initial acidity and the amount of moisture present. This was usually accelerated by the action of air and light and the presence of fat splitting enzymes. The second stage was the oxidation of free fatty acids, the intensity of which depends on the amount of hydrolysis. Kunkel *et al.* (1946) reported that increase in moisture content between 1 to 4.5 per cent had much greater influence on the rate of deterioration of dried ice cream mix at 60°C.

Tarassuk and Jack (1948) observed that high moisture, oxygen, metallic contamination and high storage temperature were responsible for flavour deterioration in dried ice cream mix. They reported that powder with less than 3 per cent moisture kept well for two years at 30 and 40°C when stored in gas packed tins. Sood and Srinivasan (1975) observed that the

FF of ice cream mix powder increased at a greater rate under nitrogen gas packing during storage. Thiobarbituric acid (TBA) values showed a greater increase under air packing than under nitrogen packaging. The product could be kept in good condition for four months under air packing.

Desai (1977) investigated the changes in the dried ice cream mix during storage and observed that the samples had acceptable colour. The moisture and TBA values decreased during storage, whereas FF content increased. Rajor (1980) observed that when SSI powder incorporating soya solids were stored for one year at 30±1°C in polyethylene bags the changes observed were as follows. Moisture increased from 1.2911 to 4.3743 per cent, NPN increased from 0.0894 to 0.3725 per cent, FF (per cent of total fat) increased from 38.6489 to 96.0093. Changes in other properties such as PV (meq/kg fat) from 0.00 to 27.9983, SI (ml) from 9.00 to 10.45, BD (g/ml) from 0.6170 to 0.4685, APD (g/ml) from 1.1420 to 0.9870, and PVPP from 59.5230 to 37.9240 were also reported.

The Prevention of Food Adulteration Act-1954 permit the use of butylated hydroxyanisole (BHA) at the rate of 0.01 per cent by weight of the finished product in the manufacture of milk powder as a preservative.

Malhotra and Mann (1989) prepared coffee complete powder and stored them in metallised polyester-LDPE laminate and

stored at 30°C and observed the changes after a storage period of 90 days. Moisture content increased from 2.28 to 2.40 per cent and FF from 10.86 to 11.73 per cent. At the same time pH decreased from 6.45 to 6.37, and also BD from 0.65 to 0.60 (g/ml).

Kumar and Murthy (1992) conducted storage studies on dried whole buffalo milk powder packed in high density polyethylene bags (HDPE) and stored at a temperature ranging from 22-38°C. Initial moisture content was between 2.62 to 3.73 per cent which increased significantly during storage. There was an increase in titratable acidity and free fatty acids during the storage period.

Kumar and Murthy (1994) studied the auto oxidation changes in buffalo milk powder during storage for 12 months. Peroxide value when determined by iodometric and colorimetric method did not give a reliable indication of the extent of milk fat oxidation. Thiobarbituric acid (TBA) value increased gradually throughout storage and this increase was correlated with moisture content and temperature of storage. It was suggested that a TBA value of 0.05 be taken as a limit for TBA in dried whole milk for storage without development of detectable oxidised flavour.

Lim *et al.* (1994) studied the physico-chemical properties of dried whole milk stored for four months at different

temperature levels. Powder packed in kraft paper/nylon-polyethylene (NY-PE) with nitrogen and aluminium-polyethylene laminate under vacuum had lower PV and TBA value during storage.

2.11 Reconstituted ice cream

Ice cream mix powder can be reconstituted by adding water at 50°C and best quality of ice cream was obtained after freezing the mix. Tracy and Pyenson (1944) conducted extensive studies to determine the effect of drying conditions, temperature of reconstitution of the dry mix and ageing on the whippability and body characters of reconstituted ice cream. Mix reconstituted at 60°C and aged overnight at 4.4°C before freezing gave quality ice cream. Sood and Srinivasn (1975) prepared ice cream mix powder and was later reconstituted and frozen. The product had a coarse and icy texture due to low viscosity after reconstitution. The melt down was foamy and watery in general.

Rajor (1980) studied the characteristics of reconstituted spray dried SSI mix powder made by incorporating soya solids and butter milk solids. The properties of the product were: relative viscosity (RV)-1.85 centipoise, surface tension (ST) 50.50 dynes per cm, specific gravity (SG)-1.0462, and overrun-42.27 percentage.

Spray dried ice cream mix powder was prepared by Bhandari and Balachandran (1984) and packed in metallised polyester-polyethylene pouches and stored at 30°C. After 10 months of storage ice cream was prepared using the powder. The reconstituted product had lower viscosity together with deterioration in flavour, body, texture and meltdown characteristics.

2.12 Nutritive value of oil seeds and carbohydrates

Thomas (1966) conducted trials using rats to evaluate the biological utilisation of few carbohydrates. It was concluded that diet containing tapioca starch and 10 per cent casein had on an average food efficiency (FE) of 0.30 and protein efficiency value (PEV) of 2.96. Coconut protein like any other oilseed protein is deficient in lysine, methionine and threonine. The nutritive value of the coconut meal has been reported to be fairly good but the meal has some limitations for human consumption due to its fibre content (Francis, 1984). The protein efficiency ratio (PER) of groundnut protein isolate was studied by Francis (1984) and found that PER is 1.49 without treating it with bacterial cultures. When treated with bacterial cultures it had not improved the PER.

Bhat (1991) concluded that the defatted coconut protein containing all the essential amino acids is an excellent material for the preparation of baby foods, weaning foods etc.

In an experiment conducted by Darwis (1991), the nutritive value of two weaning foods containing coconut protein concentrate and rice flour were carried out. Both the foods gave good results and the PER of the formula one was 2.11 and for the second it was 2.72. According to Prasad and Azeemoddin (1994) the percentage of assimilable glycerides in coconut oil was 91.0 per cent and the digestibility co efficient was 99.3 per cent. The values for cows milk and butter were 63.0 and 97.2 per cent respectively.

2.13 Pathogenisis of atherosclerosis

Brown and Goldstein (1984) studied the circulation pattern of cholesterol. Cholesterol being hydrophobic in nature does not circulate freely in the blood but only in association with lipoproteins, low density lipoproteins (LDL) and high density lipoproteins (HDL). The level of LDL particles in blood is affected by specialised proteins called LDL receptors. These receptors bind the LDL particles and extract from them the fluid that baths the cells. The LDL was broken down in the cells and cholesterol was used for biological functions. When the need is low the cells make fewer LDL receptors thus LDL level in the blood rises accumulating excess cholesterol in arteries which accelerates the atherosclerosis. The inadequacy in LDL receptors has been attributed to both genetic and environmental factors.

The possibility of atherosclerosis being an autoimmune disease was discussed by Wick *et al.* (1992). He opined that nutritional, genetic, hormonal, infectious, autoimmune and behavioral factors were all involved in the development of atherosclerosis. However, the initiating events remain to be defined. The role of hyperlipidiemia and disorders of lipoprotein metabolism were generally accepted.

There are several factors that influence serum lipids and atherogenesis. The nature and quality of carbohydrates, proteins, fat, dietary fibre, the deficiency of certain vitamins, trace elements in the diet, extent of physical activities, stress and strain etc. were also known to influence serum lipids and atherogenesis (Kurup and Rajmohan, 1994). In a clinical trial conducted by Paul and Mukkadan (1994) found that lipids were probably not the major risk factor in patients with myocardial infarction. Eraly (1994) observed that most of the heart patients in Kerala do not have high cholesterol in their blood.

2.14 Diet and cholesterol

Keys *et al.* (1957) reported that saturated fatty acids were approximately twice as potent in raising serum cholesterol as compared to poly unsaturated fatty acids (PUFA) which has a lowering effect on it. Thus the ratio (P/S) of polyunsaturated to saturated fatty acid in the diet is important. The

correlation between cholesterol level in blood and blood pressure to atherosclerosis has been proved by Spain (1966). Kritchevskz *et al.* (1976) compared coconut oil to butterfat, peanut oil and corn oil by feeding them to rabbits. Coconut oil fed groups showed similar serum lipid values compared to butter but higher than peanut oil or corn oil.

Hostmark *et al.* (1980) compared the effects of diets containing 10 per cent coconut fat and 10 per cent sunflower oil in lipoprotein distribution in male rats. Coconut oil feeding produced significantly lower levels of very low Density Lipoproteins (VLDL) and significantly higher HDL as compared to sunflower oil feeding. Srivastava *et al.* (1986) conducted feeding trials using albino rats to see how serum cholesterol level was influenced by dietary fat. They concluded that the feeding of fat especially the saturated ones elevated the blood cholesterol level. Haug and Hostmark (1987) found that whole plasma triglycerol, cholesterol and phospholipid concentrations were appreciably lower when rats were fed with purified diet containing fish oil as compared to diet containing coconut oil.

Van Heek and Zilversmit (1988) reported that rabbits fed a commercial diet containing 0.5 per cent cholesterol and 14 per cent coconut oil developed more severe hyperlipidemia and atherosclerosis than rabbits fed the same diet containing olive

oil in place of coconut fat. Beynen *et al.* (1989) studied the liver cholesterol concentrations in mice after feeding them for 30 days with cholesterol free semipurified diets. The amount of fat in the diet in the form of either corn oil or coconut fat had no significant effect on liver cholesterol. It was concluded that the type of carbohydrates and fat in the diet are major determinants of liver cholesterol in mice.

Remla *et al.* (1991) studied the effect of coconut oil and safflower oils on isoproterenol induced myocardial infraction in rats. Based on the survival rate and histopathological examination, safflower oil was found to offer better protection than coconut oil.

Naresh Kumar and Singhal (1992) suggested that further studies are required to ascertain the effect of diet on atherosclerosis. It was suggested that factors such as hypertension, physical inactivity, diabetes mellitus and obesity together with a host of other factors such as age, sex and family history can also affect the development of athreosclerosis.

Sivakumar (1991) reported that ice cream incorporating soy flour and soya oil had beneficial dietary effects because its consumption resulted in a significant reduction in the level of blood serum cholesterol in rats. A long term clinical study was carried out to investigate the effect of soluble and insoluble

dietary fibre on blood lipids and fecal composition of healthy humans. Significant reduction in the levels of serum total and LDL cholesterol were obtained when dietary fibre was there in the diet (Rao, 1993).

Purushothama *et al.* (1993) fed palm oil to rats at 5 and 20 per cent levels for a period of 18 weeks. A group of rats maintained on ground nut oil served as controls. Plasma cholesterol and triglyceride level measured were comparatively higher in 20 per cent oil fed groups as compared to 5 per cent oil fed groups. It was also observed that the higher content of total saturated fatty acids in palm oil (41 per cent as compared to 19 per cent in ground nut oil) had not elevated cholesterol levels significantly.

Sindhu Rani *et al.* (1993) conducted trials using rats to study the effect of coconut oil and coconut kernel on serum and tissue lipid profile. There was no significant effect on serum total cholesterol in the rats fed coconut oil (10 g/100 g), when compared to groundnut oil. But the rats fed coconut kernel alone without any free oil had significantly lower serum cholesterol when compared to the rats fed coconut oil or groundnut oil. Inclusion of coconut kernel along with groundnut oil resulted in lowering of serum cholesterol in both the groups. There was no significant difference in the triglycerides levels in rats fed coconut oil or groundnut oil. Inclusion of coconut kernel in the free oil diet had not

produced any significant alteration in triglycerides either in the groundnut oil or coconut oil fed groups. There was no significant difference in HDL cholesterol in the rats fed groundnut oil or coconut oil while rats fed coconut kernel had lower HDL and VLDL + LDL levels in both the cases. Inclusion of coconut oil or groundnut oil groups resulted in the lowering of VLDL + LDL cholesterol but not HDL cholesterol.

Kurup and Rajmohan (1994) estimated the serum cholesterol in 3000 persons free from any disease and who consumed coconut oil and kernel daily. The serum cholesterol ranged from 180 to 220 mg/100 ml serum with an an average of 200 mg/100 ml. It was concluded that consumption of coconut oil with kernel to humans produced decrease in serum total cholesterol, increase in HDL cholesterol and decrease in LDL cholesterol. The effect was assumed to be due to the proteins and the dietary fibre in the kernel.

Sivaramakrishnan *et al.* (1994) reported that replacement of milk fat by cotton seed oil in the preparation of SSI had reduced the production cost and blood cholesterol levels in humans and mice. Enig (1995) reported that coconut oil decreased atherogenicity and had beneficial effect for prevention of some heart diseases.

2.15 Properties of coconut oil

Coconut oil is high in saturated fatty acids especially lauric and myristic acids, and is low in unsaturated fatty acids and polyunsaturated fatty acids particularly linoleic acid when compared to other vegetable oils. Coconut oil have the following fatty acid composition (percentage): A. saturated: caproic-0.37, caprylic-8.21, capric-5.59, lauric-47.01, myristic-19.42, palmitic-7.5, stearic-4.29 and arachidic-1.03. B. Unsaturated: oleic-4.3, linoleic-1.81. The glycerol content of coconut oil is 13.8 per cent (Prasad and Azeemoddin, 1994).

Kurup and Rajmohan (1994) reported that the saturated fatty acids contribute 92 per cent of the total fatty acids of which the short chain fatty acids form 15 per cent, medium chain fatty acids 65 per cent and the long chain fatty acids 12 per cent. Monounsaturated fatty acids which is mostly oleic acid form 6 per cent while poly unsaturated fatty acids mostly linoleic acid forms 2 per cent.

Aravindakshan (1995 a) reported that the ratio between omega 6/omega 3 in cooking oil is very important. The saturated fatty acids belong to the middle chain in coconut oil and hence have many good qualities. Since lauric acid is high in coconut oil it could prevent even AIDS. This is because of the fact that from the lauric acid our body produces monolauric acid

which can give protection from the disease (Aravindakshan, 1995a).

2.16 Serum lipid profile in rats

Spector (1956) reported that cholesterol level in rats is 52 (28-76) mg/100 ml. The values reported by Harkneis and Wagner (1989) were: serum proteins-5.6 to 7.6 g/dl, serum lipids-70 to 415 mg/dl, phospholipids-36 to 130 mg/dl, total cholesterol-40 to 130 mg/dl and triglycerides 26-145 mg/dl. Achuthan and Jose (1995) reported that the normal cholesterol, HDL cholesterol and triglyceride in rats were 57.1, 31.3 and 30.45 mg/dl respectively.

2.17 Histopathology of body organs

Remla *et al.* (1991) studied the effect of feeding coconut oil and safflower oil in rats. Histopathological examination revealed that the concentration of cholesterol and triglyceride in the heart and aorta were lower in the safflower oil fed group while the level of phospholipids was higher as compared to coconut oil fed group.

Purushothama *et al.* (1993) observed that when rats were fed palm oil at 20 per cent level for 18 months could produce mild centrolobular fatty infiltration. Enig (1995) reported that animals fed regularly with coconut oil had less cholesterol deposited in their liver and other parts of the body.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The main objective of the study was to assess the feasibility of incorporating coconut fat at varying levels in the form of coconut cream for preparation of ice cream and ice cream mix powder. The experiments were carried out in the Department of Dairy Science, College of Veterinary and Animal Sciences, Mannuthy utilising the facilities of the University Dairy Plant. The products prepared were analysed for physico-chemical properties, organoleptic qualities, nutritional parameters and biological evaluation using standard analytical procedures. Analytical grade reagents were used throughout the study. Eight replications were done and the data obtained were analysed by approved statistical methods (Snedecor and Cochran, 1967).

3.1 Collection of coconut, extraction of coconut cream and its analysis

The coconuts (*Cocos nucifera* L.) used were obtained from the palms (West Coast Tall) of the University Livestock farm, Kerala Agricultural University, Mannuthy. Mature coconuts were dehusked and broken into two halves. The kernel was grated and the coconut cream was extracted by using a screw press. The pressed liquor was sieved through a muslin cloth to remove the

solid particles to get the coconut cream. The weight of grated coconuts and the cream obtained from each coconut were recorded. The chemical composition of coconut cream was estimated.

3.1.1 Estimation of moisture and total solids

The moisture and TS of coconut cream was estimated by gravimetric method (IS:1479-Part II, 1961).

3.1.2 Estimation of fat

The fat content in the coconut cream was estimated using the Mojonnier fat extraction apparatus using diethyl ether and light petroleum as solvents (IS:SP:18-Part XI, 1981).

3.1.3 Estimation of protein

The protein content in the coconut cream was estimated by Kjeldahl method following the procedure outlined by Menefee and Overman (1940).

3.1.4 Estimation of ash

The method described in IS:1479-Part II,1961 was followed for estimation of ash in coconut cream.

3.1.5 Calculation of carbohydrate

The carbohydrate content of coconut cream was calculated by difference

Total carbohydrate (per cent by weight) =

100 - (per cent of moisture + per cent of fat + per cent of protein + per cent of ash)

3.2 Skim milk powder

Spray dried skim milk powder (Anikspray- Brook Bond Lipton (I) Ltd., Calcutta-700 001) was used in the preparation of ice cream as source of MSNF.

3.2.1 Estimation of moisture in skim milk powder

Procedure outlined in IS:SP:18 (Part XI), 1981 was followed for estimating the moisture content.

3.2.2 Estimation of fat in skim milk powder

The method described in IS:SP:18 (Part XI), 1981 was followed for estimating the fat percentage in skim milk powder.

3.3 Butter

Unsalted butter prepared in the University Dairy Plant was used for the preparation of ice cream. The moisture and fat percentage of butter was assessed by the following methods.

3.3.1 Estimation of moisture

Moisture in butter was estimated using the procedure outlined in IS:3507 (1966).

3.3.2 Estimation of fat

The method described in IS:3507 (1966) was followed for estimating the fat percentage in butter.

3.4 Sugar

Cane sugar available in the market was used in all the experiments.

3.5 Stabilizer

Alginate D 2 (SA) manufactured by Davars M.P. Organics, Tansen Road, Gwalior-474 002 and Gelatin manufactured by Corn Products of India (Ltd.), Bombay were used in the experiments.

3.6 Emulsifier

Glyceryl monosterate (GMS) having monosterate content of over 45 per cent manufactured by Davars M.P. Organics, Tansen Road, Gwalior-474 002 was used in the preparation of control and experimental ice cream.

3.7 Flavour

Liquid and powder flavour manufactured by Bush Boake Allen (India) Ltd., Cathedral Garden Road, Nungambakkam, Madras was used.

3.8 Colour

Permitted colour manufactured by Bush Boake Allen (India), Bangalore-58 was used in the ice cream preparation.

3.9 Water

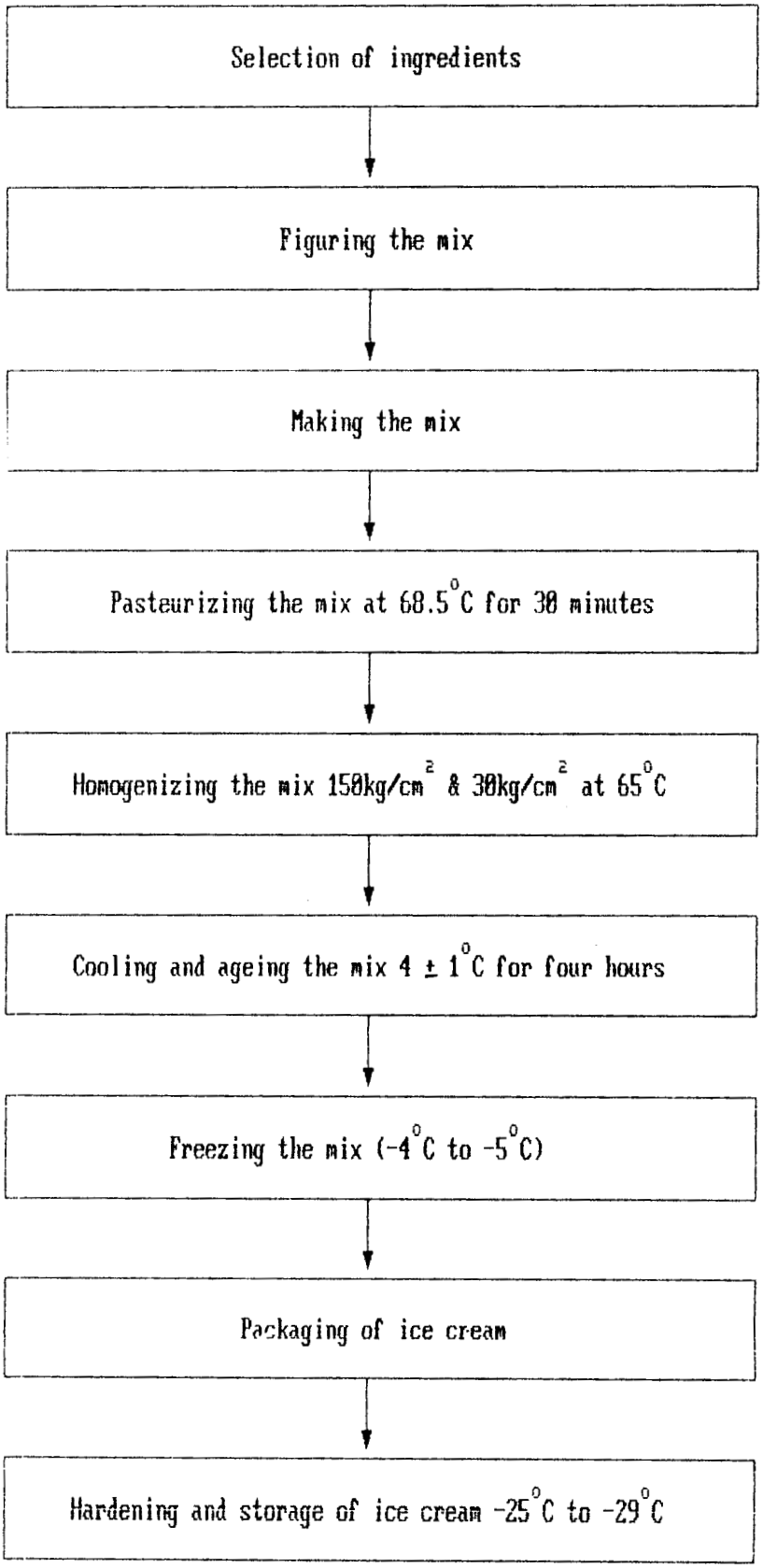
Potable water was used for the preparation of ice cream and for reconstitution of the ice cream mix powder.

3.10 Procedure for the preparation of ice cream

The guidelines prescribed in IS:5839 (1970) and the flow chart (Figure-I) given by Sukumar De (1980) was followed in the preparation of ice cream.

Fig.1

FLOW CHART FOR THE PREPARATION OF ICE CREAM



3.10.1 Selection of ingredients

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

3.10.2 Figuring the mix

The proportionate quantity of different ingredients to meet the minimum standard for fat and TS as per PFA (1954) for the preparation of ice cream were derived by Linear Programming (matrix method). The computer programme for the above is appended in Appendix-I.

3.10.3 Making the mix

Ingredients used for the preparation of ice cream except stabilizer were taken in a milk cooker and heated with frequent agitation. Stabilizer used was added to this when the mixture attained a temperature of 68°C.

3.10.4 Pasteurizing the mix

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

3.10.5 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 using an APV Goulin Homogenizer.

3.10.6 Cooling and ageing the mix

The mix after homogenization was immediately cooled to room temperature and later transferred to a cold storage maintained at a temperature of 4 $\pm$ 1°C for four hours.

3.10.7 Freezing the mix

Three milliliters of flavour per kilogram and required quantity of colour was added to the mix and mixed well. The mix was then frozen using a softy ice cream making machine of Alpha Lavel make (capacity three litres) at a temperature of -4 to -5°C.

3.10.8 Packaging of ice cream

The frozen product was collected in 30 ml ice cream cups and steel containers for organoleptic evaluation and analysis.

3.10.9 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.

3.11 Pre-trial for determining the flavour for Kera ice cream

Kera ice cream is the name given for the ice cream incorporating fat from coconut cream at different levels. A trial was conducted to evaluate the ideal flavour for Kera ice cream using different synthetic flavours such as banana, chocolate, mango, pineapple (S-3204) and vanilla. The above flavours were added at the rate of three millilitre per kilogram to the Kera ice cream mix in which all the milk fat was replaced with coconut fat. The Kera ice cream prepared with different flavours was served to a group of 55 consumers selected from different social strata. They were asked to indicate their like or dislike for the product in a nine point Hedonic scale (Appendix-II). The flavour scored high by the majority of the consumers was selected for further studies.

3.12 Pre-trial for determining the stabilizer/ emulsifier/combination in Kera ice cream

A pre trial with ten replications in each of five treatments was carried out to determine the ideal stabilizer/ emulsifier and or combination in Kera ice cream wherein milk fat was replaced with coconut fat at 100 per cent level. The treatments were as follows.

Treatments	Type of stabilizer/emulsifier and or combination
1.	1:1 proportion of GMS and gelatin to make 0.5 per cent of the mix.
2.	1:1 proportion of GMS and SA to make 0.5 per cent of the mix.
3.	Gelatin alone to make 0.5 per cent of the mix.
4.	SA alone to make 0.5 per cent of the mix.
5.	GMS alone to make 0.5 per cent of the mix

The suitable stabilizer/emulsifier and or combination was selected based on the sensory evaluation of Kera ice cream.

3.12.1 Sensory evaluation

Organoleptic qualities of Kera ice cream prepared in the above pre-trial was assessed by a panel of six selected judges with ten replications using the score card adopted by the American Dairy Science Association (Arbuckle, 1966) with slight modification for giving importance to body and texture and melting quality since these two characters are significantly affected by the stabilizers and emulsifiers. The modified score card is appended as Appendix-III.

3.13 Preparation of Kera ice cream

The physico-chemical and organoleptic properties of Kera ice cream was studied with different levels of incorporation

Table 1. Quantity of ingredients and cost of 100 g Kera ice cream and control

Treatments		Quantity of ingredients per 100 g						Total
		Coconut cream	Skim milk powder	Sugar	Butter	Water	Stabilizer+ Emulsifier	
A:Control (100 per cent milk fat)	Qty	0.00	11.16	15.00	12.26	61.08	0.50	100
	Cost	----	1.00	0.18	1.47	----	0.11	2.76
B:75 per cent milk fat + 25 per cent coconut fat	Qty	6.33	10.36	15.00	9.18	58.63	0.50	100
	Cost	0.16	0.93	0.18	1.10	----	0.11	2.48
C:50 per cent milk fat + 50 per cent coconut fat	Qty	12.67	9.56	15.00	6.10	56.17	0.50	100
	Cost	0.32	0.86	0.18	0.73	----	0.11	2.20
D:25 per cent milk fat + 75 per cent coconut fat	Qty	19.00	8.77	15.00	3.02	53.71	0.50	100
	Cost	0.48	0.79	0.18	0.36	----	0.11	1.92
*E:100 per cent coconut fat	Qty	25.21	7.99	15.00	0.00	51.30	0.50	100
	Cost	0.63	0.72	0.18	----	----	0.11	1.64

* Coconut fat replacement in Treatment E is only 99.52 since the skim milk powder contribute 0.48 per cent fat

Cost given in rupees

of coconut fat. The experiments were conducted with selected flavour, stabilizer and emulsifier for the preparation of Kera ice cream incorporating coconut fat at the rate of 25, 50, 75 and 100 per cent replacement of milk fat. The procedure outlined in 3.10 was followed in the preparation of Kera ice cream. The minimum PFA (1954) specifications with respect to fat (10 per cent) and TS (36 per cent) excluding the stabilizer and emulsifier was followed during preparation of mix. Sugar was added at the rate of 15 per cent to all the mixes. For comparing the physico-chemical and organoleptic properties of the experimental ice cream a control ice cream was prepared using milk fat (10 per cent). The proportionate quantity of different ingredients required, based on chemical analysis for figuring the mix was derived as described in 3.10.2. The proportions of ingredients used in the preparation of control and Kera ice cream were given in Table 1. Eight replications were carried out for each treatment.

The above mixes were kept for ageing for a period of four hours and analysed for the following parameters.

3.13.1 Titratable acidity

The titratable acidity (percentage of lactic acid) of control and Kera ice cream mix were determined as per the procedure outlined in IS:2802 (1964) and IS:1479 (Part-I), 1960

using twenty grams each of the sample which was diluted with about 50 ml of freshly boiled and cooled water.

3.13.2 pH

The pH of Kera ice cream mixes and the control was determined using a digital pH meter.

3.13.3 Relative viscosity

Relative viscosity (centipoise) of the mix was determined using Ostwald viscometer. The flow time for the mix and water was recorded at 24 to 25°C and the values for the relative viscosity were calculated by the formula (Plummer, 1979).

$$\text{n.rel (in centipoise)} = \frac{n1}{n2} \quad \frac{t1}{t2} \times \frac{p1}{p2}$$

where,

n1 = viscosity of ice cream mix of density p1

n2 = viscosity of water of density p2

t1 = time taken for the flow of the mix

t2 = time taken for the flow of water

3.13.4 Surface tension

The surface tension (ST) (dynes per cm) of the ice cream mix was determined using a Torsion balance as described by Sharma and Sharma (1992). A metallic ring of about 16 cm in

circumference was hung from the end of the beam of a torsion balance. The force required to lift it up from the surface of the liquid was measured by the angle through which the pointer has to be moved on the graduated disc. The angle of torsion (AT) would be proportional to the downward pull on the ring due to the surface tension of the liquid acting on it. Total surface tension acting on the ring was 2 ST x $2\pi r$ where `r' is the radius of the ring (acting on the inner and outer surfaces of the ring). Thus surface tension of mix (ST M) was proportional to the angle of torsion of mix (AT M) and the surface tension of water (ST W) was proportional to the angle of torsion of water (AT W).

Therefore $$\frac{ST\ M}{ST\ W} = \frac{AT\ M}{AT\ W}$$

Replacing the value of ST W as 72.75 dynes per cm the surface tension of the mix (ST M) was calculated.

3.13.5 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 suggested by Sommer (1951).

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

3.14 Analysis of Kera ice cream

The frozen product was analysed for the following parameters.

3.14.1 Overrun

The overrun (percentage) obtained in the control and experimental ice cream were calculated using the formula suggested by Sommer (1951).

$$\text{Percentage overrun} = \frac{\text{weight of mix - weight of equal volume of ice cream}}{\text{Weight of equal volume of ice cream}} \times 100$$

3.14.2 Meltdown time

The meltdown time (MDT) was estimated following the procedure outlined by Sommer (1951). Hundred gram of ice cream 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.

3.14.3 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 five minutes intervals up to ten minutes and weighed The loss of weight of the mix due to air incorporation was recorded.

3.14.4 Specific gravity

Specific gravity of the Kera ice cream and control was determined as per the procedure given in 3.13.5.

3.14.5 Weight per litre

The weight of ice cream per litre was calculated as per the procedure outlined in IS:2802 (1964).

3.14.6 Microscopical structure

A thin film of ice cream after hardening was photographed using a Carl Zeiss Photomicroscope III to study the structural difference between the control and experimental ice cream.

3.14.7 Sensory evaluation

Organoleptic evaluation of ice cream was assessed by a panel of eight selected judges. The evaluation was done using

the score card adopted by the American Dairy Science Association (Arbuckle, 1966). The score card is appended as Appendix IV.

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

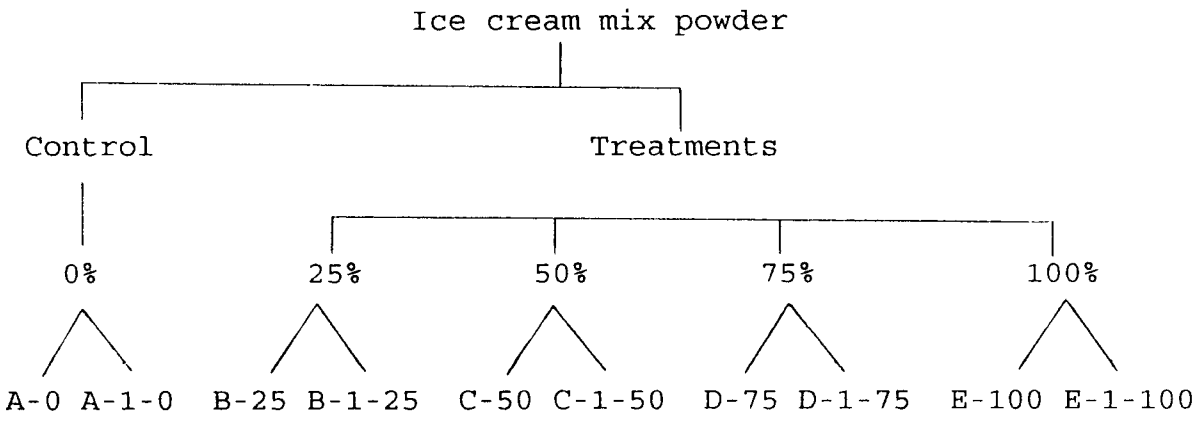
3.14.8 Cost estimation

The cost of preparation of 100 g of ice cream mix was calculated based on ingredient cost. The prevailing market rate of ingredients were taken into account for calculating the cost of ice cream (Table 1).

3.15 Preparation of ice cream mix powder

Experiments were conducted to study the feasibility of preparing ice cream mix powder. The method of mix preparation was described in 3.13 and the composition of mix in Table 1, except with the following modification. Sugar added to the mix was limited to 25 per cent of the required quantity and the amount of water added was adjusted to keep TS concentration as 36 per cent in the base mix. The treatments and control each were divided into two parts. To one part, antioxidant butylated hydroxyanisol (BHA) was added at the rate of 0.01

per cent of TS, and to the other no antioxidant was added. The treatments were as follows:



Note: % denotes the replacement of milk fat with coconut fat A, B, C, D and E are preparations without antioxidant A-1, B-1, C-1, D-1 and E-1 are preparations with antioxidant.

Butylated hydroxyanisol (100 mg),was dispersed in 20 ml water and six ml of this solution was added to one kg of the mix before homogenization. The mix thus prepared was spray dried as per the procedure described by Goyal *et al.* (1987) in an Anhydro spray drier of 35 kg water evaporation per hour. The outlet and inlet air temperature were maintained at 92 ± 2°C and 190 ± 2°C respectively. The p[illegible] collected was immediately cooled to 30°C. The remaining quantity of sugar was ground and mixed with flavour in powder form and blended with the collected mix powder. The spray dried powder was then stored in suitable packaging medium which was determined by a pre-trial.

3.16 Properties of the packaging materials

The packaging materials such as:

1. Low Density Polyethylene (LDPE)
2. High Molecular High Density Polyethylene (HMHDPE)
3. Bi-axially Oriented Polypropylene (BOPP)
4. Metallised Polyester/Polyethylene (MET/PEST/PE)
5. Low Density-Linear Low Density Co-extruded film (LD-LLD)

were selected for storing the Kera ice cream mix powder (E-100). The properties of the above packaging materials were determined with the help of Central Institute of Fisheries Technology, Cochin, which is appended in Appendix-V.

3.16.1 Storage stability of Kera ice cream mix powder

Kera ice cream mix powder containing 100 per cent replacement of milk fat with coconut fat (E-100) was stored for three months at room temperature in the above packaging materials without antioxidant. Changes on storage with respect to moisture content, peroxide value (PV), thiobarbituric acid (TBA) value, non protein nitrogen (NPN) and titratable acidity were studied based on which the suitable packaging material was selected.

3.16.2 Moisture

The moisture content of the powder was estimated initially and at the end of three months as per the procedure outlined in IS:1165 (1975).

3.16.3 Peroxide value

Peroxide value of the mix powder was estimated initially and after three months as per the procedure outlined by Smith (1938).

A clean Mojonnier flask was taken and to this added five millilitre of glacial acetic acid and five gram of powder. The mixture was warmed at 35°C for five minutes with frequent shaking. Then 45 ml of Chloroform was added and shaken well. The flasks were centrifuged for 10 minutes at 80 rpm. The content was filtered through Whatman No.1 filter paper which was washed with 20 ml mixture of acetic acid and chloroform (12:8). Saturated potassium iodide solution (1 ml) was added to the filtrate which was then titrated with 0.01 N sodium thiosulphate solution, after the addition of one millilitre of starch solution (1% w/v) as indicator. The PV was calculated as follows:

$$\text{Peroxide value as meq/1000 g of fat} = \frac{(S-B) \times N \times 1000}{\text{weight in g of fat in the sample}}$$

Where,

B = ml of sodium thiosulphate required for the blank

S = ml of 0.01 N sodium thiosulphate required for sample

N = normality of sodium thiosulphate

3.16.4 Thiobarbituric acid value

Thiobarbituric acid (TBA) value of the powder was estimated using the procedure described by Tarladgio *et al.* (1960) Ten gram of the powder was blended with 97.5 ml of distilled water for two minutes, in a one litre conical flask and about 2.5 ml of hydrochloric acid was added to adjust the pH to 1.5. Few drops of antifoam (Tween 20) was added to the flask. This was connected to a water condensor and was heated vigorously. The distillate was collected in a conical flask. Five millilitre of this distillate was taken in a glass stoppered cylinder and was mixed with five millilitre TBA reagent. The cylinder was stoppered, mixed well and immersed in a boiling water bath for 35 minutes. Distilled water TBA blank was also prepared in the same manner as that of the sample. After heating, the mixture was cooled in tap water for 10 minutes and transferred a portion to a cuvette and read the optical density of the sample against the blank at a wave length of 538 nanometer. The reading was multiplied by a factor 7.8 to convert it into mg malonaldehyde per 1000 g of fat.

3.16.5 Non protein nitrogen

The method described by Becker *et al.* (1940) was followed for determining the NPN. One gram of the sample was extracted with 40 ml of 0.8 N trichloroacetic acid for 30 minutes in a mechanical shaker. The mixture was collected in two 15 ml tubes and were centrifuged for 10 minutes at 1100 rpm and the supernatent was collected and pooled. Ten millilitre portion of the supernatent was used for nitrogen determination as described in 3.1.3.

3.16.6 Titratable acidity

The method described in IS:7839(1975) was followed.

About ten gram of the material was weighed and about 50 ml of water was added. This mixture was transferred into a 100 ml volumetric flask and made up the volume with luke warm water. Transferred 20 ml of this mixture to a porcelain dish and added one millilitre phenolphthalein indicator solution. This was titrated against standard sodium hydroxide solution until a faint pink color which persists for 30 seconds was obtained.

Calculation:

Titratable acidity (as lactic acid) percentage by weight:

$$= \frac{45\ A\ N}{M}$$

Where,

A = The volume of standard sodium hydroxide solution required for titration

N = Normality of standard sodium hydroxide solution

M = Mass in g. of material taken

3.17 Analysis of ice cream mix powder

The experimental and control ice cream mix powder were analysed initially for the following parameters:

3.17.1 Moisture

As per the procedure given in 3.16.2

3.17.2 Non protein nitrogen

As per the procedure given in 3.16.5

3.17.3 Peroxide value

As per the procedure given in 3.16.3

3.17.4 Thiobarbituric acid value

As per the procedure given in 3.16.4

3.17.5 Titratable acidity

As per the procedure given in 3.16.6

In addition to the above, analysis were carried out for the following physical and chemical properties.

3.17.6 Protein

The percentage of protein in the powder was estimated using the procedure outlined in IS:7219 (1973).

3.17.7 Fat

The method followed was that of IS:7839 (1975) and IS:1479 (Part II) 1961. One gram of powder was taken in a beaker and mixed with 10 ml of water to make it into a smooth paste. After warming the mixture, 10 ml hydrochloric acid was added and mixed thoroughly. The contents were transferred into a Mojonnier fat extraction tube and heated in a water bath for 20 minutes at 60°C with occasional shaking. Added 10 ml of ethyl alcohol and proceeded further as in IS:SP:18 (Part XI, 1981).

3.17.8 Free fat

The method described by Buma (1971) was followed for the estimation of free fat. About 2.5 g of the dried sample was transferred in to an Erlenmeyer flask and to this added 100 ml of petroleum ether having a boiling point of 40-60°C. The mixture was well shaken for 30 minutes. The contents of the flask were filtered through a Whatman No.1 filter paper and the

filtrate was evaporated using a hot plate. The percentage of FF was calculated as follows:

$$\text{Percentage of free fat} = \frac{\text{Weight in g of fat}}{\text{weight in g of the sample}}$$

3.17.9 Carbohydrate

The carbohydrate percentage was obtained by the formulae 100 - (Moisture + Fat + Protein + Ash).

3.17.10 Ash

The method described in AOAC (1990) was followed in determining the ash percentage of sample.

3.17.11 Ultrastructure of the powder particle

The powder was subjected to scanning electron microscopy (SEM) to study the internal structure as per the procedure outlined by Bhandari *et al.* (1984). Samples of ice cream mix powder (without dry blended sugar) was applied to the stub coated with an adhesive (silver paste) as such and after crushing. Excess and loosely attached particle were removed by blowing the stub with an inert gas. The mounted powder was sputter coated with gold of approximately 150 A° thickness using Taab, K 550 sputter coater and examined under a Hitachi S.530 scanning electron microscope at an accelerating voltage of 10 KV.

3.17.12 Solubility index

Solubility index (ml) of the powder samples were determined as per the procedure outlined in IS:1547 (1969).

Fourteen grams of the sample was dispersed in 100 ml distilled water at 24°C and mixed using a mixing jar for 90 seconds. The contents were then transferred to graduated centrifuge tubes of 50 ml capacity and centrifuged at 150 rpm. Direct reading of solid material remaining at bottom was recorded as solubility index (SI) in millilitres.

3.17.13 Bulk density, average particle density and percentage volume occupied by powder

The method described by Beckett *et al.* (1962) was followed for the above estimations.

Fifty millilitre hexane was poured into a 100 ml graduated cylinder and covered with an aluminium foil. The volume of hexane (V1) and total weight (W1) were recorded. Powder was then added slowly through a funnel in to the cylinder to increase the volume by about 40 ml The cylinder was then covered with aluminium foil and placed in a levelled and vibration free surface. After one hour the volume of powder (V3), the volume of powder and Hexane (V2) and the total weight (W2) were recorded.

Calculation

$$\text{Bulk density (BD) (g/ml)} = \frac{W2 - W1}{V3}$$

$$\text{Average particle density (APD) (g/ml)} = \frac{W2 - W1}{V2 - V1}$$

$$\text{Percentage volume occupied by the powder (PVPP)} = \frac{(V2 - V1)}{V3}$$

3.18 Storage studies of Kera ice cream mix powder

The experimental and control ice cream mix powder with and without antioxidant were stored in the selected packaging media at room temperature of 30 ± 2°C for six months and analysed at bi-monthly interval for the following parameters.

3.18.1 Moisture

As per the procedure given in 3.16.2

3.18.2 Titratable acidity

As per the procedure given in 3.16.6

3.18.3 Thiobarbituric acid value

As per the procedure given in 3.16.4

3.18.4 Peroxide value

As per the procedure given in 3.16.3

3.18.5 Non protein nitrogen

As per the procedure given in 3.16.5

The keeping quality of the powder was assessed based on the results of the above experiments.

3.19 Studies on reconstituted ice cream mix powder

The experimental and control ice cream mix powder were reconstituted with potable water in the proportion of 1:1.8 and frozen using a softy ice cream machine. The samples were designated as A-R, B-R, C-R, D-R and E-R. The following properties of the ice cream were studied.

3.19.1 Relative viscosity

As per the procedure given in 3.13.3

3.19.2 Specific gravity

As per the procedure given in 3.13.5

3.19.3 Overrun

As per the procedure given in 3.14.1

3.19.4 Meltdown time

As per the procedure given in 3.14.2

The reconstituted and frozen product was served to six judges to evaluate the organoleptic qualities also (3.14.7).

3.20 Feeding trials

To evaluate the nutritional qualities and plasma lipid profile of Kera ice cream and control ice cream, feeding experiments were carried out.

Forty male Sprague Dawley strain of albino rats of 24-25 days of age, weighing on an average of 35 to 45 g were selected. These animals were procured from the Small Animal Breeding Station, College of Veterinary and Animal Sciences, Mannuthy.

The rats were divided into four groups of 10 animals each. The groups were designated as reference group (R), ice cream mix powder group (M), Kera ice cream mix powder group (K), and control (farm) diet (C) group.

De-oiled coconut oil cake is powdered well and is mixed with ten times by weight of water (w/w). The pH of this mixture was adjusted to 8.5 by adding 50 per cent sodium hydroxide solution. This mixture was filtered using a muslin

cloth. The filtrate collected was centrifuged through a laboratory cream separator and the clear liquid coming through the skim milk spout was collected and the pH adjusted in between 4.5 and 4.6 by adding 40 per cent hydrochloric acid solution. The mixture was kept undisturbed for overnight and the supernatent clear fluid was poured off. The precipitated protein remaining at the bottom was again mixed with water and kept for settling and the supernatent poured off. This process is repeated for three times to remove the acidity completely. The coagulated protein was collected and dried at 45 to 50°C for 12 hours. The dried precipitate was collected and powdered and analysed for use in the experiments.

Edible casein was prepared from fresh cow skim milk as per the procedure outlined in IS:1167 (1965).

The vitamin and salt mixture manufactured by Alembic Chemical Works Co. Ltd., Vadodara was used. The composition of this mixture was given in Appendix-VI.

The other feed ingredients such as ground nut oil, corn starch, sugar were purchased from the local market.

The energy value of the feed mixes was estimated using a parr oxygen adiabatic bomb calorimeter following the method prescribed by the manufacturer.

3.20.1 Determination of protein efficiency value

The method described by Osborne and Mendel (1917) was used to determine the protein efficiency value (PEV) with slight modifications. Of the three sets of rats maintained for evaluating the nutritional properties, Reference group of rats (R) were maintained on a diet consisting of 10 per cent groundnut oil, 14 per cent sugar, 4 per cent vitamin and salt mixture, 12.1 per cent casein (to get 10 per cent of protein) and 59.9 per cent of corn starch. Second set of rats (M group) were maintained on an ice cream mix powder diet replacing a part of the casein in the reference diet with the protein from the ice cream mix powder. Third sets of (K Group) rats were maintained on Kera ice cream mix powder diet wherein the protein requirement is met from the coconut protein and milk protein. In the M group and the K-group the protein, fat and the sugar content were limited to 10, 10 and 14 per cent respectively. The composition of the diets were presented in Appendix-VII. The food and water were supplied *ad libitum*, for a period of eight weeks. Individual cages were provided with feeders to reduce spoilage. Experiment was laid out using completely randomised design in which blocks represented initial variation in weight was used. Weekly feed consumption and body weight were recorded. After eight weeks of experimental period the PEV of each feed was calculated and compared with that of the reference casein diet.

$$PEV = \frac{\text{Gain in weight of rats (g)}}{\text{Protein consumed (g)}}$$

3.20.2 Feed efficiency

Body weights of the rats were recorded at weekly intervals. Feed efficiency was calculated as follows.

$$\text{Feed efficiency} = \frac{\text{Weight gain (g)}}{\text{unit of food consumed (dry matter basis)}}$$

3.20.3 Serum lipid profile

The cholesterol and triglyceride levels of the serum collected from the rats of experimental, control and farm diet were estimated after feeding a period of three months.

At the end of the feeding experiments the rats under the four groups were starved overnight. They were anesthetised using chloroform and blood collected by retrobulbar puncture using heparinised capillary tubes. Serum was separated from each sample and the following analysis were carried out.

3.20.3.1 Total serum cholesterol

The total serum cholesterol was estimated using the Cholzyme -M diagnostic kit supplied by M/S Ortho Diagnostic System. The procedure given by the company was followed in the estimation. Added one millilitre each of working reagent to

three test tubes marked Test (T), Standard (S) and Blank (B). To the test tubes marked T, S and B added 20 µl each of serum, standard and distilled water, respectively and mixed well. Later four millilitre each of distilled water was added to the tubes, mixed well and the optical density was read at 515 nanometer (500-530 nm) adjusting against the blank.

$$\text{Calculation} = \frac{\text{Optical density of the test}}{\text{Optical density of the standard}} \times 200$$

= Cholesterol concentration mg/dl.

3.20.3.2 Triglyceride

In vitro fully enzymatic method for the quantitative determination of triglyceride was followed using the diagnostic kit supplied by M/S Ortho Diagnostic System. The procedure outlined by the manufacturer is as follows. To three test tubes marked Test (T), Standard (S) and Blank (B) added 0.5 ml each of reagent 1 (Lyophilised enzymes) and reagent II (phenol solution). These two were mixed together and 20 µl of serum, triglyceride standard and distilled water were added to the tubes marked T, S and B respectively. Mixed the contents thoroughly and incubated at 37 ± 0.5°C for 10 minutes in a water bath. The optical density (OD) was measured at 500 nanometer (range 500-530 nm) adjusting against the blank.

$$\text{Calculation} = \frac{\text{Optical density of the test}}{\text{Optical density of the standard}} \times 300$$

= Triglyceride concentration (mg/dl)

3.21 Examination of tissues

The experimental animals were slaughtered at the end of the experimentation period and were subjected to detailed autopsy examination adopting standard techniques. The general condition and macroscopic changes if any in all organs and body cavities were examined and recorded.

Tissues from different organs were collected for histopathological studies. Pieces of tissues from heart, liver, kidney and aorta were fixed in 10 per cent formalin (neutral) and processed using routine techniques. Paraffin sections cut at 5-6 micron thickness were stained with haematoxyline and eosin and examined under microscope to detect cellular alterations.

3.22 Statistical analyses

Statistical analyses of the data were carried out using student's 't' test, analysis of variance and analysis of covariance techniques given by Snedecor and Cochran (1967).

RESULTS

4. RESULTS

A study was conducted in detail to assess the feasibility of incorporating coconut fat in place of milk fat at different levels in the preparation of ice cream and to ascertain the different qualities of this product. The results of the experiments are presented in the following section.

4.1 Extraction and analysis of coconut cream

The gratings obtained from 50 individual coconuts were weighed separately and the weight of the gratings ranged from 150 to 315 g with a mean of 266 g. The weight of the coconut cream extracted from individual coconut ranged from 70 g to 245 g with a mean of 122 g. The percentage of coconut cream collected from individual coconut gratings ranged from 46.66 to 77.77 with a mean of 58.291. The mean with standard error of the values are presented in Table 2.

The coconut cream obtained were analysed for moisture, TS, fat, protein, carbohydrate and ash percentage and the mean ± standard error are presented in Table 2 and depicted in Figure 2, the values in percentage being 47.71, 52.29, 38.950, 5.771, 6.549 and 1.020 respectively.

Table 2. Yield per nut and composition of coconut cream

A. Yield		Mean ± SE
Weight of gratings(g)	-	266.000 ± 19.276
Weight of coconut cream (g)	-	122.000 ± 16.042
Percentage of coconut cream	-	58.291 ± 3.172
B. Composition (Percentage)		
Moisture	-	47.710 ± 0.266
Total solids	-	52.290 ± 0.266
Fat	-	38.950 ± 0.234
Protein	-	5.771 ± 0.120
Carbohydrate	-	6.549 ± 0.254
Ash	-	1.020 ± 0.022

4.2 Analysis of skim milk powder and butter

The mean fat, TS and moisture percentage of the dairy ingredients used for the preparation of ice cream are presented in Table 3. The mean fat, TS and moisture percentage in skim milk powder were 0.6, 97.81 and 2.19 respectively. In the case of butter the mean percentage for fat, TS and moisture content were recorded as 81.02, 82.29 and 17.71 respectively.

Table 3. Mean fat, total solids and moisture percentage in skim milk powder and butter

Ingredient	Fat	Total solids	Moisture
Skim milk powder	0.6	97.81	2.19
Butter	81.02	82.29	17.71

Fig.2
CHEMICAL COMPOSITION OF COCONUT CREAM

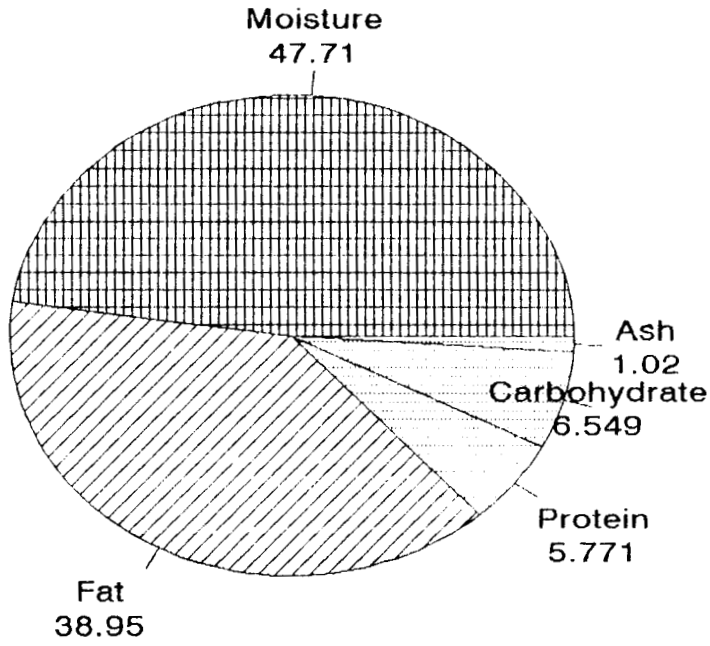
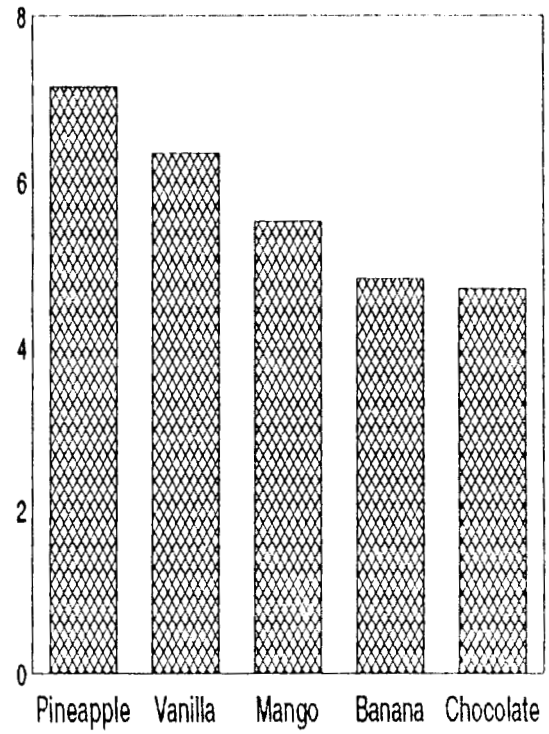


Fig. 3
SCORE FOR KERA ICE CREAM WITH DIFFERENT FLAVOURS



4.3 Evaluation of flavour for ice cream

The analysis of the data pertaining to consumer acceptance studies revealed that pineapple flavour scored the maximum with 7.15 points followed by vanilla flavour with 6.35 points. The scores obtained for the other flavours studied were mango 5.53, banana 4.84 and chocolate 4.71. The results indicated that pineapple flavour was most acceptable to consumers and thus subsequent studies were carried out using pineapple flavour only (Fig.3).

4.4 Evaluation of ideal stabilizer/emulsifier and or combination for ice cream

To determine an ideal combination of stabilizer/ emulsifier for Kera ice cream, a pre-trial was carried out in which the product was served to judges and the sensory evaluation was made.

4.4.1 Sensory evaluation

The results of the sensory evaluation of Kera ice cream (Table 4) revealed a highly significant ($P<0.01$) difference, with respect to body and texture existing between the five treatments such as (1) GMS + Gelatin, (2) GMS + Sodium alginate, (3) Gelatin, (4) Sodium alginate and (5) GMS. Comparison of means using the critical difference showed that treatment 1 was significantly different from treatment 2, 3

Table 4. Sensory evaluation of Kera ice cream with different stabilizers and emulsifiers

Character	Mean and Range	Treatments 1 GMS + Gel	2 GMS +SA	3 Gelatin	4 SA	5 GMS
Body and texture	Mean ± SE	b 82.192 ± 0.3881	a 84.175 ± 0.2155	a,c 83.375 ± 0.3284	a,c 83.300 ± 0.3165	b,c 82.675 ± 0.3869
	Range	70-85	75-85	70-85	70-85	70-85
Melting quality	Mean ±SE	14.500 ± 0.0905	14.650 ± 0.0745	14.617 ± 0.0792	14.517 ± 0.0840	14.600 ± 0.0830
	Range	13-15	13-15	13-15	12-15	13-15

F-Value for comparing the treatment means (body and texture)=6.499 (P< 0.01)
CD at 1% for comparing body and texture means = 1.06
F-value for comparing the treatment means (melting quality) = 1.671 (NS)
Means bearing the common letters as superscript are statistically not significant

Table 5. Titratable acidity and pH of control and experimental ice cream

Property	Mean and Range	Control A	Treatments B	C	D	E
Titrtable acidity (% of lactic acid	Mean ± SE	0.164± 0.006	0.174± 0.007	0.177± 0.008	0.175± 0.008	0.185± 0.008
	Range	0.135- 0.180	0.140- 0.203	0.158- 0.207	0.144- 0.198	0.167- 0.221
pH	Mean ± SE	6.641± 0.081	6.776± 0.067	6.724± 0.046	6.734± 0.035	6.634± 0.071
	Range	6.31- 6.94	6.53- 6.99	6.60- 6.95	6.61- 6.90	6.30- 6.98

F-Value for comparing the titratable acidity = 1.498 (NS)
F-value for comparing the pH = 0.989 (NS)

and 4. The treatments 2 and 5 were also significantly different. It can be noticed that eventhough treatments 2, 3 and 4 do not differ statistically, treatment 2 obtained the highest mean score as far as the body and texture is concerned (Fig.4). It was further observed that no significant difference existed between the five treatments as far as the melting quality was concerned. Based on the above, the treatment 2 which secured the highest score for body and texture quality was selected. The subsequent trials were conducted using a combination of 0.25% sodium alginate and 0.25% GMS.

4.5 Analysis of control and experimental ice cream mix

The physico-chemical properties of control and experimental ice cream mixes were studied with eight replications and the results obtained are presented below:

4.5.1 Titratable acidity

The titratable acidity (percentage of lactic acid) for control and treatments are presented in Table 5. Analysis of variance showed no significant difference among the treatments as well as between the treatments and control. Overall minimum and maximum titratable acidity for the treatments were 0.140 and 0.221 respectively with a mean of 0.175.

Fig. 4

SCORE FOR BODY AND TEXTURE FOR KERA ICE CREAM WITH DIFFERENT STABILIZER AND EMULSIFIER

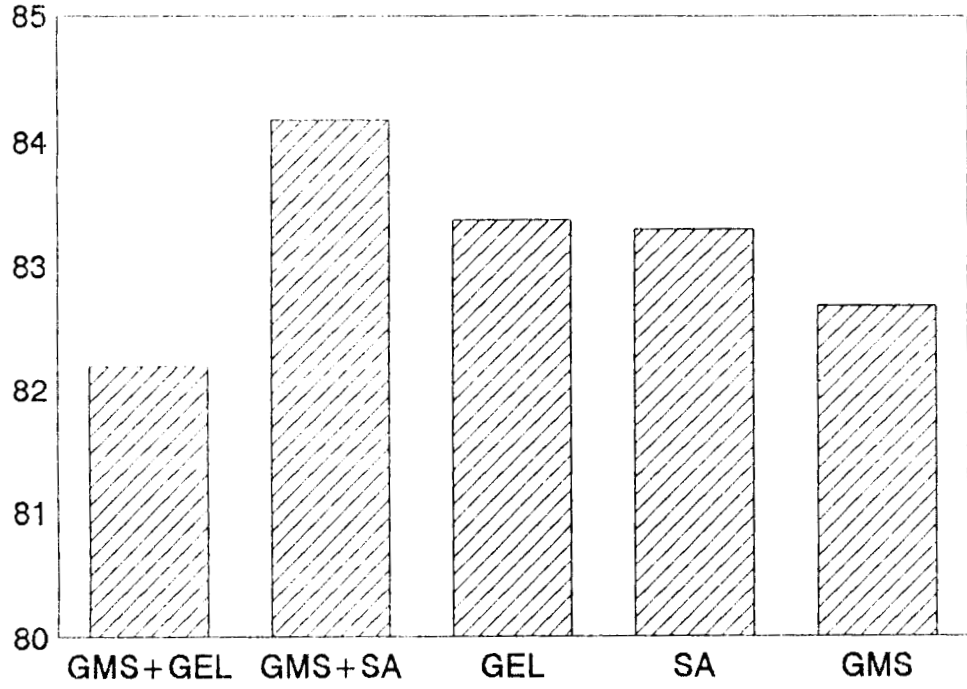
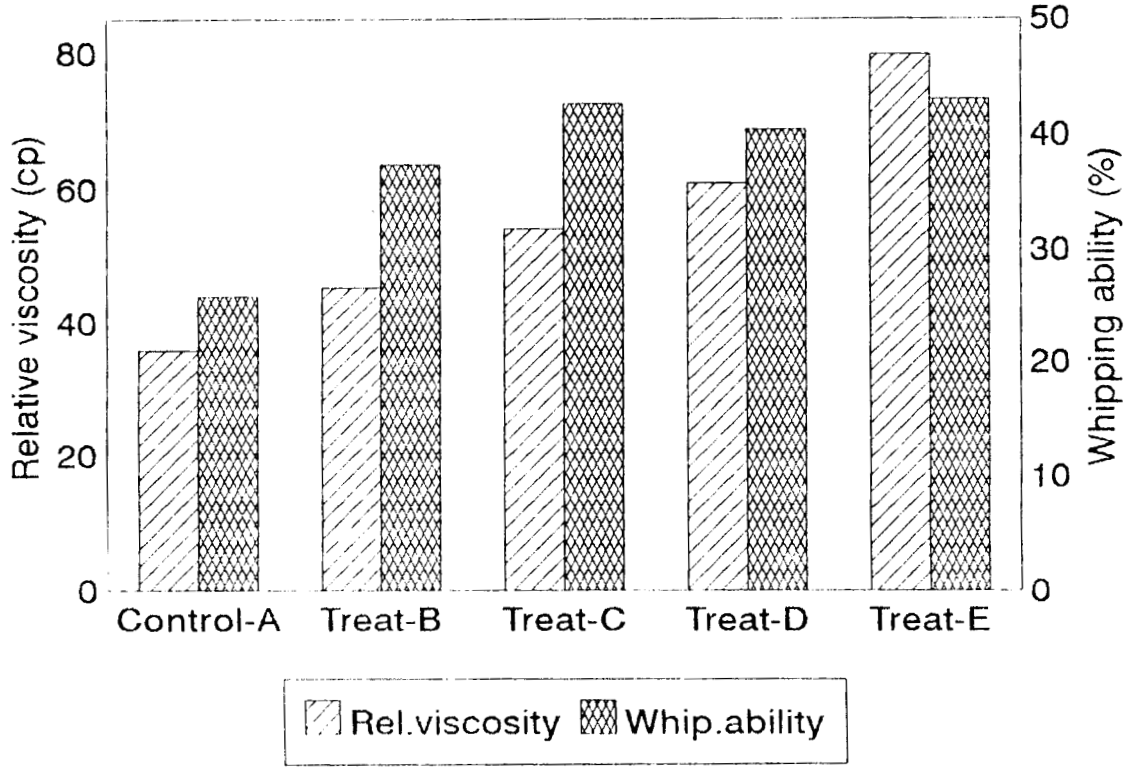


Fig. 5

RELATIVE VISCOSITY AND WHIPPING ABILITY (FIRST 5 MTS) OF CONTROL AND EXPERIMENTAL ICE CREAM



4.5.2 pH

The pH for the control and experimental ice cream are presented in Table 5. The statistical analysis of the data revealed no significant difference between the four treatments and control. Overall pH values for both the treatments and control ranged from 6.30 to 6.99.

4.5.3 Relative viscosity

The mean, SE and range with regard to relative viscosity (cp) for the control and treatment ice cream mixes are presented in Table 6 and Fig.5. Mean relative viscosity values increased as the fat substitution level increased, from 25 to 100 percentage in the treatments. Mean relative viscosity values was 35.760 for the control and 79.593 for the treatment E. Statistical analysis of the data revealed significant differences between the control and different treatments ($P<0.01$), indicating that fat replacement at 25, 50, 75 and 100 per cent level cause significant difference in relative viscosity as compared to control.

4.5.4 Surface tension

Summary statistics of surface tension (dynes/cm) with regard to mean, SE and range for control and treatments are shown in Table 6 and presented in Fig.6. Among the treatments surface tension values showed a slight increase as the

Table 6. Relative viscosity and surface tension of control and experimental ice cream

Property	Mean and Range	Control A	Treatments B	C	D	E
Relative viscosity (Centi-poise	Mean ± SE	a 35.760± 0.7036	b 45.278± 0.5127	c 54.041± 0.8627	d 60.797± 1.1632	e 79.593± 0.8556
	Range	34.05-38.64	42.65-47.33	50.72-58.37	55.62-64.27	74.54-82.69
Surface tension (dynes/cm)	Mean ±SE	c 61.919± 0.569	b 54.319± 0.545	b 55.128± 0.690	a 57.715± 0.484	a 58.524± 0.803
	Range	59.49-64.67	51.73-55.61	51.73-58.20	55.61-59.49	55.61-62.08

F-Value for comparing relative viscosity = 384.393 (P<0.01)
CD at 1% for comparing viscosity = 3.2643
F-value for comparing ST = 23.022 (P<0.01)
CD at 1% for comparing ST = 2.421
Means bearing the common letters as superscript are statistically not significant.

Table 7. Specific gravity (mix and ice cream) and weight in grams/litre for control and experimental ice cream

Property	Mean and Range	Control A	Treatments B	C	D	E
Specific gravity of ice cream mix	Mean ± SE	1.053± 0.004	1.052± 0.003	1.052± 0.003	1.056± 0.004	1.056± 0.004
	Range	1.043-1.060	1.041-1.068	1.033-1.065	1.046-1.065	1.028-1.067
Specific gravity of ice cream	Mean ± SE	c 0.875± 0.004	b,c 0.867± 0.004	a,b,c 0.863± 0.004	a,b 0.857± 0.003	a 0.851± 0.003
	Range	0.861-0.894	0.851-0.894	0.845-0.889	0.840-0.883	0.840-0.880
Weight in grams/ litre	Mean ± SE	711.250± 21.210	704.375± 20.711	700.000± 20.089	694.375± 20.231	689.375± 20.033
	Range	675-850	670-840	660-830	660-825	650-820

F-Value for comparing the specific gravity (mix) = 0.401 (NS)
F-value for comparing the specific gravity of ice cream = 3.743 (P<0.05)
CD at 5% for comparing the specific gravity = 0.013
F-value for comparing weight in grams/litre = 0.173 (NS)
Means bearing common letters as superscript are statistically not significant

percentage of fat replacement increased. The mean surface tension value of control was significantly ($P<0.01$) higher than treatment groups. Treatments B and C, D and E were statistically at par.

4.5.5 Specific gravity of ice cream mix

The mean, SE and the range for the specific gravity are presented in Table 7. Mean specific gravity of control and treatment mix were in the range of 1.052 to 1.056 with an overall mean of 1.054. Statistical analysis revealed no significant difference between control and treatments, and between the treatments.

4.5.6 Overrun

Summary statistics with regard to overrun (percentage) for the control and treatments are presented in Table 8 and Fig.7. As the percentage replacement of milk fat with coconut fat increased an obvious increase in overrun was observed. The overrun percentages ranged from 47.306 (control) to 61.580 (100% fat substitution) Significant difference ($P<0.01$) was observed between control and treatments D and E. An appreciable increase in overrun was noticed in treatments where 75 per cent and 100 per cent fat were replaced. Among treatments significant difference was noticed between Treatments B and E only.

Table 8. Overrun and meltdown time for control and experimental ice cream

Property	Mean and Range	Control A	Treatments B	C	D	E
Overrun(%)	Mean ± SE	c 47.306± 2.401	b,c 51.612± 2.425	a,b,c 53.710± 2.676	a,b 57.385± 2.659	a 61.580± 2.270
	Range	32.35- 53.57	38.46- 60.71	40.63- 62.96	44.26- 66.66	47.54- 66.66
Meltdown time (min)	Mean ± SE	d 59.625± 0.488	c 55.175± 1.100	b,c 53.055± 1.089	b 48.900± 1.679	a 43.694± 0.771
	Range	56.4- 61.0	50.0- 60.0	48.0- 59.0	44.0- 58.3	40.0- 47.0

F-Value for comparing overrun (%) = 4.793 (P<0.01)
CD at 1% for comparing overrun (%) = 9.597
F-value for comparing meltdown time = 30.599 (P<0.01)
CD at 1% for comparing meltdown time = 4.235
Means bearing common letters as superscript are statistically not significant.

Table 9. Whipping ability at five minutes interval based on overrun percentage

Property	Mean and Range	Control A	Treatments B	C	D	E
Whipping ability (first 5 min)	Mean ± SE	b 25.850± 2.316	a 37.450± 2.365	a 42.563± 1.782	a 40.400± 2.210	a 42.963± 2.758
	Range	20.0- 32.4	28.6- 47.5	36.4- 50.0	33.3- 50.0	30.4- 50.0
Whipping ability (second 5 min)	Mean ± SE	b 18.615± 2.722	a 9.863± 1.305	a 8.163± 1.641	a 10.600± 0.629	a 13.226± 2.121
	Range	6.9-25.9	5.1-14.8	3.1-14.8	8.2-14.3	8.9-27.8

F-value for comparing whipping ability at first 5 min = 9.344 (P<0.01)
CD at 1% for comparing whipping ability at first 5 min = 8.889
F-value for comparing whipping ability at 2nd 5 min = 4.972 (P<0.01)
CD at 5% for comparing whipping ability at 2nd 5 min = 5.249
Means bearing the common letters as superscript are statistically not significant.

Fig. 6

SURFACE TENSION OF CONTROL AND EXPERIMENTAL ICE CREAM

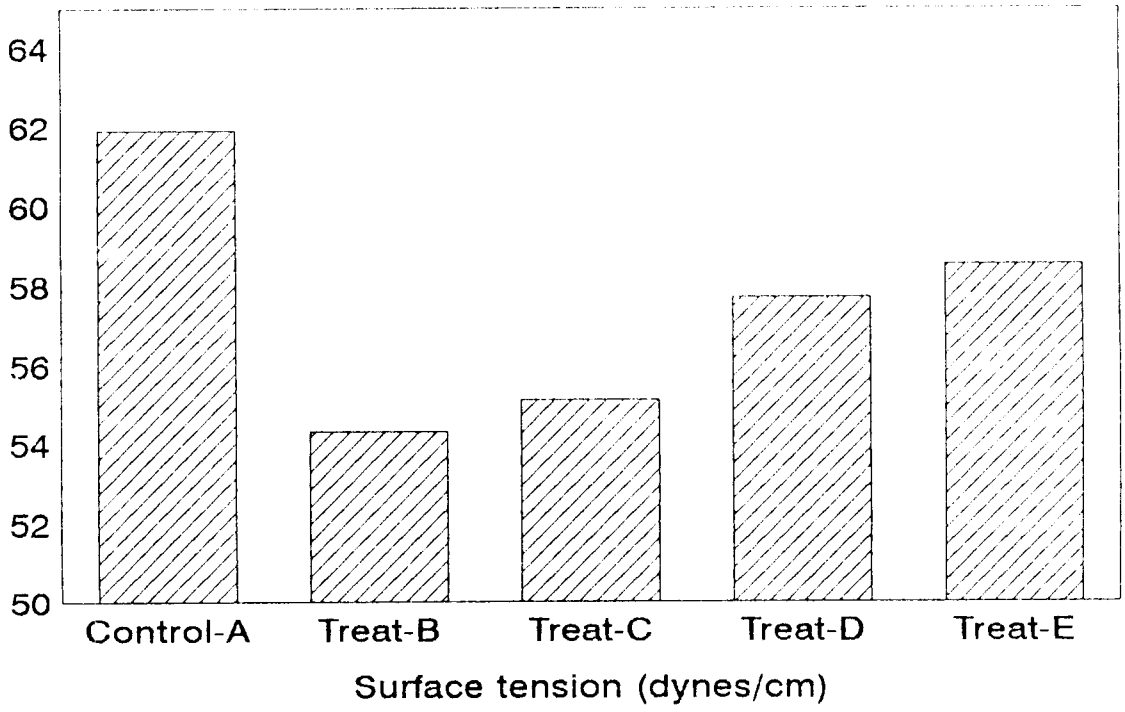
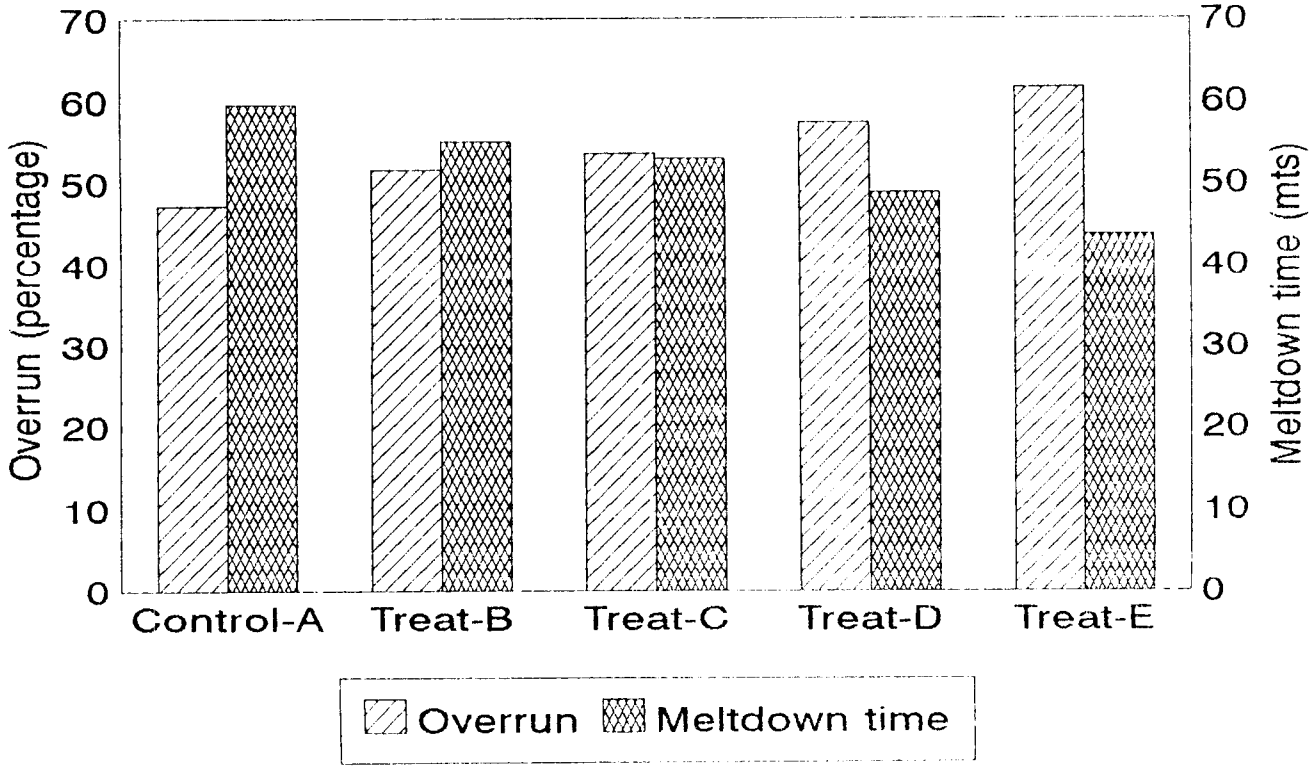


Fig. 7

OVERRUN AND MELTDOWN TIME FOR CONTROL AND EXPERIMENTAL ICE CREAM



4.5.7 Meltdown time

A decreasing trend was observed in MDT (minutes) as percentage replacement of milk fat increased (Table 8 and Fig.7). Highest MDT was observed for control (no fat substitution) and the lowest for Treatment E (100% fat substitution). Statistical analysis showed that MDT for control was significantly ($P<0.01$) higher than all the four treatments. Comparison of the means using critical difference revealed that Treatments B and C were comparable. Similarly Treatments C and D were also statistically identical.

4.5.8 Whipping ability

Whipping ability mean values and range calculated from the overrun percentage for the treatments and control for the first five minutes and second five minutes are presented in Table 9. and Fig.5). Whipping ability was lowest for the control in the first five minutes as compared to the treatments. In the second five minutes control had the highest whipping ability. Significant difference ($P<0.01$) was observed between the treatments and control for both time interval. All the four treatments were homogenous for both periods. Comparison of whipping ability between treatments and control at both time interval are presented in Fig.5.

Fig. 8

SPECIFIC GRAVITY AND WEIGHT IN GRAMS PER LITRE OF CONTROL AND EXPERIMENTAL ICE CREAM

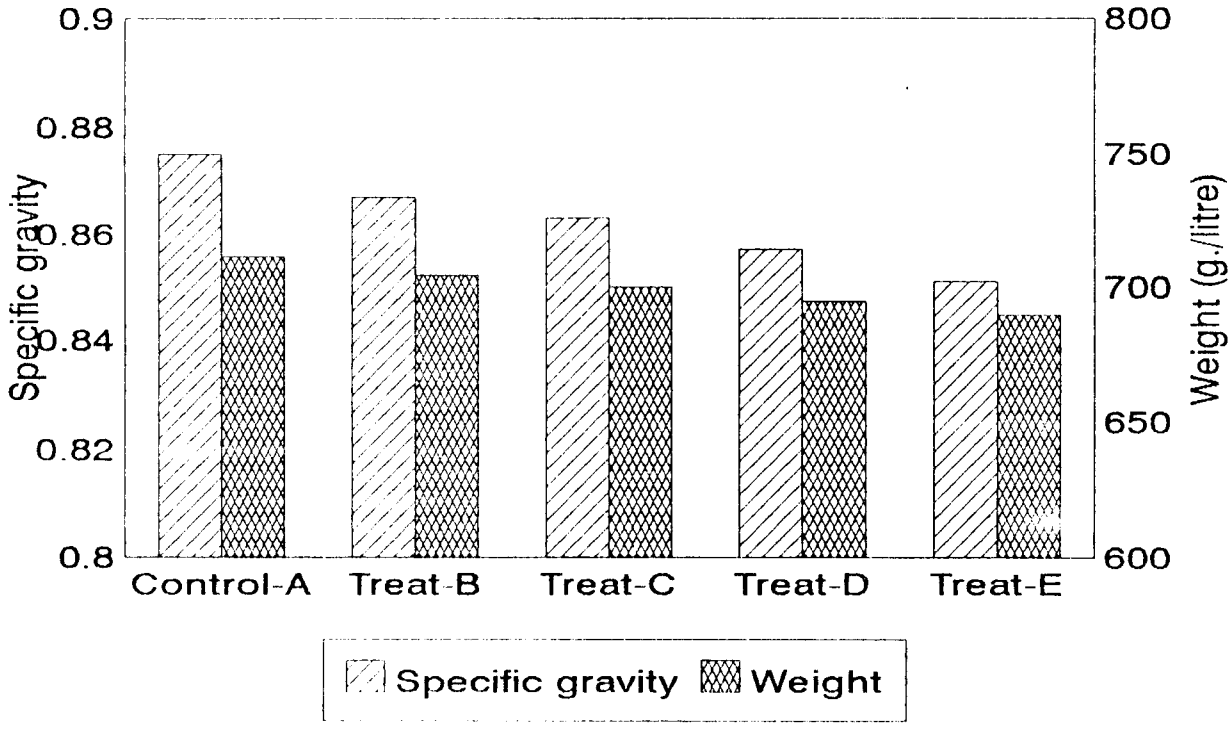
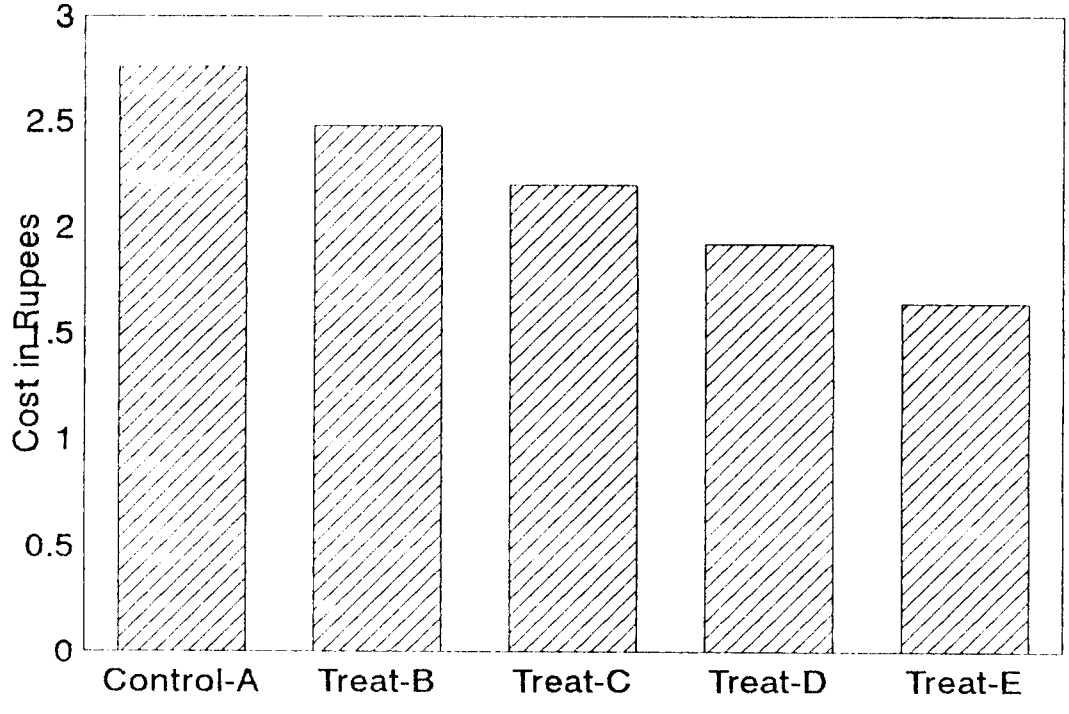


Fig. 9

COST OF 100 GRAM OF CONTROL AND EXPERIMENTAL ICE CREAM



4.5.9 Specific gravity of ice cream

Specific gravity (mean) of the five groups of samples were in the range of 0.851 to 0.875 with an overall mean of 0.863. (Table 7 and Fig.8). The highest specific gravity was observed for the control (A) and lowest for Treatment E (100% fat substitution). Significant difference was observed between the control and Treatments D and E ($P<0.05$) indicating that specific gravity decreases as fat substitution increases. Among the treatments significant difference was observed ($P<0.05$) only between Treatments B and E.

4.5.10 Weight in grams per litre

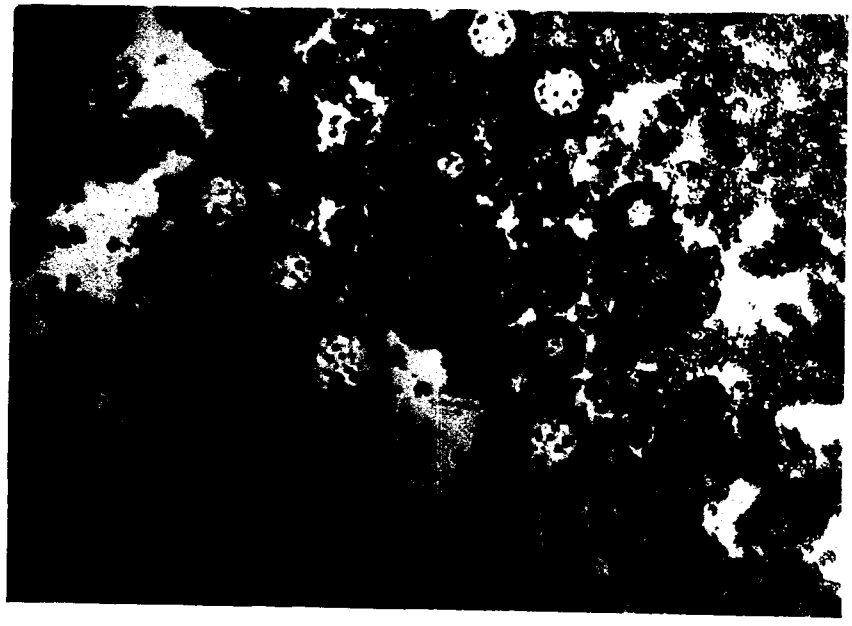
The Mean, SE and range for weight in g per litre for the control and treatments are shown in Table 7 and Fig.8. Eventhough control showed highest mean weight in g per litre (711.250) and the treatment E gave the lowest mean (689.375) statistical analysis revealed no significant difference between the control and treatments.

4.5.11 Microscopical structure

The control and experimental ice cream were viewed under microscope to study the difference in structure. The average and range in diameter of the air cells (microns) were for sample A 13 (4-24), B:13 (5-26), C:20 (5-32), D:20 (5-29) and E:24 (10-48). Samples A, B, C and D had more or less uniform

Plate 1 Structure of ice cream:Control:A (x 375)
Average air cell diameter:13 μ (4-24)

Plate 2 Structure of ice cream: Control (x 600)
Uniform distribution of air cells with thin cell walls



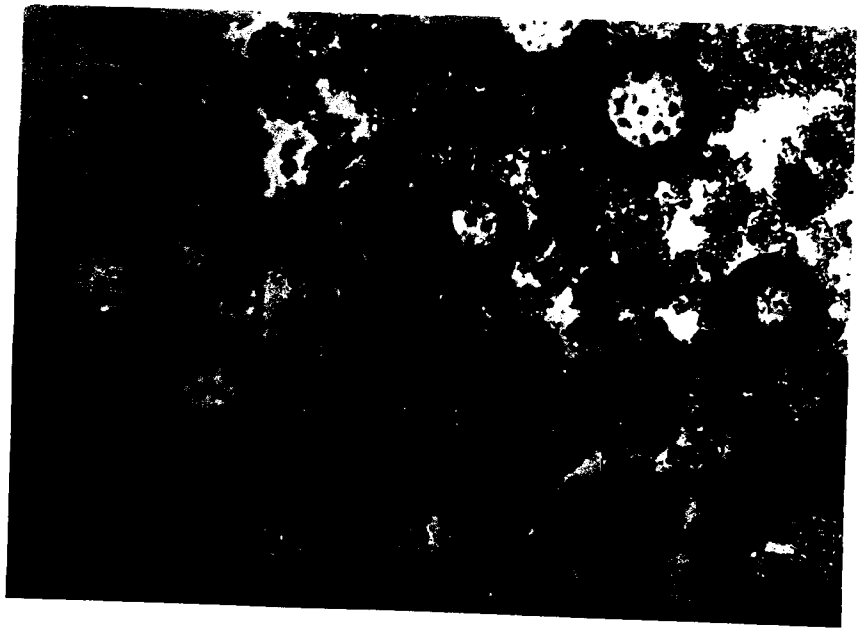
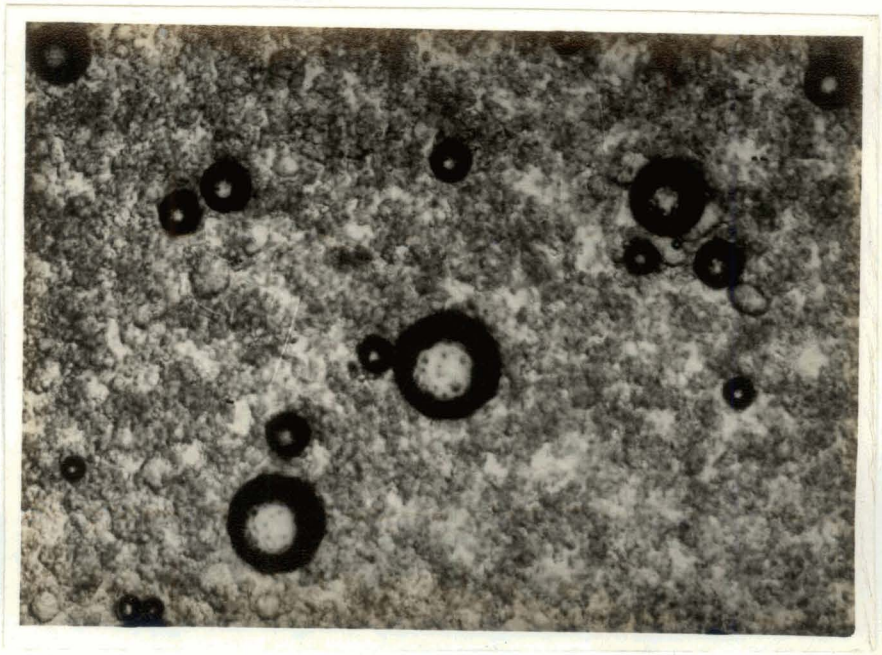


Plate 3 Structure of Kera ice cream: B (x 375)
Average air cell diameter: 13 μ (5-26)

Plate 4 Structure of Kęra ice cream:B (x 600)



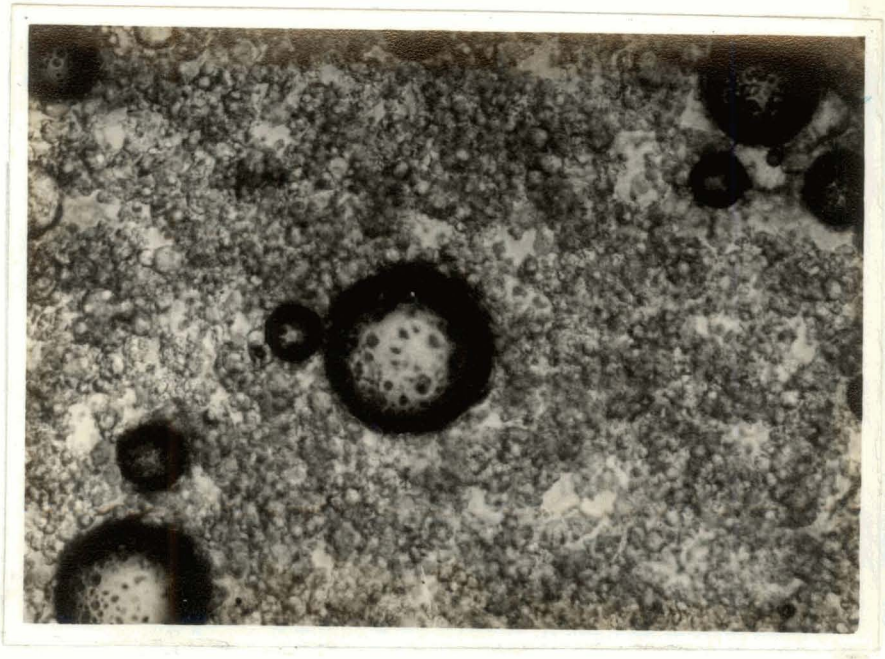
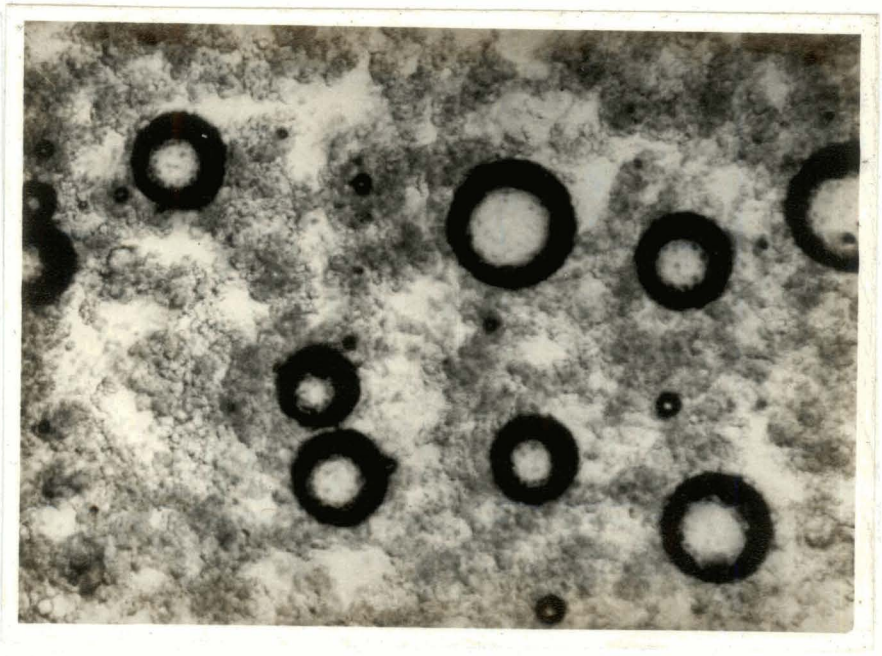


Plate 5 **Structure of Kera ice cream: C (x 375)**
Average air cell diameter : 20 μ (5-32)

Plate 6 **Structure of Kera ice cream: C (x 600)**



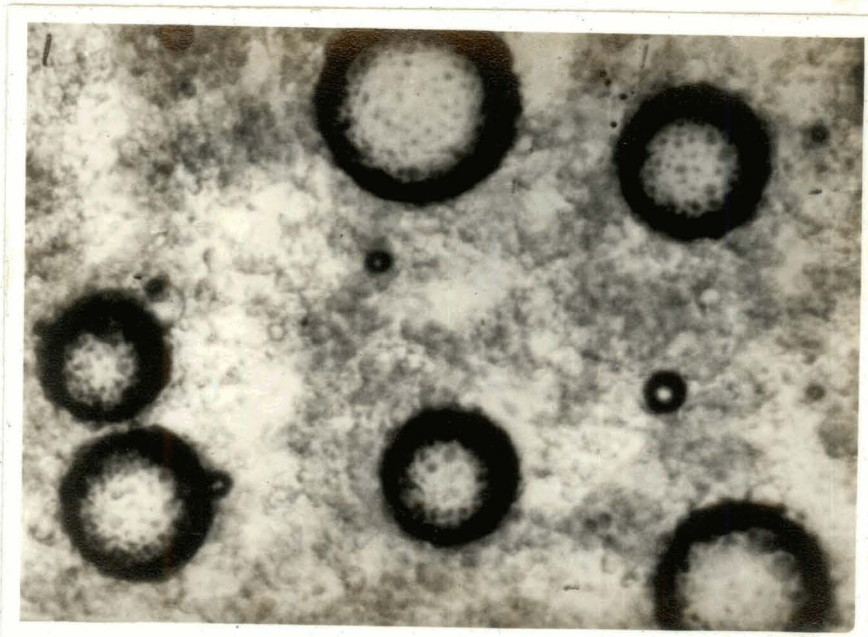
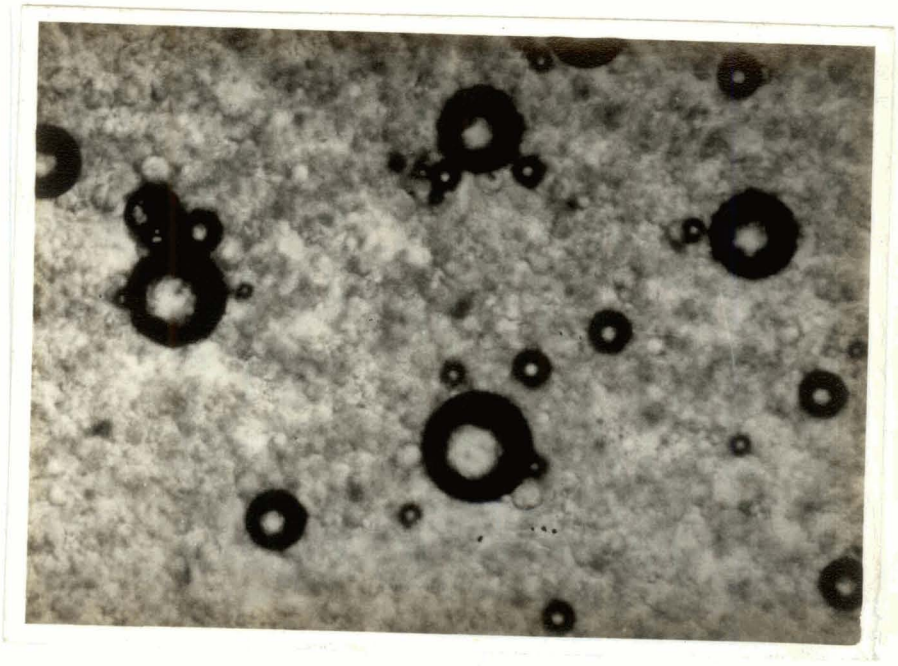


Plate 7 **Structure of Kera ice cream: D (x 375)**
Average air cell diameter: 20 μ (5-29)

Plate 8 **Structure of Kera ice cream: D (x 600)**



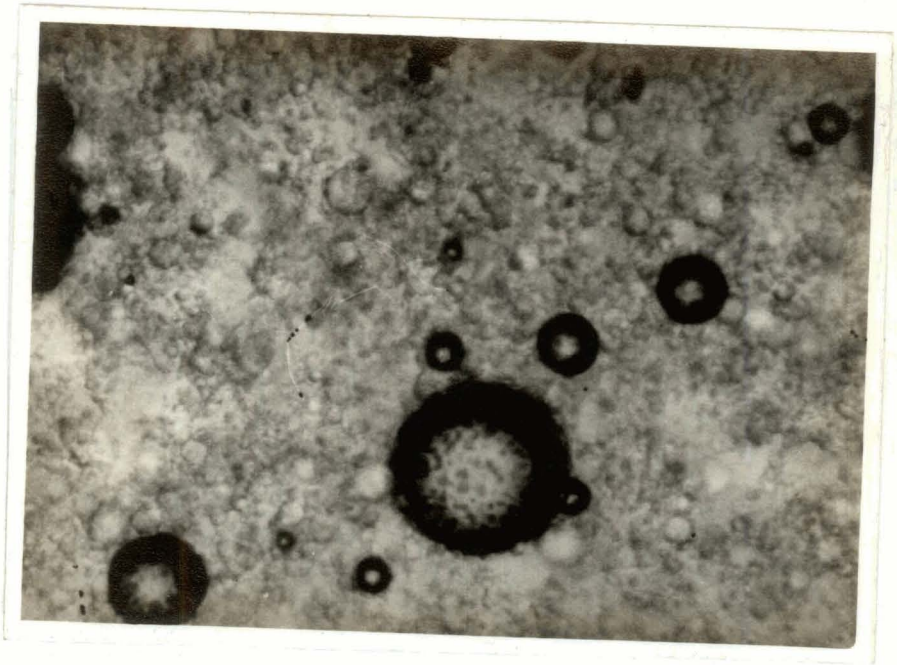
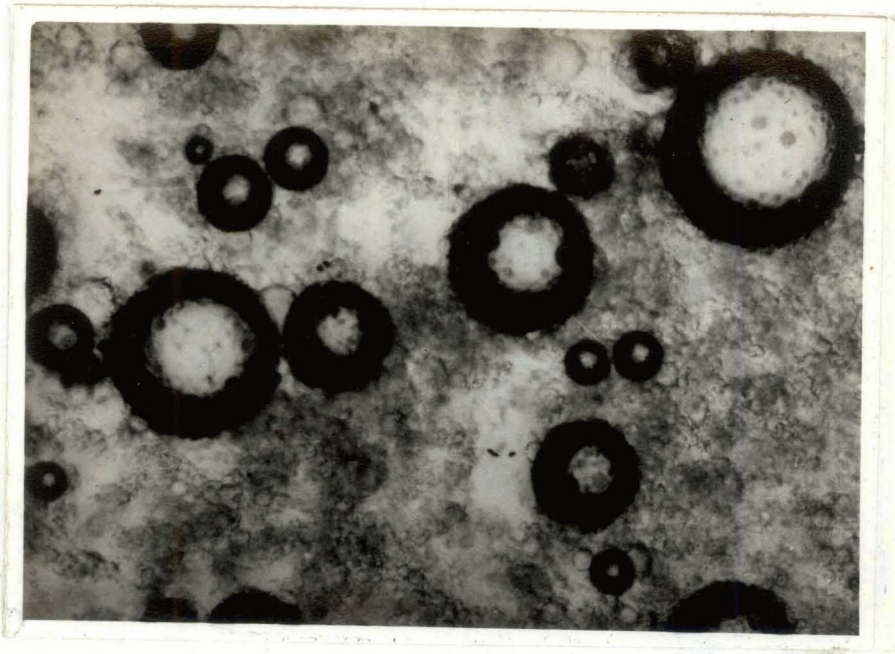
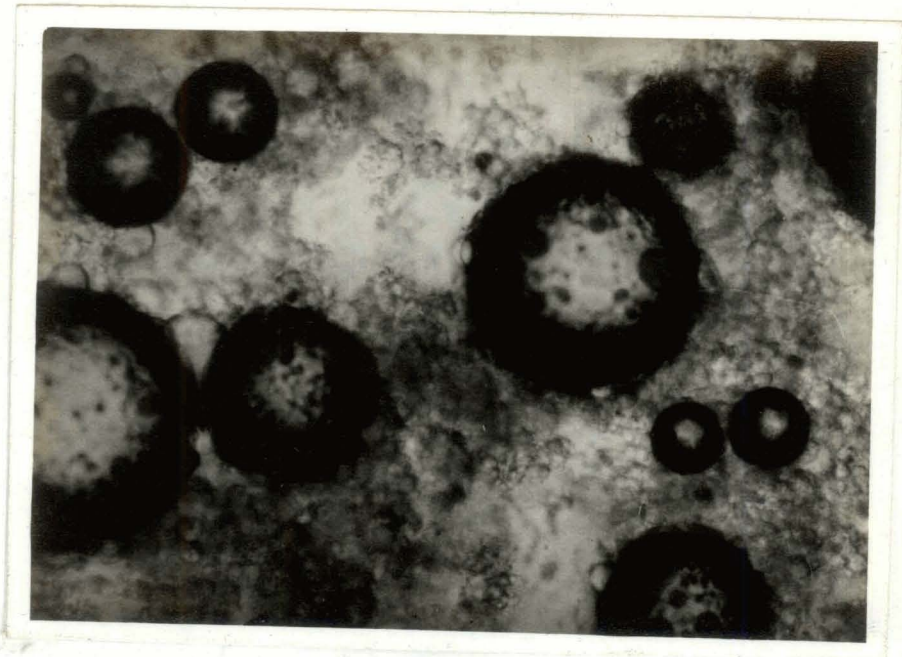


Plate 9 **Structure of Kera ice cream: E (x 375)**
Average air cell diameter: 24 μ (10-48)

Plate 10 **Structure of Kera ice cream: E (x 600)**





range as far as air cell size are concerned. Sample E (Plate 9 and 10) had the highest mean and range air cell diameter. Control ice cream (Plate 1 and 2) revealed uniform distribution of small air cells with thin cell walls. The liquid portion showed uniform distribution of visible particles. The thickness of the air cell wall increased when the replacement level of milk fat with coconut fat increased. The periphery of the air cells had a distorted appearance especially for sample E (Plate 9 and 10). In the liquid portion the solid particles were not so visible and homogenous, as the replacement level increased. The photographs of the sample under low power and high power are presented in Plates 1 to 10.

4.5.12 Sensory evaluation

The mean scores obtained for control and experimental ice cream with regard to characters like flavour, body and texture, melting quality, colour and package, bacterial count and total score are furnished in Table 10. The differences between individual scores for the above characters and the total score were analysed statistically and found to be not significant.

4.5.13 Cost estimation

The cost of production of 100 g of control and experimental ice cream was calculated based on the ingredient cost. The then prevailing cost of ingredients for one kg were: coconut cream Rs.25/-, skim milk powder Rs.90/-, butter

Table 10. Organoleptic quality of control and experimental ice cream

Property	Max. score	Mean & Range	Treatments Control A	B	C	D	E
Flavour	45	Mean±SE	39.444± 0.421	40.276± 0.456	40.901± 0.513	40.829± 0.442	40.625± 0.350
		Range	37-45	36-45	36-45	37-45	36-45
Body and texture	30	Mean±SE	29.007± 0.219	29.141± 0.177	29.058± 0.279	29.501± 0.124	29.485± 0.198
		Range	28-30	28-30	27-30	28-30	28-30
Melting quality	5	Mean±SE	4.868± 0.074	4.866± 0.064	4.923± 0.053	4.851± 0.117	4.930± 0.025
		Range	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0
Colour & package	5	Mean±SE	4.993± 0.007	4.993± 0.007	4.985± 0.014	4.978± 0.014	4.993± 0.007
		Range	4.75-5	4.75-5.0	4.75-5	4.75-5	4.75-5.
Bacteria	15	Mean±SE	15±0	15±0	15±0	15±0	15±0
		Range	----	----	----	-----	-----
Total	100	Mean±SE	93.085± 0.417	93.992± 0.559	94.611± 0.633	95.009± 0.569	95.084± 0.438
		Range	91-94.8	92.3-96.6	92.8-97.9	93.2-97.1	93.3-97.5

F-values for comparing

1. Flavour - 1.825 (NS)
2. Body and texture - 1.325 (NS)
3. Melting quality - 0.248 (NS)
4. Colour & package - 0.320 (NS)
5. Bacteria - 0.00 (NS)
6. Total - 2.520 (NS)

Table 10. Organoleptic quality of control and experimental ice cream

Property	Max. score	Mean & Range	Control A	Treatments B	C	D	E
Flavour	45	Mean±SE	39.444± 0.421	40.276± 0.456	40.901± 0.513	40.829± 0.442	40.625± 0.350
		Range	37-45	36-45	36-45	37-45	36-45
Body and texture	30	Mean±SE	29.007± 0.219	29.141± 0.177	29.058± 0.279	29.501± 0.124	29.485± 0.198
		Range	28-30	28-30	27-30	28-30	28-30
Melting quality	5	Mean±SE	4.868± 0.074	4.866± 0.064	4.923± 0.053	4.851± 0.117	4.930± 0.025
		Range	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0	4.5-5.0
Colour & package	5	Mean±SE	4.993± 0.007	4.993± 0.007	4.985± 0.014	4.978± 0.014	4.993± 0.007
		Range	4.75-5	4.75-5.0	4.75-5	4.75-5	4.75-5.
Bacteria	15	Mean±SE	15±0	15±0	15±0	15±0	15±0
		Range	----	----	----	----	-----
Total	100	Mean±SE	93.085± 0.417	93.992± 0.559	94.611± 0.633	95.009± 0.569	95.084± 0.438
		Range	91-94.8	92.3-96.6	92.8-97.1	93.2-97.1	93.3-97.5

F-values for comparing

1. Flavour - 1.825 (NS)
2. Body and texture - 1.325 (NS)
3. Melting quality - 0.248 (NS)
4. Colour & package - 0.320 (NS)
5. Bacteria - 0.00 (NS)
6. Total - 2.520 (NS)

Rs.120/-, sugar Rs.12/- and stabilizers + emulsifier Rs.225/-. The cost of ingredients for 100 g control ice cream was Rs.2.76/- whereas for the treatments B, C, D and E the cost were calculated as Rs.2.48, Rs.2.20, Rs.1.92 and Rs.1.64 respectively. The savings in cost of ingredients will be 10.14 per cent, 20.29 per cent, 30.43 per cent and 40.57 per cent, when the fat replacement level was 25, 50, 75 and 100 per cent respectively (Table 1 and Fig.9).

4.6 Packaging material for the Kera ice cream mix powder

Spray dried Kera ice cream mix powder with 100 per cent substitution (E-100) of milk fat was stored in different packaging media to assess the suitability of the material for storing the product. The properties such as moisture, titratable acidity, thiobarbituric acid value, peroxide value and NPN were estimated after storing the product for three months and the results are presented in Table 11.

4.6.1 Moisture

Significant difference ($P<0.01$) was observed in moisture content of the mix powder stored in the five packaging materials numbered 1 to 5. Though lowest moisture content was observed for packaging material 2 (HMHDPE) it was statistically at par with material 4 (MET/PEST/PE).

4.6.2 Peroxide value

Peroxide value (meq/1000 g fat) of the material packed in material 3 (BOPP) and 4 (MET/PEST/PE) were zero indicating no significant difference. Moreover all the other three packaging material gave values ranging from 0.414 to 1.614.

4.6.3 Thiobarbituric acid value

Thiobarbituric acid (mg malonaldehyde) value given in Table 11 clearly indicated that powder packed in material 4 (MET/PEST/PE) gave the least value and is significantly superior to all the other four packaging materials.

4.6.4 Non protein nitrogen

Non protein nitrogen value of the five powders stored in separate packaging materials stored for three months presented in Table 11 showed that powder in packaging material 3 (BOPP) was statistically superior to all the other four packaging materials. It was also observed that powder in packaging material 4 (MET/PEST/PE) and 5 (LD/LLD) occupied the second position but the variation in NPN among them were not statistically significant.

4.6.5 Titratable acidity

Acidity (percentage of lactic acid) of powder stored in the five packaging materials also differed significantly.

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Table 11. Storage characteristics of ice cream mix powder stored in different packaging materials

Property	Mean & Range	Packaging materials 1 LDPE	2 HMHDPE	3 BOPP	4 MET/PEST/PE	5 LD/LLD
Moisture	Mean±SE	a 4.668± 0.086	e 2.257± 0.037	b,c 2.704± 0.074	d,e 2.418± 0.025	c,d 2.622± 0.033
	Range	4.489- 4.997	2.148- 2.412	2.344- 2.831	2.317- 2.509	2.519- 2.712
Peroxide value (meq/kg fat)	Mean±SE	a 1.464± 0.041	b 0.445± 0.012	e 0±0	d,e 0±0	c 0.264± 0.025
	Range	1.323- 1.614	0.414- 0.498	-----	-----	0.194- 0.313
TBA (mg.malon-aldehyde)	Mean±SE	a 0.493± 0.004	b 0.424± 0.004	d 0.371± 0.012	e 0.255± 0.004	c,d 0.379± 0.008
	Range	0.472- 0.514	0.417- 0.432	0.348- 0.410	0.241- 0.281	0.341- 0.410
NPN(%)	Mean±SE	a 0.667± 0.004	b 0.619± 0.004	e 0.363± 0.016	d 0.428± 0.008	c,d 0.449± 0.008
	Range	0.652- 0.681	0.608- 0.638	0.297- 0.391	0.398- 0.448	0.424- 0.471
Titratable acidity (% lactic acid)	Mean±SE	a 1.145± 0.016	c,d 0.683± 0.008	a 1.153± 0.004	d 0.682± 0.004	b 0.992± 0.012
	Range	1.092- 1.213	0.635- 0.701	1.142- 1.162	0.671- 0.700	0.964- 1.041

F-values for comparing		corresponding CD at 1 %
1. Moisture	= 304.022 (P<0.01)	0.222
2. PV	= 819.146 (P<0.01)	0.088
3. TBA	= 137.206 (P<0.01)	0.029
4. NPN	= 229.600 (P<0.01)	0.034
5. Acidity	= 534.007 (P<0.01)	0.051

Means bearing the common letters as superscript are statistically not significant

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Lowest mean acidity was observed for ice cream powder stored in MET/PEST/PE followed by that stored in HMHDPE, but was not statistically significant. The highest acidity was observed for powder stored in BOPP.

4.7 Chemical composition of control and treatment mix powder

The chemical composition of control and experimental mix powder at 0 day without the addition of antioxidant are presented in Table 12 and Fig.10. The moisture percentage varied from 1.036 (Treatment E-100) to 1.518 (Treatment C-50). The protein percentage showed a gradual increase as the percentage replacement of milk fat with coconut fat increased. The lowest value was recorded for the control (10.461) and highest value of 12.857 for treatment E-100 (100 per cent replacement of milk fat). Non protein nitrogen content remained almost same for the treatments, but the control had the lowest mean NPN value as compared to the treatments. The fat percentage remained almost same for the treatments and the control. The lowest value (27.313) was observed for the control, whereas the treatment E-100 had 27.645 per cent of fat. The free fat (FF) content in the powder showed an increasing trend as percentage replacement increased. The carbohydrate content as determined by difference revealed a decreasing trend as milk fat was replaced by coconut fat. The highest mean carbohydrate percentage was observed for the

Table 12. Chemical composition of control and experimental mix powder (0 day without addition of antioxidant)

Constituent	Control A-0	Treatments B-25	C-50	D-75	E-100
1. Moisture	1.185± 0.097	1.321± 0.086	1.518± 0.126	1.340± 0.107	1.036± 0.061
2. (a) Protein	10.461± 0.113	11.666± 0.014	11.727± 0.029	12.319± 0.033	12.857± 0.033
(b) Non protein nitrogen	0.340± 0.005	0.459± 0.22	0.459± 0.026	0.457± 0.033	0.458± 0.033
3. (a) Fat	27.313± 0.050	27.398± 0.071	27.470± 0.074	27.560± 0.038	27.645± 0.031
(b) Free fat	10.745± 0.033	11.543± 0.032	11.975± 0.016	11.973± 0.117	12.279± 0.026
4. Carbohydrate	59.195± 0.090	57.761± 0.099	57.341± 0.110	56.872± 0.141	55.978± 0.097
5. Ash	1.846± 0.017	1.853± 0.087	1.944± 0.023	1.935± 0.022	2.214± 0.038

control (59.195) whereas lowest value was recorded for the Treatment E-100 (55.978). The ash content was lowest (1.846) for the control and highest (2.214) was observed in Treatment E-100, where replacement was at 100 per cent level.

4.7.1 Ultrastructure of the powder particle

The powder particles were subjected to Scanning electron microscopy and the findings were as follows.

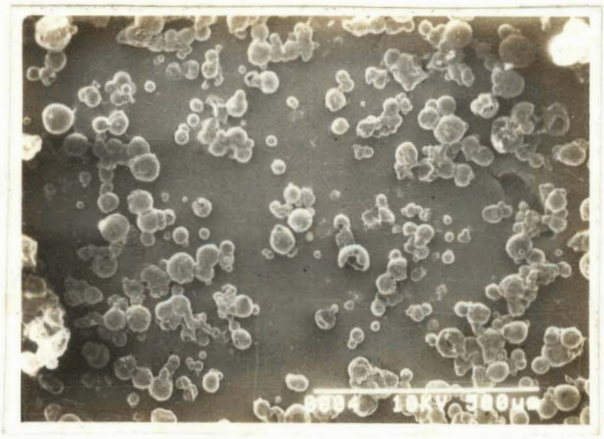
Control (A-0): Scanning electron microscopy (Plate 11-13) revealed uniform distribution of well defined spherical particles of varying sizes. Occasionally some of these were grouped together, but there was no tendency for clumping. At high power, samples showed spherical structures varying in diameter from 10 to 35 µm. In general the particles were smooth or had a slightly crinkled surface with a golf ball like profile. The depressions noticed on the surface were not deep and presented a uniform pattern. Exaggerated distortions were not observed. Fractured particles revealed solid core with few air pockets or an outer moderately thick coat with one or more large air pockets with thin walls extending from the outer layer.

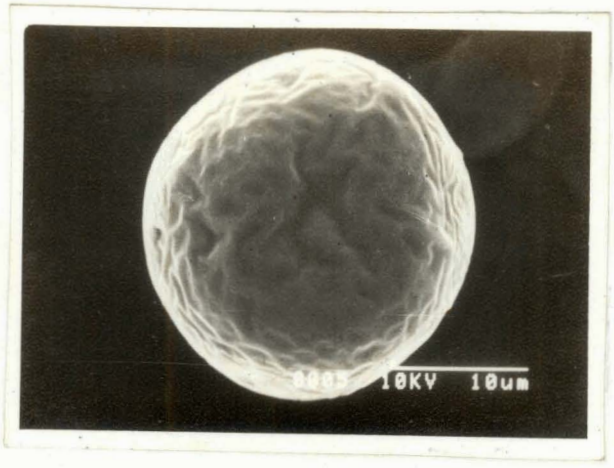
Treatment B-25: The distribution of the particles (Plates 14 to 16) were not as uniform as in the previous case. Comparatively the particles appeared larger measuring 20 to 45 µm in diameter. In addition to the slightly wrinkled appearance

Plate 11 Electron micrograph of ice cream mix powder: Control A-0
Uniform distribution of well defined particles

Plate 12 Electron micrograph of single particle: A-0
Spherical particles ranging in diameter from 10-35 μm

Plate 13 Electron micrograph of fractured particle: A-0
Solid core with few air pockets

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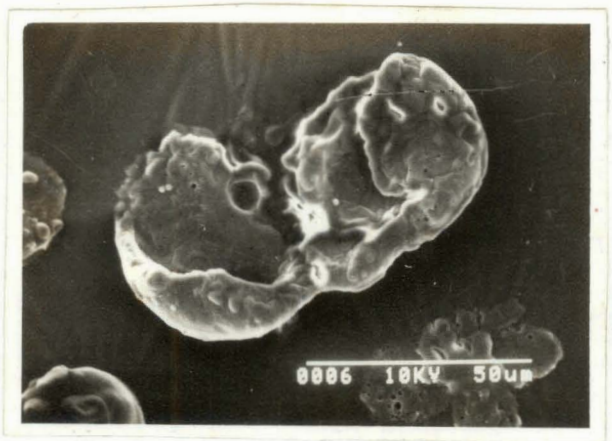
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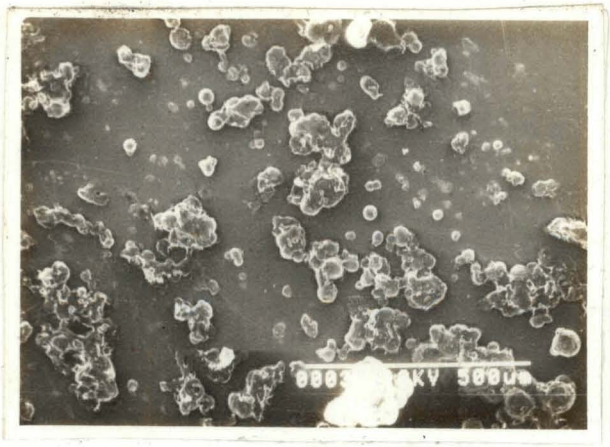
Plate 14 Electron micrograph of Kera ice cream mix powder: B-25
Distribution of particles not uniform

Plate 15 Electron micrograph of single particle: B-25
Particles were slightly wrinkled with diameter ranging from 20-45 μm

Plate 16 Electron micrograph of fractured particle: B-25
Extension of air pockets found inside the particle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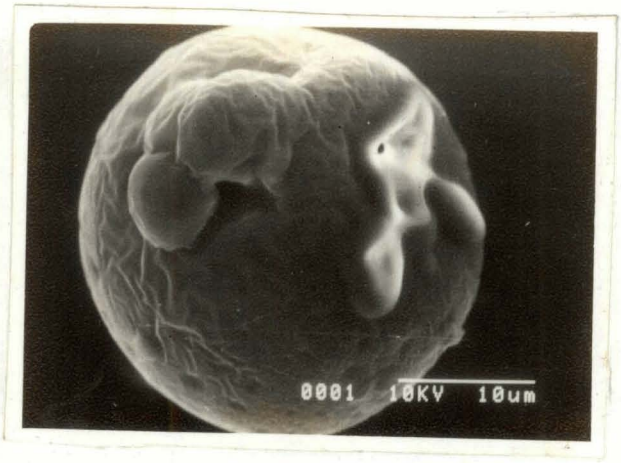
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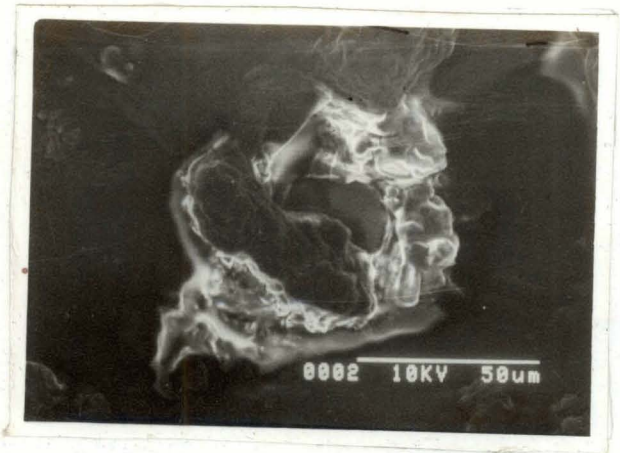
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numerous protrusions of the outer surface were noticed. They were spherical or irregularly elongated. Occasionally blobs were found protruding from the surface. In many cases the blobs tended to flatten out on being crushed. When fractured they were seen as extension of air pockets found inside the particles.

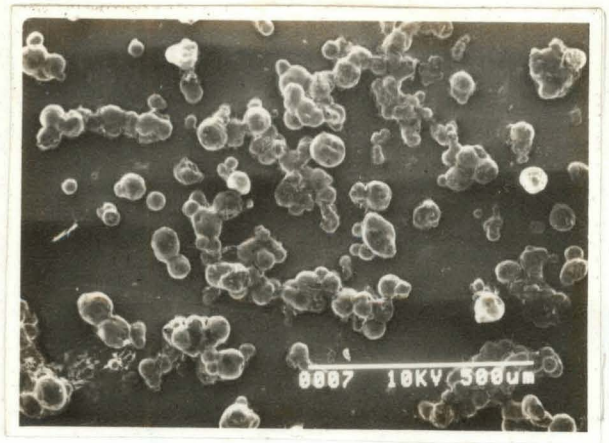
Treatment C-50: The particles were uniformly larger with a diameter ranging from 20 to 45 µm (Plates 17-19). The surface was irregularly crinkled. Pits, crevices and protrusions were found on the outer surface. The fractured particles shared an outer wall of varying thickness and few irregularly distributed air pockets inside.

Treatment D-75: Electron microscopic appearance of the particles (Plates 20-22) showed them to be polymorphic in appearance and size. Instead of the uniform pattern of distribution, the particles appeared clumped and irregularly distributed. The particles were highly pleomorphic with size ranging from 25 to 50 µm. Though basically spherical they had a distorted appearance. The surface was rough with numerous crevices, craters, blobs and protuberances. Some filamentous extrusions were occasionally seen hanging out from the surface. Fractured particles in general had a thin outer rim usually with larger air pockets eventhough small pockets were also observed. These were seen connected by thin material extending from the outer coat.

Plate 17 **Electron micrograph of Kera ice cream mix powder: C-50**
Distribution of particles not uniform

Plate 18 **Electron micrograph of single particle: C-50**
Particles uniformly larger ranging in diameter from 20-45 μm

Plate 19 **Electron micrograph of fractured particle: C-50**
Few irregularly distributed air pockets inside the particle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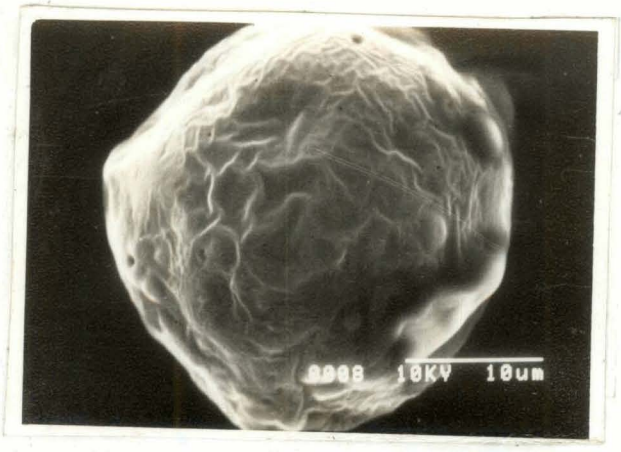
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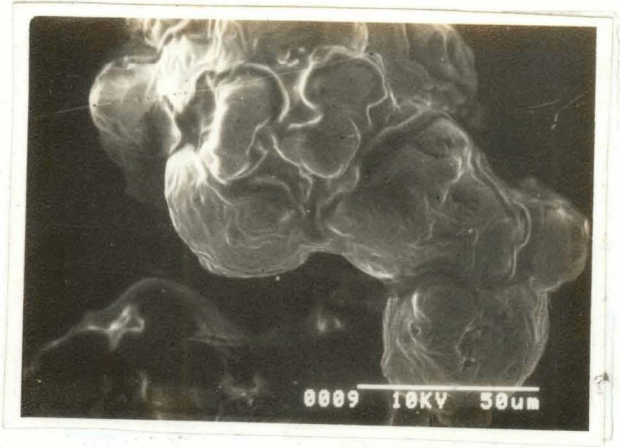
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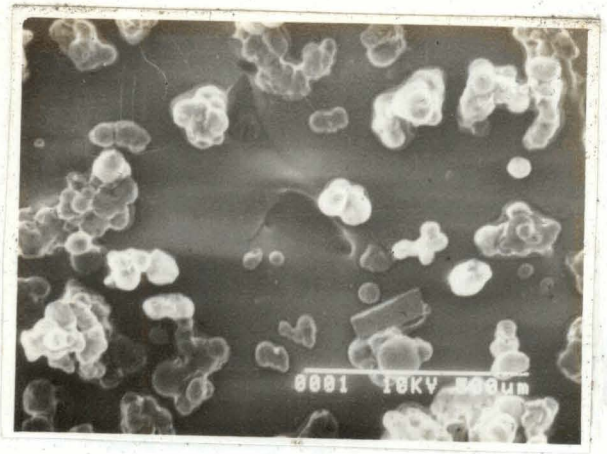
Plate 20 **Electron micrograph of Kera ice cream mix powder: D-75**
Particles are clumped and irregularly distributed

Plate 21 **Electron micrograph of single particle: D-75**
Particles were highly pleomorphic with size ranging from 25-50 μm

Plate 22 **Electron micrograph of fractured particle: D-75**
Thin outer rim with large air pockets and few small air pockets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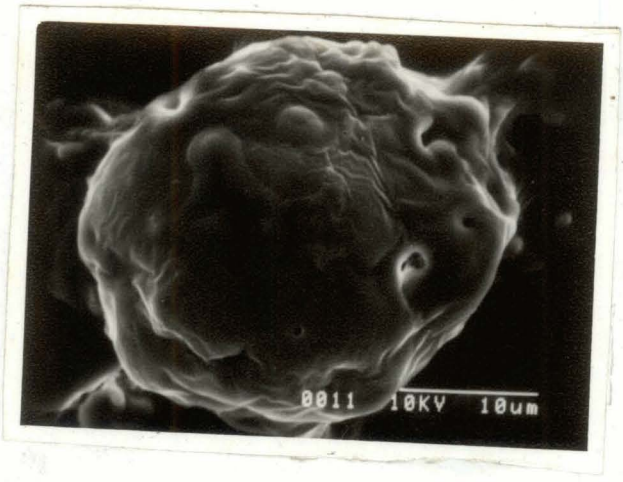
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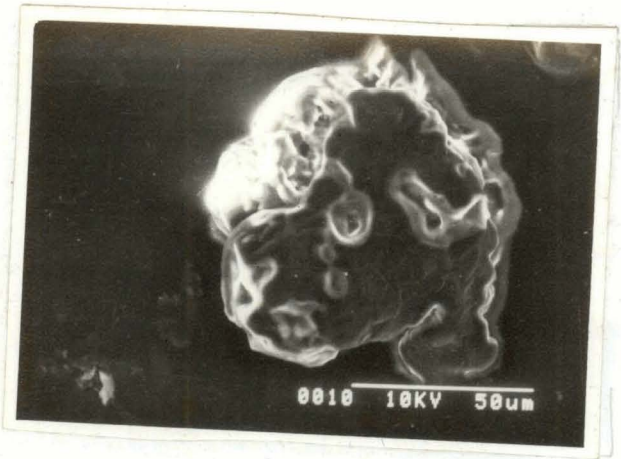
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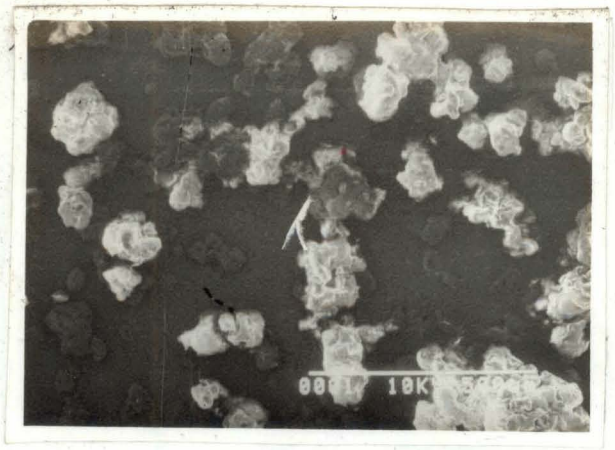
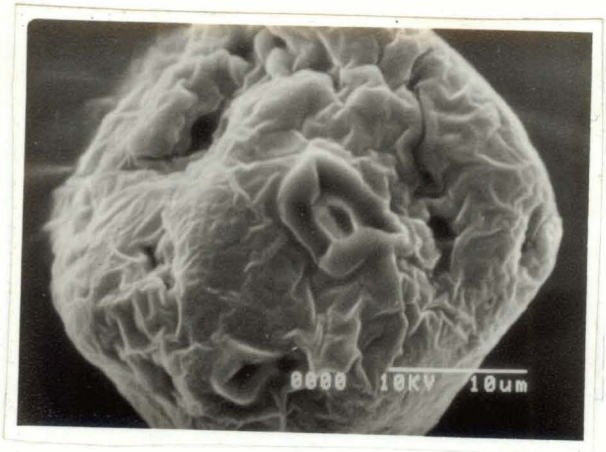
Plate 23 **Electron micrograph of Kera ice crem mix powder: E-100**
Conglomerated nature of the particles in clumps of varying sizes

Plate 24 **Electron micrograph of single particle: E-100**
Markedly deformed particles with an irregular surface ranging in diameter from 25-50 μm

Plate 25 **Electron micrograph of fractured particle: E-100**
Multilocular appearence of particles with irregularly distributed pockets

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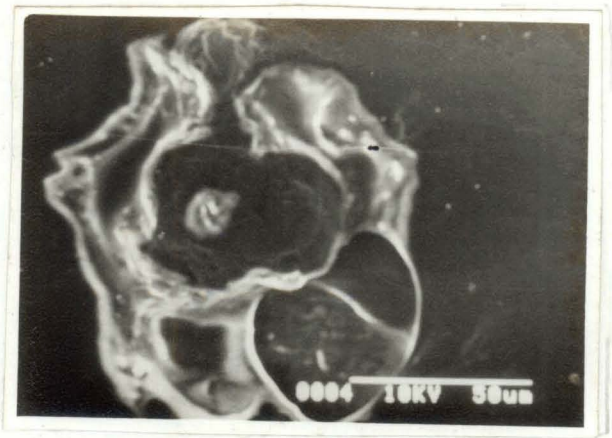
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Treatment E-100: The consistent feature (Plate 23-25) when seen with the microscope was the conglomerated nature of the particles in clumps of varying sizes. Rarely individual particles were noticed which had a size of 25 to 50 µm. Markedly deformed particles which had an irregular surface were seen. They appeared rough, wrinkled and distorted. The spherical appearance of the particles was not uniformly maintained and very often it was lost. Irregular elevated exanthematous crater like profiles, irregular crevices and depressions were consistently found. Many particles appeared convoluted. Fractured particles had a multiloculated appearance with irregularly distributed air pockets with moderately thick outer rim and thin separating walls.

4.8 Physico-chemical properties of the control and treatment mix powder

The physico-chemical properties of the control and treatment mix powder at 0 day were studied and the results are furnished in Table 13.

4.8.1 Peroxide value

No peroxides could be measured both in the treatment and control ice cream mix powder at initial stages.

4.8.2 Thiobarbituric acid value

The lowest mean TBA value (0.073 mg malonaldehyde) observed for treatment C-0 (50 per cent fat replacement) and highest for the control (0.085). However, the statistical analysis of the data revealed no significant difference between the treatments and control.

4.8.3 Titratable acidity

The mean titratable acidity (percentage of lactic acid) ranged from 0.470 to 0.572 in the control and the treatment groups. Statistical analysis of the data revealed no significant difference between the different treatments and control indicating that replacement of milk fat with coconut fat will not produce any difference in the titratable acidity of the mix powder initially.

4.8.4 Solubility index

Solubility index (ml) of the mix powder at 0 day are presented in Table 13 and depicted in Fig.11. Statistical analysis of the data revealed significant difference ($P<0.01$) between the different treatments and control. Treatment B-25 and control (A-0) were homogenous whereas treatment C-50 was statistically different from all other treatments and control. Treatments D-75 and E-100 were statistically at par.

Table 13. Physio-chemical properties of control and experimental mix powder (0 day without addition of antioxidant)

Property	Mean & Range	Control A-0	Treatments B-25	C-50	D-75	E-100
Peroxide value (meq/kg fat)	Mean±SE	0	0	0	0	0
	Range	0	0	0	0	0
Thiobarbituric acid (mg.malonaldehyde	Mean±SE	0.085± 0.0035	0.081± 0.0035	0.073± 0.0071	0.081± 0.0035	0.081± 0.0035
	Range	0.076- 0.101	0.068- 0.094	0.038- 0.091	0.068- 0.094	0.068- 0.094.
Titratable acidity (% lactic acid	Mean±SE	0.485± 0.0414	0.565± 0.0414	0.470± 0.0311	0.483± 0.0261	0.572± 0.0331
	Range	0.392- 0.736	0.392- 0.741	0.331- 0.621	0.389- 0.740	0.396 0.672
Solubility index (ml)	Mean±SE	a 0.700± 0.0177	a 0.700± 0.0177	b 0.900± 0.0028	c 1.500± 0.0283	c,d 1.500± 0.0283
	Range	0.6-0.8	0.6-0.8	0.89-0.09	1.4-1.6	1.4-1.6
Bulk density (g/ml)	Mean±SE	a 0.527± 0.0035	b 0.535± 0.0035	a 0.527± 0.0035	a 0.524± 0.0028	b 0.535± 0.0035
	Range	0.519- 0.538	0.525- 0.549	0.515- 0.539	0.519 0.531	0.529- 0.549
Average particle density (g/ml)	Mean±SE	1.033± 0.0035	1.041± 0.0035	1.036± 0.0035	1.038± 0.0035	1.036± 0.0071
	Range	1.020- 1.040	1.025- 1.054	1.025- 1.048	1.030- 1.048	1.00- 1.049
Percent volume occupied by powder particle	Mean±SE	a 50.504± 0.0319	b 50.325± 0.0424	b 50.407± 0.0283	b 50.396± 0.0247	b 50.388± 0.0354
	Range	50.361- 50.664	50.104- 50.460	50.279- 50.512	50.286- 50.499	50.234- 50.332

F-value for comparing the TBA value = 1.154 (NS)
F-value for comparing the titratable acidity = 1.744 (NS)
F-value for comparing the solubility index = 392.000 (P<0.01)
CD at 1% for comparing solubility index = 3.91
F-value for comparing the bulk density = 3.856 (P<0.05)
CD at 5% for comparing bulk density = 2.03
F-value for comparing the average particle density = 0.629 (NS)
F-value for comparing percent volume occupied by powder particle = 3.746 (P<0.05)
CD at 5% for comparing percent volume occupied by powder particle = 2.03
Means bearing the common letters as superscript are statistically not significant

4.8.5 Bulk density

Analysis of the data pertaining to bulk density (g/ml) revealed significant difference ($P<0.05$) between the treatments and control. Powder with 50 and 75 per cent replacement of milk fat (Treatment C-50 and D-75) with coconut fat was statistically at par with the control. Treatments B-25 (25 per cent replacement)and E-100 (100 per cent replacement) were statistically homogenous (Fig.11).

4.8.6 Average particle density

Mean, SE and range with respect to the APD (g/ml) are presented in Table 13. The mean PD for the control and the treatments ranged from 1.033 to 1.041 and analysis of the data revealed no significant difference between the treatments or treatments and the control, indicating that replacement of milk fat with coconut fat at any level did not produce any difference in the APD.

4.8.7 Percent volume occupied by the powder particle

There exists significant difference ($P<0.05$) between treatments and control with regard to the PVPP (Table 13). Comparison of means using critical difference revealed that all the four treatments were homogenous and they differ from the control. The results indicated that the PVPP does not vary significantly at different replacement levels.

Fig. 10
CHEMICAL COMPOSITION OF CONTROL AND TREATMENT ICE CREAM MIX POWDER

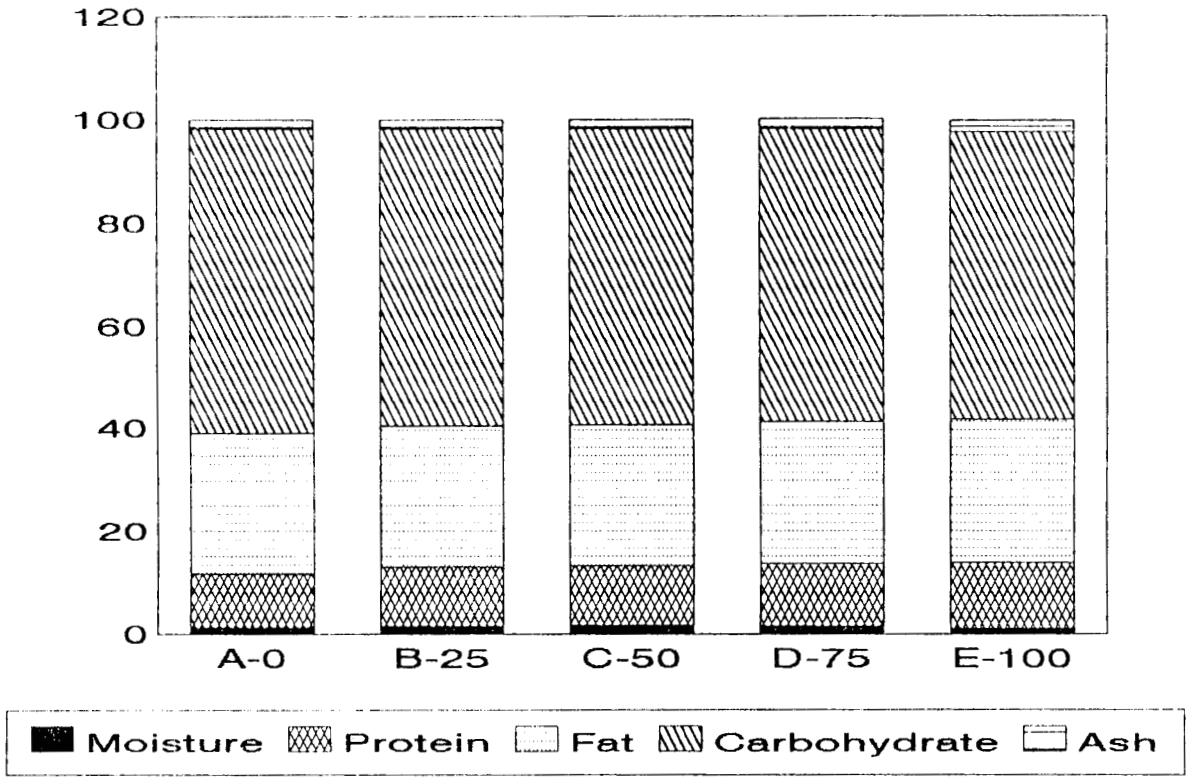
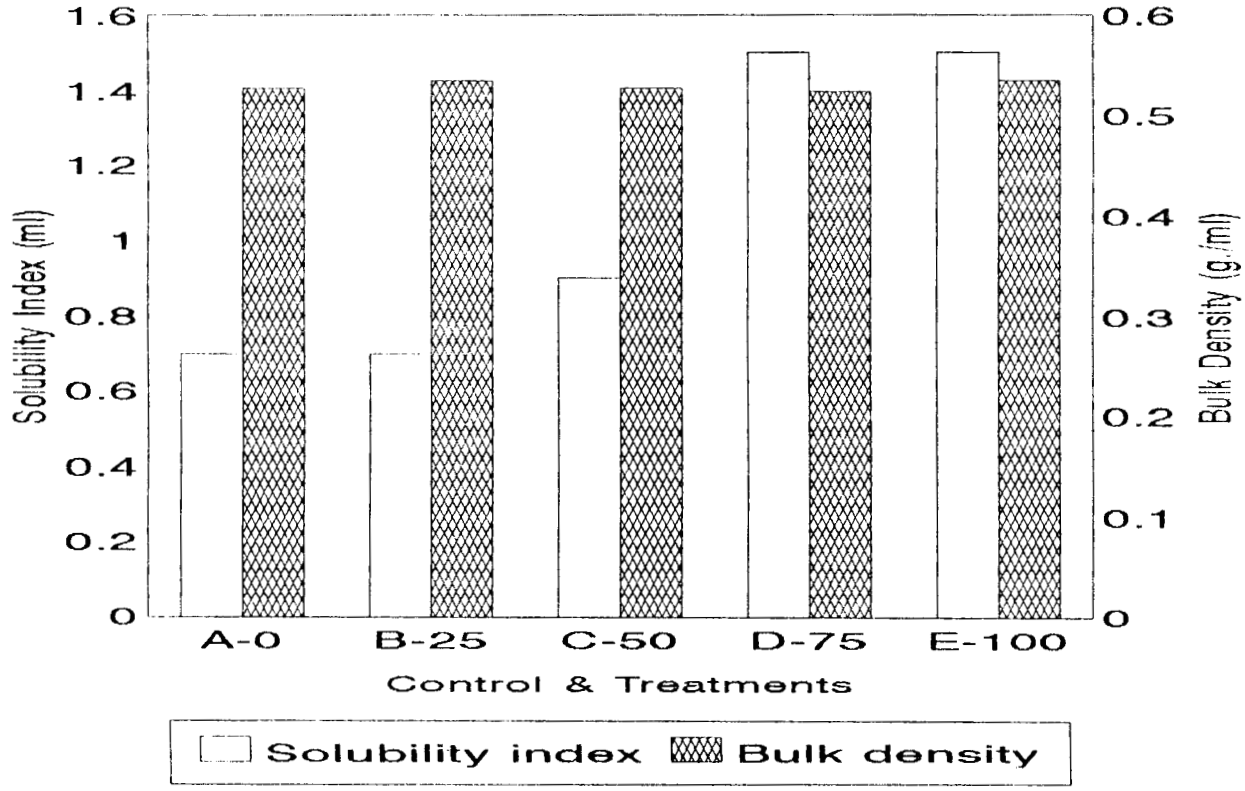


Fig. 11
SOLUBILITY INDEX AND BULK DENSITY OF CONTROL AND TREATMENT ICE CREAM MIX POWDER



4.9 Storage stability of Kera ice cream mix powder

To assess the storage stability of Kera ice cream mix powder containing various replacement levels of coconut cream was stored at room temperature for 180 days. The powder was stored with butylated hydroxyanisol (0.01%) and without the antioxidant to study the efficiency of antioxidant in prolonging the keeping quality of the powder. The powder was analysed for moisture, titratable acidity, TBA, PV and NPN initially and at 2 months interval for six months. The effect of replacement level and addition of antioxidant on the keeping quality of the powder was arrived at by comparing the mean values of the respective groups with its control using the student's-t test. The results of the various parameters are presented hereunder.

4.9.1 Moisture

The mean and SE with respect to various treatments are presented in Table 14 and Fig 12. The mean moisture content with respect to treatments at 0 day did not differ significantly indicating that replacement of milk fat with coconut fat does not influence the moisture content in powder initially. Comparisons were made for different levels of replacement at each period of storage with its corresponding control separately for the two groups viz., with BHA and without BHA.

Table 14. Moisture percentage (Mean ± SE) of control and experimental mix powder at different storage period

Day	Control	Treatments							
	A-0	A-1-0	B-25	B-1-25	C-50	C-1-50	D-75	D-1-75	E-100	E-1-100
0	1.185± 0.097	1.260± 0.083	1.321± 0.086	1.319± 0.036	1.518± 0.126	1.460± 0.100	1.340± 0.107	1.392± 0.123	1.306± 0.061	1.427± 0.05
60	1.635± 0.192	1.644± 0.092	2.135± 0.158	1.684± 0.059	2.070± 0.091	1.764± 0.067	1.988± 0.069	1.754± 0.114	2.083± 0.206	1.670± 0.056
120	2.640± 0.096	2.627± 0.092	2.440± 0.131	2.478± 0.161	2.50± 0.082	2.458± 0.081	2.674± 0.049	2.449± 0.114	2.813± 0.079	2.812± 0.079
180	2.960± 0.108	3.052± 0.104	3.296± 0.104	2.409± 0.097	3.298± 0.098	3.447± 0.087	3.269± 0.044	3.395± 0.035	3.408± 0.051	3.413± 0.055

t-values for comparing moisture % at 180 days

A-0 Vs B-25 = 2.24 (P<0.05)
A-0 Vs C-50 = 2.32 (P<0.05)
A-0 Vs D-75 = 2.65 (P<0.05)
A-0 Vs E-100 = 3.75 (P<0.01)

A-1-0 Vs B-1-25 = 2.51 (P<0.05)
A-1-0 Vs C-1-50 = 2.93 (P<0.05)
A-1-0 Vs D-1-75 = 3.13 (P<0.01)
A-1-0 Vs E-1-100= 3.07 (P<0.01)

Table 15. Acidity percentage(mean±SE) of control and experimental mix powder at different storage period

Day	Control	Treatments							
	A-0	A-1-0	B-25	B-1-25	C-50	C-1-50	D-75	D-1-75	E-100	E-1-100
0	0.485± 0.044	0.486± 0.008	0.565± 0.044	0.459± 0.017	0.470± 0.033	0.488± 0.010	0.483± 0.026	0.461± 0.010	0.572± 0.033	0.455± 0.014
60	0.560± 0.044	0.565± 0.016	0.648± 0.047	0.561± 0.012	0.558± 0.022	0.563± 0.012	0.535± 0.026	0.565± 0.008	0.616± 0.023	0.564± 0.009
120	0.665± 0.054	0.677± 0.011	0.760± 0.048	0.659± 0.007	0.771± 0.018	0.672± 0.007	0.680± 0.017	0.701± 0.011	0.687± 0.026	0.685± 0.011
180	0.765± 0.050	0.772± 0.009	0.933± 0.046	0.931± 0.007	0.914± 0.024	0.919± 0.010	1.103± 0.036	1.041± 0.020	1.162± 0.022	1.126± 0.031

t-values for comparing acidity % at 180 days

A-0 Vs B-25 = 2.47(P<0.05)
A-0 Vs C-50 = 2.68(P<0.05)
A-0 Vs D-75 = 5.49(P<0.01)
A-0 Vs E-100 = 7.26(P<0.01)

A-1-0 Vs B-1-25 : 13.97(P<0.01)
A-1-0 Vs C-1-50 : 11.19(P<0.01)
A-1-0 Vs D-1-75 : 12.18(P<0.01)
A-1-0 Vs E-1-100: 10.94(P<0.01)

Fig.12 MOISTURE OF CONTROL AND EXPERIMENTAL
ICE CREAM MIX POWDER AT DIFFERENT STORAGE PERIODS

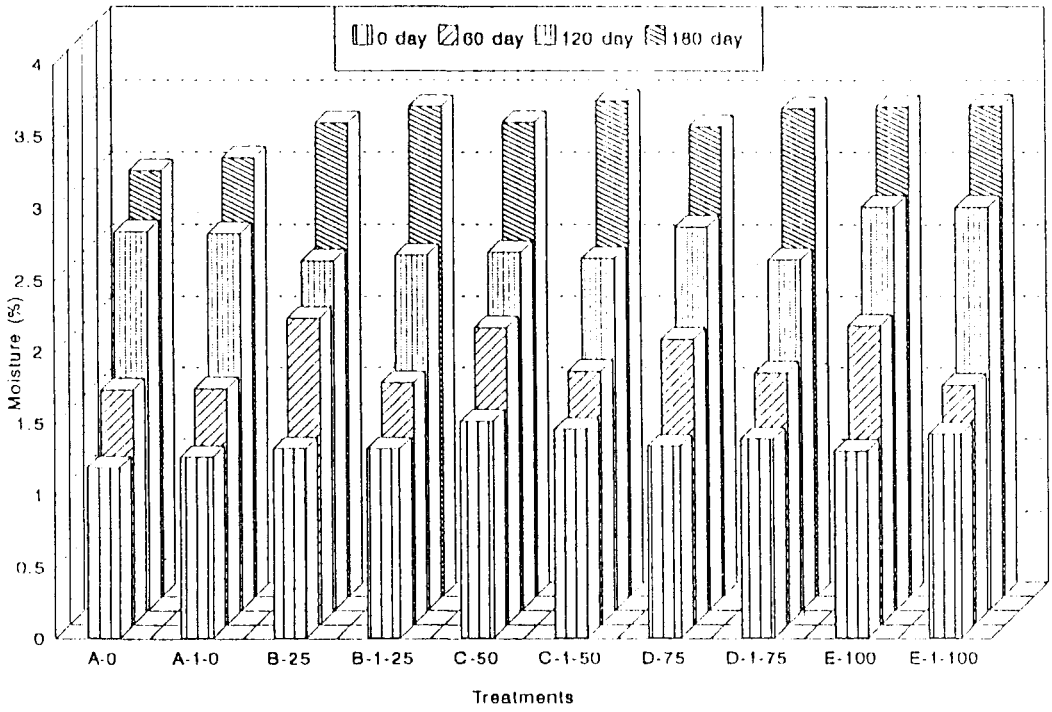
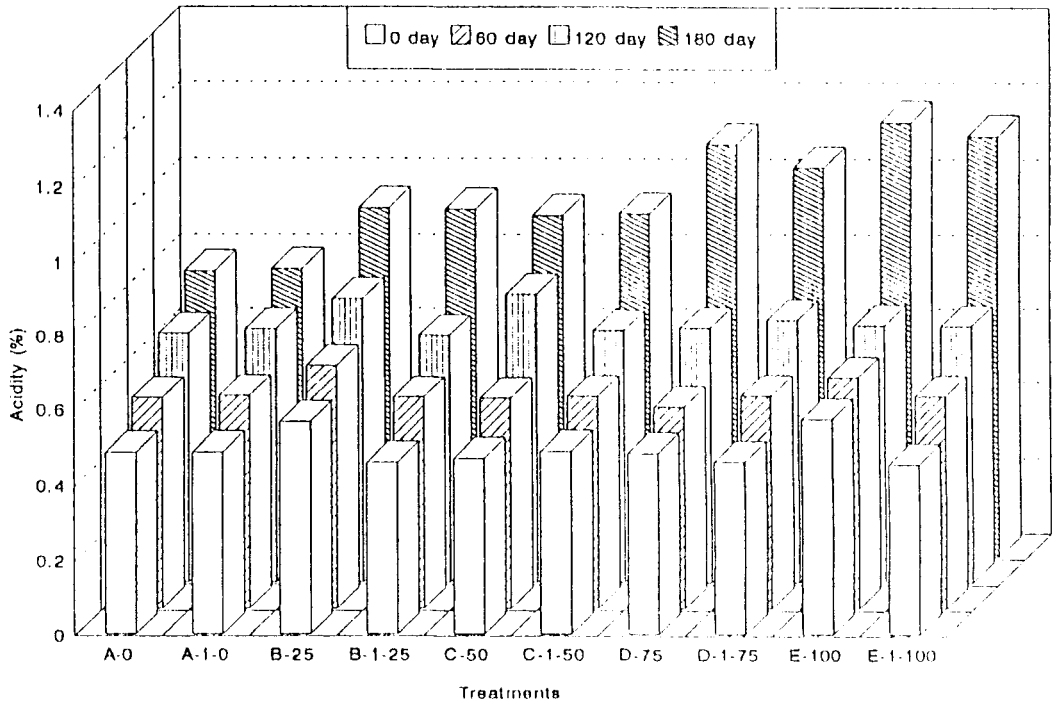


Fig.13 ACIDITY OF CONTROL AND EXPERIMENTAL
ICE CREAM MIX POWDER AT DIFFERENT STORAGE PERIODS



Analysis of the data for 0, 60 and 120 days revealed that replacement levels upto 100 per cent and addition of antioxidant did not cause any significant change in moisture percentage as compared to its control. Analysis of the data pertaining to moisture percentage in the powder stored for 180 days at various replacement levels with and without antioxidant showed significant ($P<0.01/<0.05$) difference as compared to its control. This indicated that Kera ice cream mix powder with or without antiodixant had significantly ($P<0.01/0.05$) higher moisture at any replacement level at 180 days as compared to control. It is also clear from the table that as period of storage increased the moisture percentage in powder also increased irrespective of the replacement level.

4.9.2 Titratable acidity

The mean and standard error with respect to acidity for various treatments at different storage periods are presented in Table 15 and Fig.13. Comparison of acidity percentage for different replacement levels of milk fat with coconut fat on 0 day as compared to its pair with BHA revealed significant ($P<0.01$) difference between treatments B-25 and B-1-25, and E-100 and E-1-100 only. Pairwise comparison using student's 't' test for various treatments at each period of storage revealed that treatments with or without antioxidant and replacement upto 100 per cent did not reveal any significant change in the acidity percentage upto 120 days. It can be

confirmed that the mix powder with various replacement levels had acidity comparable to its control upto four months of storage. Similarly if mix powder was stored upto 180 days with or without addition of antioxidant significant increase ($P<0.01/0.05$) in acidity could be observed for all levels of replacement as compared to its control. This indicated that with or without antioxidant the mix had significantly higher acidity at any replacement level at 180 days of storage. The addition of antioxidant at different levels of replacement and during different storage periods revealed that it had no significant effect as compared to powder stored without antioxidant as far as the titratable acidity is concerned. It is also evident from the table that as period of storage increased the acidity also increased irrespective of the level of replacement.

4.9.3 Thiobarbituric acid value

The TBA values with respect to various treatments during different storage periods are presented in Table 16 and Fig.14. Comparison of the TBA means at 0 day using analysis of variance revealed no significant difference between the various treatments indicating that addition of antioxidant does not have any influence on the initial TBA value, at different replacement levels. Comparison of means using student's 't' test between the treated and the untreated compared to its control revealed that powder had TBA values comparable to its

control for 60 days at any replacement level with or without antioxidant. Analysis of the TBA value at 120 and 180 days revealed significant difference ($P<0.01$) for untreated powder at different levels of replacement as compared to control. It was found that the mix at any replacement level cannot be stored upto 120 days without the addition of antioxidant, if TBA value is taken as an index for rancidity. In the case of the antioxidant treated mix powder, it was shown that the product could be stored for 120 days at any replacement level. But for 180 days the TBA values showed significant difference ($P<0.01$) as compared to control. From the foregoing it can be concluded that powder cannot be stored for 180 days even if antioxidant was added.

4.9.4 Peroxide value

The different treatments were analysed at different time intervals for peroxide value. The quantity of peroxide released were very negligible and thus could not be detected by the experimental procedure mentioned earlier. So all the values were recorded as 0 and hence no analysis was carried out.

4.9.5 Non protein nitrogen

The data pertaining to NPN of different treatments and periods are presented in Table 17 and Fig 15. Comparison of NPN values at 0 day for different treatments showed significant

Table 16. Thiobarbituric acid value (Mean ± SE) of control and experimental mix powder at different storage period

Day	Control		Treatments							
	A-0	A-1-0	B-25	B-1-25	C-50	C-1-50	D-75	D-1-75	E-100	E-1-100
0	0.085± 0.003	0.093± 0.009	0.081± 0.003	0.083± 0.003	0.073± 0.007	0.091± 0.004	0.081± 0.003	0.083± 0.004	0.081± 0.003	0.091± 0.004
60	0.096± 0.007	0.100± 0.01	0.096± 0.007	0.107± 0.006	0.096± 0.007	0.117± 0.007	0.096± 0.006	0.112± 0.004	0.099± 0.007	0.113± 0.096
120	0.142± 0.010	0.118± 0.01	0.204± 0.019	0.128± 0.004	0.227± 0.021	0.133± 0.005	0.223± 0.020	0.142± 0.009	0.224± 0.020	0.144± 0.011
180	0.183± 0.013	0.123± 0.011	0.240± 0.107	0.154± 0.009	0.275± 0.025	0.189± 0.013	0.263± 0.007	0.236± 0.006	0.267± 0.007	0.240± 0.006

F -value for comparing TBA at 0 day = 1.654 (NS)
t values for comparing TBA at

120 days

A-0 Vs B-25 = 2.85
A-0 Vs C-50 = 3.75
A-0 Vs D-75 = 3.70
A-0 Vs E-100 = 3.68

180 days

A-0 Vs B-25 = 2.20
A-0 Vs C-50 = 3.29
A-0 Vs D-75 = 5.33
A-0 Vs E-100= 5.49

A-1-0 Vs B-1-25 = 2.18
A-1-0 Vs C-1-50 = 3.89
A-1-0 Vs D-1-75 = 8.99
A-1-0 Vs E-1-100 = 9.14

Note:-(P<0.01) in all cases except A-0 Vs B-25 2.20 (P<0.05)

Table 17. Non protein nitrogen (Mean ± SE) of control and experimental mix powder at different storage period

Day	Control		Treatments							
	A-0	A-1-0	B-25	B-1-25	C-50	C-1-50	D-75	D-1-75	E-100	E-1-100
0	0.340± 0.005	0.322± 0.018	0.459± 0.022	0.449± 0.012	0.459± 0.026	0.456± 0.013	0.457± 0.033	0.451± 0.032	0.458± 0.033	0.448± 0.032
60	0.462± 0.013	0.386± 0.019	0.535± 0.037	0.479± 0.012	0.543± 0.028	0.518± 0.021	0.534± 0.027	0.525± 0.042	0.535± 0.027	0.520± 0.040
120	0.480± 0.014	0.400± 0.019	0.642± 0.034	0.494± 0.013	0.620± 0.023	0.541± 0.013	0.611± 0.030	0.560± 0.036	0.612± 0.029	0.561± 0.036
180	0.571± 0.050	0.420± 0.02	0.771± 0.037	0.517± 0.027	0.759± 0.028	0.550± 0.014	0.760± 0.030	0.633± 0.031	0.756± 0.031	0.632± 0.031

F-value for comparing NPN at 180 days = 11.70 (P<0.01)
CD at 1 % for comparing NPN = 0.106
Note:-NPN means were compared using analysis of covariance
The following treatment pairs were significantly different at 180 days by comparing the adjusted means

A-1-0 Vs D-1-75
A-1-0 Vs E-1-100
A-0 Vs B-25
A-0 Vs C-50
A-0 Vs D-75
A-0 Vs E-100

Fig.14 THIOBARBITURIC ACID VALUE OF CONTROL AND EXPERIMENTAL ICE CREAM MIX POWDER AT DIFFERENT STORAGE PERIODS

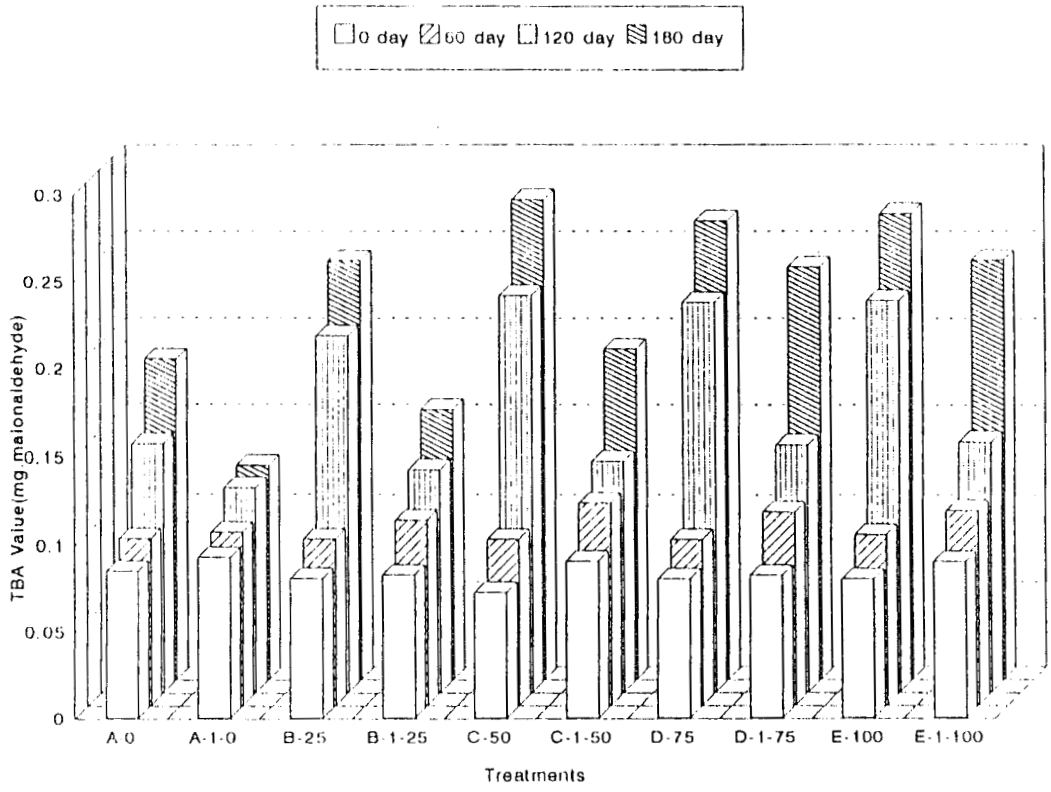
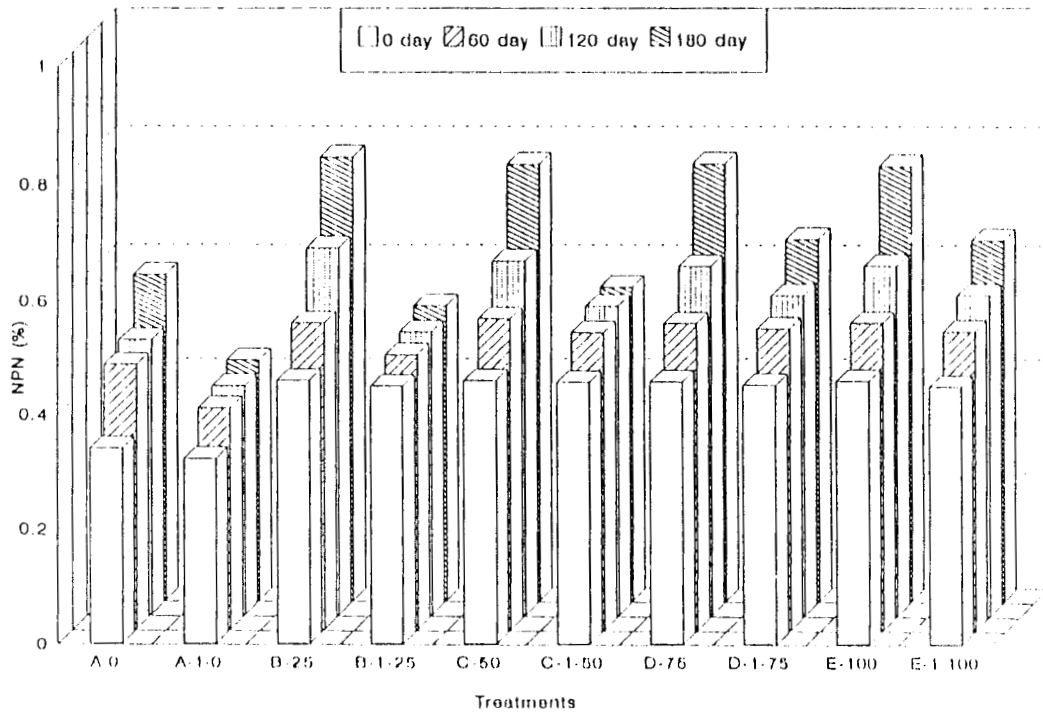


Fig.15 NON PROTEIN NITROGEN OF CONTROL AND EXPERIMENTAL ICE CREAM MIX POWDER AT DIFFERENT STORAGE PERIODS



($P<0.01$) difference between the treatments. This indicated that replacement of fat at various levels could affect the NPN content of the mix powder. Since NPN values showed significant difference ($P<0.01$) at 0 day itself, analysis of covariance was done to compare the NPN means. Comparison of NPN means at 60 and 120 days revealed no significant difference as compared to the control. This indicated that NPN content of the powder were comparable to the control up to 120 days at any replacement level with or without BHA. At 180 days powder without BHA at any replacement level showed significant ($P<0.01$) difference as compared to the control, whereas while antioxidant was added significant difference ($P<0.01$) could be noticed at 75 and 100 per cent fat replacement levels.

4.10 Properties of reconstituted ice cream

The physical and organoleptic properties of the ice cream mix powder after reconstitution with potable water were studied and the results of these experiments are presented in the following sections.

4.10.1 Relative viscosity

Data pertaining to relative viscosity (cp) of reconstituted ice cream mix are presented in Table 18. The mean relative viscosity values ranged from 8.331 to 8.408 in various treatments and control. Analysis of the data revealed

no significant difference between the treatments and control indicating that replacement of milk fat with coconut fat does not produce any significant difference in relative viscosity as compared to control.

4.10.2 Specific gravity

Analysis of the data presented in Table 18 with respect to specific gravity revealed no significant difference between treatments or with the control. The lowest mean specific gravity was 1.051 (control) and highest for treatment D-R and E-R (1.055). It was conclusively proved that replacement levels of coconut fat at any percentage did not affect the specific gravity of reconstituted Kera ice cream.

4.10.3 Overrun

The Mean, SE and range with respect to the overrun percentage are presented in Table 18 and Fig.16. It was observed that the overrun percentage gradually increased as the percentage replacement of the coconut fat increased. Lowest mean overrun was recorded for control (49.637) and highest (58.875) for treatment E-R in which milk fat was completely replaced by coconut fat. Statistical analysis of the data revealed significant difference ($P<0.01$) between the various treatments. Control and treatment B-R, treatment B-R and C-R, and C-R and D-R were statistically at par. Treatment E-R was not comparable with the other three treatments and control.

Table 18. Physical properties of reconstituted control and experimental ice cream

Property	Mean & Range	Control A-R	Treatments B-R	C-R	D-R	E-E
Relative viscosity (cp)	Mean±SE	8.385± 0.203	8.381± 0.152	8.388± 0.192	8.408± 0.204	8.331± 0.248
	Range	7.63- 9.34	7.76- 9.06	7.25- 9.12	7.42- 9.00	7.41- 9.37
Specific gravity	Mean±SE	1.051± 0.002	1.051± 0.004	1.053± 0.002	1.055± 0.002	1.055± 0.001
	Range	1.0417- 1.0592	1.0325- 1.0630	1.0431- 1.0567	1.0443- 1.0608	1.0492- 1.0601
Overrun (%)	Mean±SE	a 49.637± 2.204	ac 51.143± 2.066	bcd 53.125± 1.995	d 55.625± 2.129	e 58.875± 2.133
	Range	42.86- 58.32	43.33- 59.40	47.00- 60.00	48.00- 65.00	53.00- 69.00
Meltdown time (min)	Mean±SE	a 61.422± 0.956	b 59.201± 1.058	c 56.622± 0.952	d 54.480± 0.826	e 52.240± 0.401
	Range	58.25- 66.50	56.20- 64.40	53.47- 60.02	51.45- 58.05	50.47- 54.21

F-value for comparing relative viscosity = 0.0187 (NS)
F-value for comparing specific gravity = 0.8659 (NS)
F-value for comparing overrun % = 23.245 (P<0.01)
CD at 1% for comparing overrun % = 2.974
F-value for comparing meltdown time = 44.456 (P<0.01)
CD at 1% for comparing meltdown time = 2.1404
Means bearing the common letters as superscript are statistically not significant

Fig.16

OVERRUN AND MELTDOWN TIME OF RECONSTITUTED CONTROL AND EXPERIMENTAL ICE CREAM

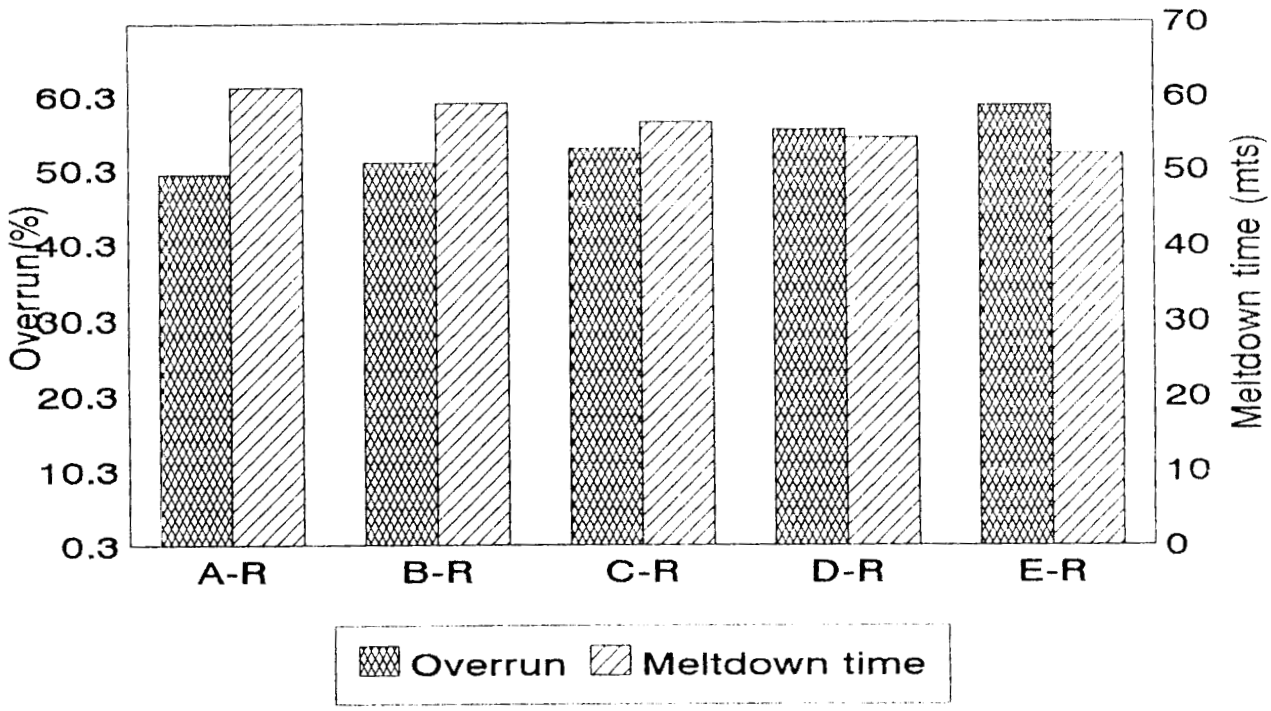
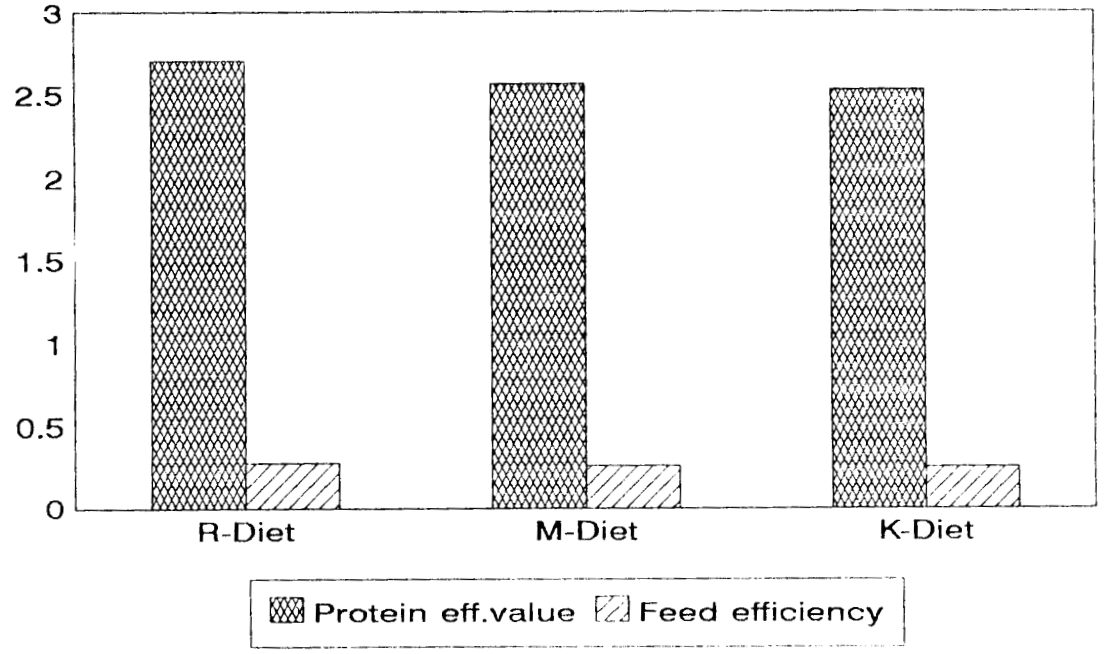


Fig.17

NUTRITIONAL QUALITY OF CONTROL AND KERA ICE CREAM



4.10.4 Meltdown time

Analysis of the data presented in Table 18 and represented in Fig.16 with respect to MDT revealed significant difference ($P<0.01$) between the various treatments and control. Comparison of the means using the critical difference revealed that all the four treatments and control were heterogenous. It was observed that the mean MDT decreased as the percentage replacement of milk fat with coconut fat increased.

4.10.5 Organoleptic quality of reconstituted ice cream

The organoleptic qualities of reconstituted and frozen Kera ice cream and control were evaluated by a panel of six judges. No significant difference could be observed for the various qualities such as flavour, body and texture, melting quality, colour and package, bacterial count and total score among the various treatments (Table 19). The results indicated that the ice cream mix powder incorporating coconut fat at various levels could not produce any difference in organoleptic quality as compared to the control mix powder, after reconstitution.

4.11 Nutritional qualities of Kera ice cream

The nutritional qualities of Kera ice cream as compared to ice cream and reference diet were evaluated by rat feeding

Table 19. Organoleptic quality of reconstituted control and experimental ice cream

Property	Max score	Mean & range	Control A-R	Treatments B-R	C-R	D-R	E-R
Flavour	45	Mean±SE	39.552± 0.740	40.048± 0.659	39.540± 0.503	39.917± 0.732	40.007± 0.668
		Range	37.81- 42.94	38.60- 42.13	38.69- 41.69	38.00- 42.63	37.81- 42.63
Body and texture	30	Mean±SE	29.163± 0.270	29.115± 0.206	29.140± 0.192	28.908± 0.267	28.902± 0.272
		Range	20.19- 30.00	28.5- 30.00	28.75- 30.00	27.88- 29.81	28.06- 30.00
Melting quality	5	Mean±SE	4.908± 0.047	4.923± 0.019	4.877± 0.036	4.937± 0.016	4.877± 0.056
		Range	4.69- 5.00	4.88- 5.00	4.75- 5.00	4.88- 5.00	4.63- 5.00
Colour and package	5	Mean±SE	4.981± 0.017	4.980± 0.020	4.980± 0.020	4.960± 0.025	5.000± 0.00
		Range	4.9- 5.00	4.88- 5.00	4.88- 5.00	4.88- 5.00	5.00- 5.00
Bacteria	15	Mean±SE	15±0.0	15±0.0	15±0.0	15±0.0	15±0.0
		Range	----	----	----	----	-----
Total	100	Mean±SE	93.607± 0.779	94.067± 0.650	93.537± 0.598	93.722± 0.884	93.785± 0.843
		Range	92.07- 97.34	92.25- 96.03	92.34- 95.63	90.80- 96.38	90.81- 96.14

F-values for comparing

1. Flavour = 0.3439 (NS)
2. Body and texture = 0.7037 (NS)
3. Melting quality = 1.4777 (NS)
4. Colour & package = 0.8939 (NS)
5. Bacteria = 0.000 (NS)
6. Total score = 0.1620 (NS)

trials. The qualities were assessed by determining the protein efficiency value and the feed efficiency values.

4.11.1 Protein efficiency value

The mean PEV for reference diet, ice cream diet and Kera ice cream diet were 2.706, 2.563 and 2.524 respectively. Analysis of the data presented in Table 20 and depicted in Fig.17 revealed significant difference ($P<0.01$) between the three diets. PEV for the ice cream diet and Kera ice cream diet were statistically at par and is significantly ($P<0.01$) different from the reference diet. The results indicated that reference diet incorporating casein was superior to ice cream diet and Kera ice cream diet. It was also revealed that ice cream diet and Kera ice cream diet were comparable as far as the PEV is concerned.

4.11.2 Feed efficiency

Data relating to feed efficiency values presented in Table 20 and Fig 17 revealed that significant difference ($P<0.01$) exists between the different treatments. Ice cream diet and Kera ice cream diet were having mean feed efficiency of 0.257, and 0.251 respectively,and comparison of means using critical difference revealed that these two treatments were at par. The reference casein diet had a mean FE of 0.271 and was significantly ($P<0.01$) superior from the other two treatments. The results indicated that ice cream incorporating coconut fat

Table 20. Nutritional quality of control and Kera ice cream

Quality	Mean and Range	Reference diet (R)	Ice cream diet (M)	Kera ice cream diet (K)
Protein efficiency value	Mean ± SE	a 2.706± 0.025	b 2.563± 0.020	b 2.524± 0.034
	Range	2.65± 2.82	2.46± 2.63	2.35± 2.68
Feed efficiency	Mean ± SE	a 0.271± 0.002	b 0.257± 0.002	b 0.251± 0.004
	Range	0.26± 0.28	0.25± 0.27	0.23± 0.27

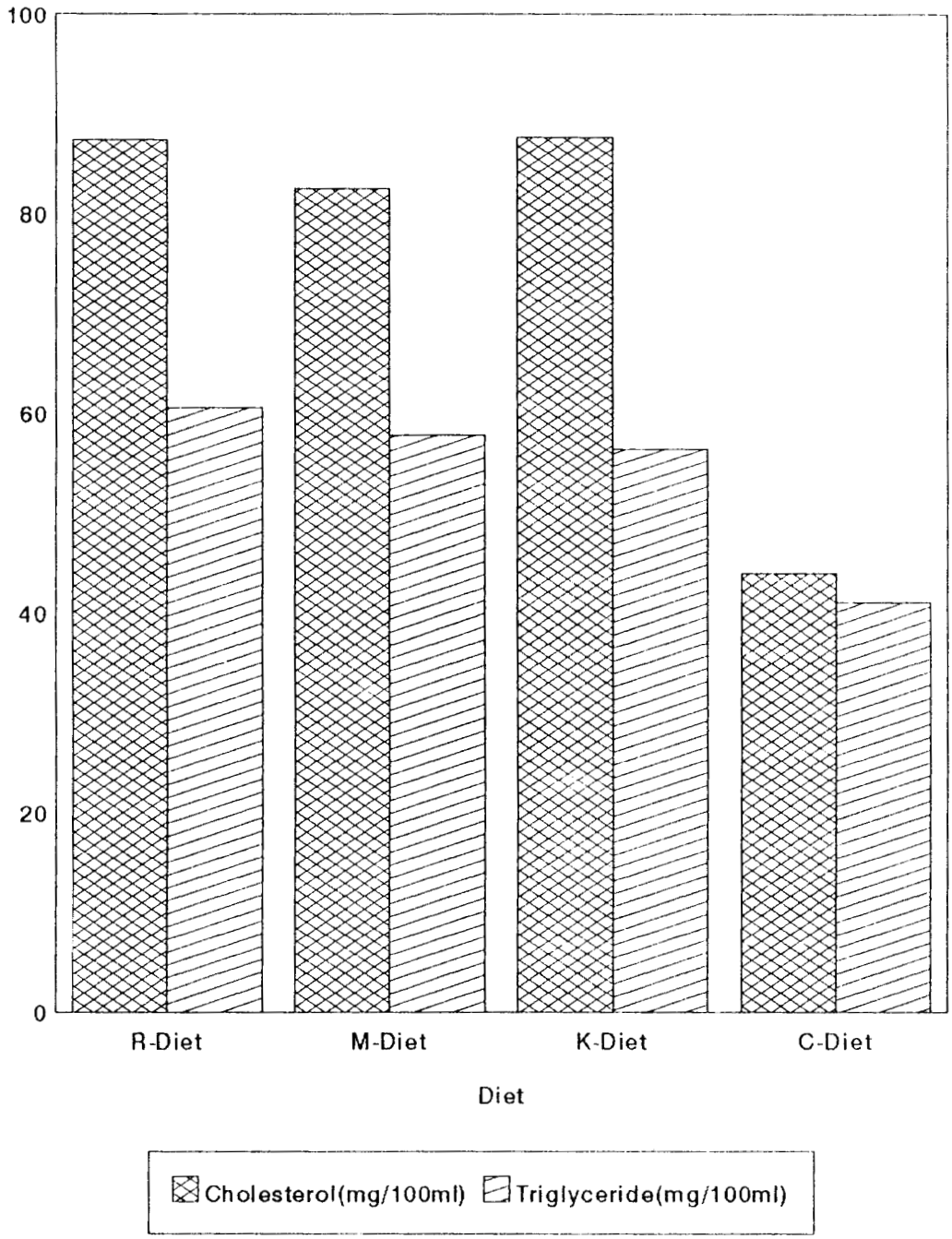
F-value for comparing the protein efficiency value = 11.3711 (P<0.01)
CD at 1% for PEV = 0.1151
F-value for comparing feed efficiency = 11.6557 (P<0.01)
CD at 1% for FE = 0.0135
Means bearing the common letters as superscript are statistically not significant

Table 21. Cholesterol and triglyceride content in blood serum of rats fed with different diets

Lipid Profile	Mean & Range	Reference diet (R)	Ice cream diet (M)	Kera ice cream diet (K)	Control diet (C)
Cholesterol (mg/100ml)	Mean ± SE	b 87.372± 1.193	b 82.418± 1.749	b 87.672± 1.763	a 43.847± 1.443
	Range	80.52- 92.30	74.42- 90.14	76.66- 94.55	36.73- 50.69
Triglyceride (mg/100ml)	Mean ± SE	b 60.517± 1.531	b 57.745± 1.743	b 56.327± 1.993	a 40.959± 1.126
	Range	51.53- 68.84	49.66- 65.50	47.44- 69.30	36.47- 48.64

F-value for comparing cholesterol = 184.552 (P<0.01)
CD at 1% for comparing cholesterol = 5.99
F-value for comparing triglyceride = 29.117 (P<0.01)
CD at 1% for comparing triglyceride = 6.28
Means bearing the common letters as superscript are statistically not significant

Fig.18
CHOLESTEROL AND TRIGLYCERIDE CONTENT IN BLOOD SERUM OF RATS FED WITH DIFFERENT DIETS



and milk fat were comparable as far as the feed efficiency is concerned.

4.12 Serum lipid profile

After the experimental period the animals in the four groups were slaughtered and the serum lipid profile were estimated.

4.12.1 Total serum cholesterol

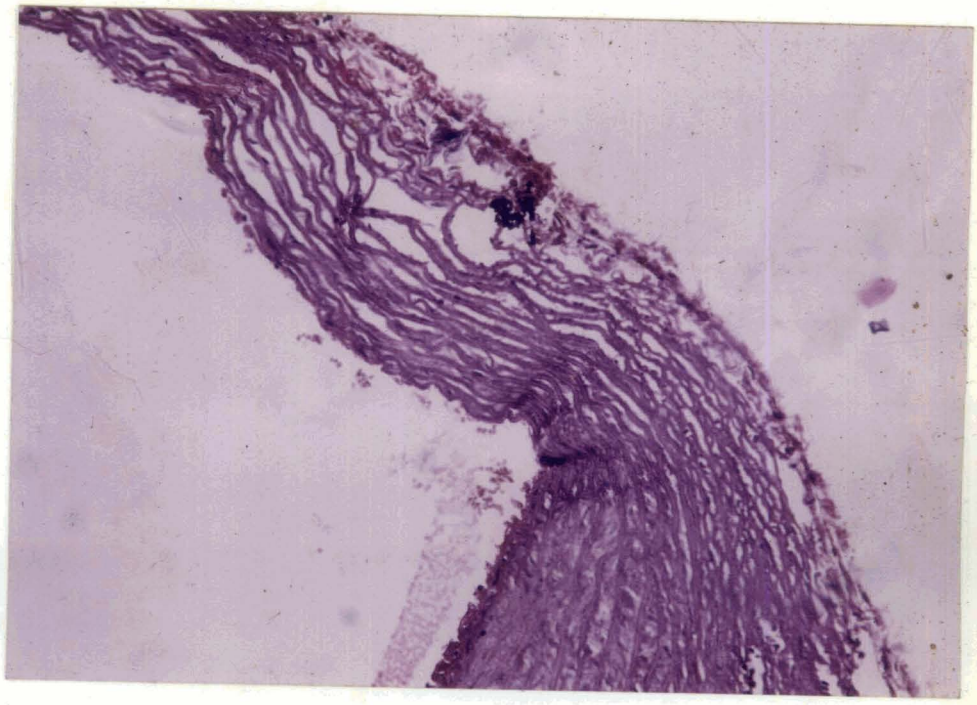
The mean, SE and range with respect to serum cholesterol (mg/100 ml) of animals fed with the four diets are presented in Table 21 (Fig.18). Analysis of the data revealed significant difference ($P<0.01$) in serum cholesterol between the control (farm) diet-C (43.847) and the other three diets such as Reference diet-R (87.372), ice cream diet-M (82.418), and Kera ice cream diet-K (87.672). The cholesterol levels in animals fed on diets R, M and K were statistically at par. It was concluded that the animals receiving the R, M and K diets were having significantly ($P<0.01$) higher serum cholesterol than the animals receiving the farm diet (C).

4.12.2 Triglycerides

Analysis of the data presented in Table 21 (Fig.18) with respect to mean, SE and range of triglycerides in blood serum of rats fed on the four diets revealed significant difference

Plate 26 Section of Aorta: Rats fed with diet-R (H&E x 250)
No lesions detected

Plate 27 Section of Aorta: Rats fed with diet-M (H&E x 250)
No lesions detected



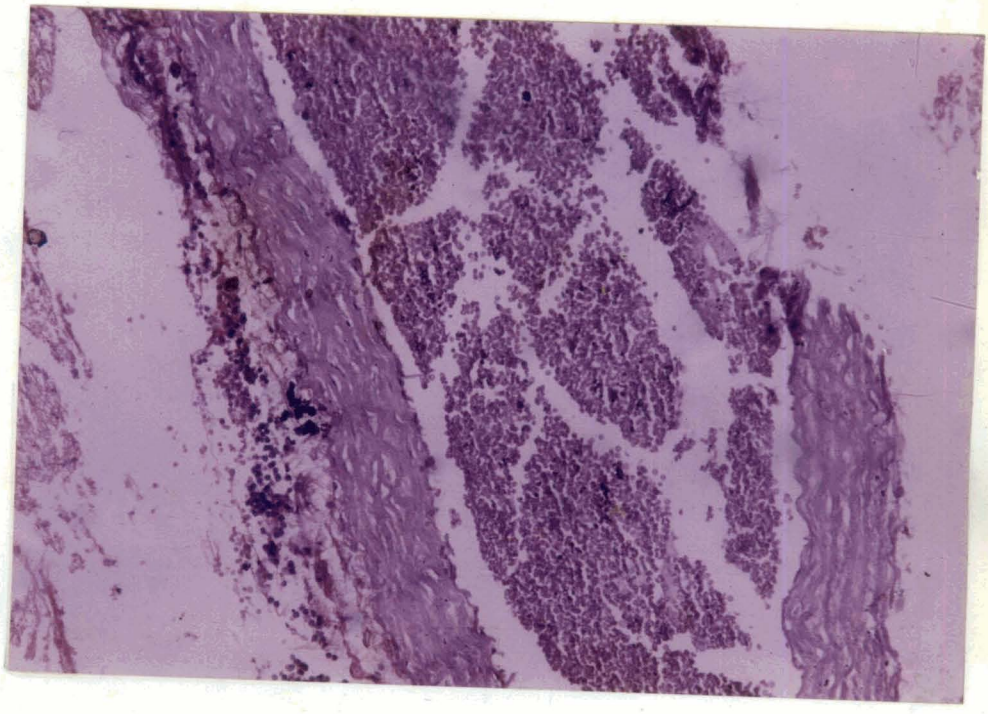
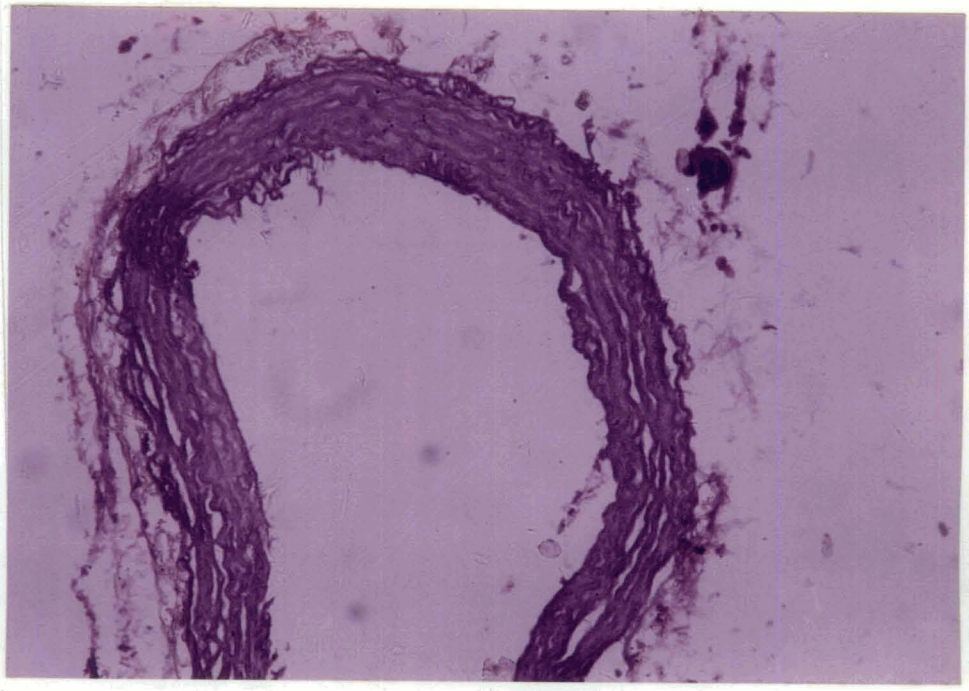
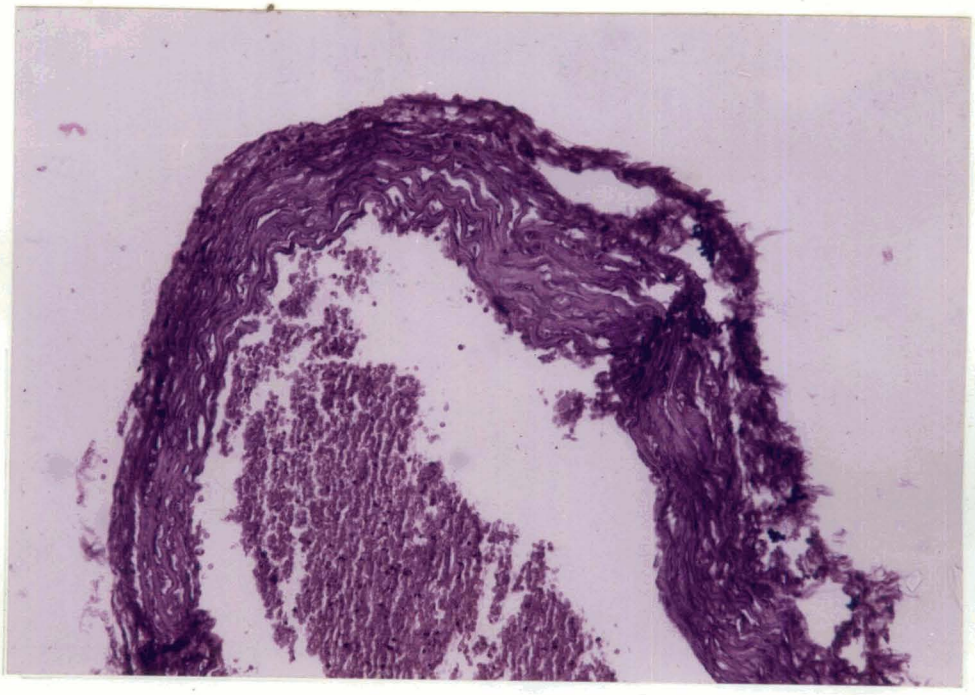


Plate 28 Section of Aorta: Rats fed with diet-K (H&E x 250)
No lesions detected

Plate 29 Section of Aorta: Rats fed with Diet-C (H&E z 250)
No s lesions detected





between the control (farm) diet-C and the other diets such as R, M and K. The mean triglycerides (mg/100 ml) in the serum of the animals fed on purified diets R, M and K were 60.517, 57.745 and 56.327 respectively as compared to a value of 40.959 in the farm diet group. The serum triglycerides of animals fed on diets R, M and K were statistically homogenous.

4.13 Pathological findings

Gross pathology: No gross lesions were detected in any organ of the animals under the control and the treatment groups.

Histopathology: Cellular degeneration and focal necrosis were observed in few hepatocytes in C 1. The aorta of this laboratory animal revealed focal area of separation of the intimal layer and deposition of scanty amount of faintly eosinophilic material in the subintimal space. Moderate level of epithelial desquamation was observed in few proximal convoluted tubules of the kidney.

Mild alterations occurred in the liver, kidney and aorta of two animals in the R group. These included focal hepatocellular degeneration, vacuolar changes in the epithelium of few glomeruli and desquamation of epithelial cells of few proximal convoluted tubules. Mild vacuolar changes occurred in the sub intimal space of one of the animals.

Histological changes were not present in tissues of animals of any other group (Plates 26-29).

DISCUSSION

5. DISCUSSION

Milk fat is the most important constituent of ice cream and it contributes to the rich, creamy flavour and smoothness in texture of ice cream. This study was undertaken to explore the feasibility of using coconut fat in the form of coconut cream replacing milk fat at various levels for the manufacture of ice cream and ice cream mix powder. The products prepared were analysed for various physico-chemical properties and sensory attributes and were compared to normal ice cream. The results of the findings are discussed in this chapter.

5.1 Extraction and analysis of coconut cream

The yield and composition of coconut cream collected from individual coconuts without addition of water are presented in Table 2. The mean weight of coconut cream extracted from individual coconuts was 122±16.042 g.

The average chemical composition of coconut cream is presented in Table 2 and Fig.2. The mean moisture percentage in coconut cream was 47.71 which was in close resemblance with the values of 50 and 46.5 reported by Jaganathan (1970) and Banzon (1978). The mean fat percentage in the coconut cream was 38.950 which was similar to the value of 38-40 reported by Thampan (1984) and 40 reported by Jaganathan

(1970). The protein percentage in coconut cream reported by Thampan (1984) was 5.8 and in the present study a value of 5.771 was recorded. The carbohydrate contents reported by Walker (1906) and Jaganathan (1970) were 5.0 and 5.5 and in the present analysis it was 6.549 per cent. The mean mineral percentage recorded in the present study was 1.020 which was supported by the findings of Walker (1906) and Jaganathan (1970). They reported values of 1.2 and 1.5 respectively for ash.

With respect to the fat, protein and minerals, the difference in values recorded in the present analysis from those of Walker (1906), Jaganathan (1970) and Thampan (1984) may be attributed to several factors such as manuring, climatic conditions, type of the palm, season etc. The values obtained in the present investigation for most of the constituents, were in close agreement with the reports available.

5.2 Analysis of skim milk powder and butter

The dairy ingredients such as skim milk powder and butter used in the preparation of ice cream were analysed for fat, total solids and moisture percentage and the results obtained are presented in Table 3. The composition obtained in the present investigation was in close agreement to the values

reported by Sukumar De (1980) and within minimum limit prescribed by the Prevention of Food Adulteration Act, 1954.

5.3 Evaluation of flavour for ice cream

A pre-trial was conducted to select the suitable flavour for ice cream replacing milk fat with coconut fat at 100 per cent level. The analysis of the data depicted in Fig.3 with regard to consumer acceptance studies using a nine point hedonic scale revealed that pineapple flavour was most acceptable for the ice cream incorporating coconut fat. Consumer acceptance studies conducted by Rajor (1980) also revealed that pineapple flavour was liked by majority of consumers when soya solids and buttermilk solids were incorporated in ice cream. However Nair and Geevarghese (1988) reported that chocolate flavour was most suited for Kera cream followed by pineapple flavour.

5.4 Evaluation of ideal stabilizer/emulsifier and or combination for ice cream

A pre-trial was carried out with different stabilizer/ emulsifier/and or combination in ice cream containing 100 per cent coconut fat to select the ideal one. Since combination containing sodium alginate (SA) and GMS in the proportion of 1:1 added at the rate of 0.5 per cent obtained a total mean score of 84.175 (Table 4 and Fig.4) which was higher than all

the other four treatments, and hence this combination was selected for use in the subsequent experiments.

The efficiency of emulsifier as such or in combination with stabilizers on the whipping ability of ice cream mix were discussed by Defew and Dyers (1925), Sommer (1927) and Leighton (1941). The result of this experiment was supported by the findings of Turnbow *et al.* (1956) who suggested that sodium alginate has considerable merit as a stabilizer for ice cream.

Further Arbuckle (1966) reported that, sodium alginate improved the whipping ability and leaves a slightly cleaner flavour in the mouth. Moreover smooth body and texture of ice cream were attributed to the emulsifiers in ice cream (Frandsen and Arbuckle, 1961; Turnbow *et al.*, 1956). Minhas and Bains (1984) suggested that body, texture and flavour of ice cream were inter-related. The result of the present investigation is also supported by the findings of Tekinsen and Karacabey (1984), who suggested that combination of stabilizer and emulsifier gave higher body and texture scores for ice cream. Lucas (1941) concluded that combination of monoglycerides, and gelatin improved the body of the ice cream, as compared with the results obtained with gelatin alone.

Scores obtained for the melting quality (Table 4) of the product, as evaluated by the judges had not revealed any significant difference between the five treatments. This could be attributed to the fact that same amount of stabilizer/emulsifier were added to all the treatments and no defects could be noted in any of the samples and all had a uniform meltdown.

5.5 Analysis of control and experimental ice cream mix

5.5.1 Titratable acidity

Analysis of the data with regard to the titratable acidity (percentage of lactic acid) presented in Table 5 revealed that replacement of milk fat with coconut fat at any level will not influence the acidity of ice cream mixes. The mean acidity for control and treatments B, C, D and E were 0.164, 0.174, 0.177, 0.175 and 0.185 respectively.

Sukumar De (1980) suggested that normal acidity of 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 0.25 per cent. Indian Standards also prescribe an acidity of less than 0.25 per cent for ice cream mixes.

On the contrary, El Safty *et al.* (1978), Naidu *et al.* (1986), Gonc *et al.* (1988) and Das *et al.* (1989) reported that acidity of

ice cream mixes increased by incorporating hydrogenated oils, whey solids, margarine and potato pulp. On the other hand, acidity was reported to be decreased by the addition of arrowroot powder (Venkateswarlu *et al.*, 1990) and sunflower or maize oil (Al Saleh and Hammad 1992). 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 freshly prepared ingredients such as coconut cream and butter were used, which had low acidity. This in turn resulted in ice cream mixes with low acidity. The values obtained in the present study was in close resemblance to the value of 0.198 per cent reported by Arbuckle, 1966 and Frandsen and Arbuckle, 1961. Turnbow *et al.* (1956) reported a value of 0.145 per cent acidity for mix with 12 per cent fat and 8 per cent MSNF.

5.5.2 pH

Analysis of the pH values (mean, SE and range) presented in Table 5 indicated that replacement of milk fat with coconut fat at any level have no effect on the pH of the ice cream mixes. The mean pH values ranged from 6.634 (Treatment E) to 6.776 (Treatment B). The observations made in the study was similar to the values reported (6.25-6.39) by Turnbow *et al.* (1956) for normal ice cream mixes. Frandsen and Arbuckle (1961) and Arbuckle (1966) respectively reported pH values of 6.3 and 6.3 to 6.4 for normal ice cream. Nair and Geevarghese

(1988) reported that 80 per cent replacement of milk fat with coconut fat does not produce an appreciable difference in pH of ice cream mixes. Moreover the findings of this study was supported by the observations made by Cheema and Arora (1991a) and Jayaprakasha and Venkateshaiah (1995), who observed that incorporation of groundnut, soyabean, corn oil and palmolein oil did not affect the pH of filled ice cream and were statistically at par with control ice cream.

Elhami *et al.* (1977), Naidu *et al.* (1986) Das *et al.* (1989) and Umesh *et al.* (1989) concluded that filled ice cream incorporating margarine, whey solids, potato pulp and vanaspathi could decrease the pH. Again Venkateswarlu *et al.* (1990) reported that replacement of milk SNF with arrowroot powder increased pH of ice cream mixes. This increase or decrease in pH reported by the above authors can be attributed to the initial pH of the basic ingredients used in the preparation which directly affected the pH of the mix.

5.5.3 Relative viscosity

The data with respect to the relative viscosity (cp) presented in Table 6 and Fig.5 indicated that the viscosity values increased as the percentage replacement of milk fat with coconut fat increased. The mean relative viscosity values were 35.760 cp (control) and 79.593 cp for the Treatment E (100 per cent milk fat replacement). Arbuckle

(1966) reported relative viscosity values ranging 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 found to affect the relative viscosity. Contrary to this, low viscosity value of 17.4 to 27.8 cp was reported by Kozin and Rebrina (1976) for ice cream containing hydrogenated sunflower oil, coconut oil or margarine. The values reported by Sivakumar (1991) were in the range of 86.124 to 88.784 cp for ice cream containing soya oil and soya flour. Similarly, values between 57.1 and 85.4 cp were reported by Naidu *et al.* (1986) for ice cream containing whey solids.

Relative viscosity values of different categories of ice cream made by incorporating soya solids and buttermilk solids (Rajor and Gupta, 1982), coconut cream (Nair and Geevarghese, 1988), cotton seed,soyabean and faba bean flour (El Deeb (1984), ground nut protein isolate (Gabriel *et al.*, 1986), potato pulp (Das *et al.*, 1989) and arrowroot powder (Venkateswarlu *et al.*, 1990) resulted in increased viscosity of ice cream as compared to the control.

Decrease in viscosity values were reported in filled ice cream incorporating whey solids, chhana whey solids,maize and sunflower oil by Naidu *et al.* (1986), Reddy *et al.* (1987) and Al Saleh and Hammad (1992). The increase in viscosity values

noted for the treatments in this experiment and reported by many authors for filled ice cream can be attributed to the formation of fat globules into clumps of sufficient size to increase the internal friction of the solid phase and the salt content of the mix as described by Turnbow *et al.* (1956). The observations made in this study is in close agreement to the figures reported by Naidu *et al.* (1986) and Sivakumar (1991). They reported values ranging from 57.1 to 85.4 and 86.124 to 88.784 respectively for filled ice cream.

5.5.4 Surface tension

Analysis of the data with respect to surface tension (dynes/cm) presented in Table 6 and Fig 6, revealed a significant difference between the treatments and control. It was also observed that as percentage replacement of milk fat with coconut fat increased the surface tension also increased. However the control recorded the highest mean surface tension of 61.919 dynes per cm. The values recorded in the present observations were in close resemblance to the figures (46.59 to 59.54 dynes/cm.) reported by Rajor (1980). The decrease in surface tension of treatment mixes as compared to control may be due to the greater concentration of materials in the surface layer than in the body of the liquid which lower surface tension as reported by Turnbow *et al.* (1956).

5.5.5 Specific gravity of ice cream mix

Analysis of the data with respect to specific gravity of ice cream mix presented in Table 7 indicated that replacement of milk fat with coconut fat had not produced any significant difference in specific gravity.

The values recorded in the present experiment were supported by the reports of Arbuckle (1966) for ice cream. Nair and Geevarghese (1988) proved that incorporation of coconut cream in ice cream had not produced any significant difference in the specific gravity as compared to control. Similarly, El Safty *et al.* (1978) and El Deeb *et al.* (1984) concluded that addition of hydrogenated oil and vegetable flour in ice cream had not affected the specific gravity of the mixes.

Contrary to the reports of the above investigators, Reddy *et al.* (1987) reported that replacement of milk SNF by chhana whey solids increased specific gravity of ice cream. Decrease in specific gravity of ice cream, incorporating vanaspathi, potato pulp, arrowroot powder, sunflower, maize oil, and palmolein oil were reported by Umesh *et al.* (1989), Das *et al.* (1989), Venkateswarlu *et al.* (1990), Al Saleh and Hammad (1992) and Jayaprakasha and Venkateshaiah (1995). The increase or decrease in specific gravity of ice cream mixes can be attributed to the specific gravity of the components used in

mix preparation. In the present investigation mainly milk fat was replaced by coconut fat and both of them had almost similar specific gravity which could not produce any significant change in the viscosity of the mixes.

5.5.6 Overrun

It was concluded from the analysis of the data pertaining to overrun (percentage) presented in Table 8 and Fig 7 that replacement of milk fat with coconut fat produced a significant increase in overrun. Significant increase ($P<0.01$) in overrun was observed when replacement level was 75 and 100 per cent as compared to control. The mean overrun percentage were 51.612, 53.710, 57.385 and 61.58 for treatments B, C, D and E respectively as compared to 47.306 for the control. The overrun obtained in the present investigation was in close agreement to the values reported by Arbuckle (1966) for ice cream and Kozin and Rebrina (1976) for filled ice cream. It should also be considered that different factors such as concentration and type of ingredients in the mix, sharpness of scrapper blades, speed of dasher, volume and temperature of the refrigerant etc. will influence the overrun. It may also be noted that in this experiment a softy ice cream freezer was used which does not have a provision to incorporate air at higher levels.

El Hami *et al.* (1977), Reddy *et al.* (1987) and Jayaprakasha and Venkateshaiah (1995) proved that replacement of milk fat with margarine, vanaspathi and palmolein oil decreased overrun. Contrary to this, in the present trial an increase in overrun was obtained. This can be attributed to the protein content of coconut cream which is a natural emusifier (Thyagarajan, 1987) and it might have increased the overrun.

5.5.7 Meltdown time

Perusal of the data with respect to mean, SE and range of meltdown time (min) revealed that the time required for meltdown decreased as percentage replacement of milk fat with coconut fat increased (Table 8 and Fig.7). Mean meltdown time for the control was 59.625 min as compared to a time of 43.694 min for the treatment E (100 per cent fat substitution) and was statistically significant ($P<0.01$). The result of this study was in close resemblance to the values reported by Sivakumar (1991), who observed that mean MDT for control ice cream was 49.1 min and that for ice cream incorporating soya oil and soya flour the mean MDT was 42.2 min. Similarly, Gabriel *et al.* (1986) reported that incorporation of groundnut protein isolate in place of milk SNF decreased meltdown time.

The reason for the decreased meltdown values observed in the present experiment may be due to the increased overrun observed in the treatment groups as compared to the control

(Table 8). Umesh *et al.* (1989), and Jayaprakasha and Venkateshaiah (1995) observed that replacement of milk fat with margarine and palmolein oil decreased overrun which had resulted in an increased melting resistance. Coconut oil contain more of short chain fatty acids compared to milk fat (Jain, 1991). This might also have contributed to the lower MDT for ice cream incorporating coconut fat.

5.5.8 Whipping ability

Whipping ability based on the percentage of overrun obtained during the first (Fig.5) and second five minutes of freezing presented in Table 9 indicated that whipping ability during first five minutes, was significantly superior for the treatments as compared to the control indicating that replacement of milk fat with coconut fat in ice cream had a better ability to incorporate air at a faster rate. In the second five minutes, control had significantly ($P<0.01$) superior whipping ability. Higher whipping ability observed for the treatments in the first five minutes can be correlated to the findings of Washburn (1910), Brown (1913) and Baer (1916) who proved that high viscosity of the mixes is conducive to good whipping ability. Viscosity values presented in Table 6, indicated that replacement of milk fat with coconut fat increased the viscosity of the mix.

The findings of Davis (1916), Lucas and Roberts (1927), Hening and Dahlberg (1929) and Dahle (1930) established that whipping ability could not be explained on the basis of viscosity. But Washburn (1910) proved that aged mixes which has increased viscosity had better whipping characteristics. Another reason for increased whipping ability observed in the present experiment for the treatments could be attributed to the proteins in the coconut cream. Similarly the trials conducted by Miglani *et al.* (1988) and Cheema and Arora (1991a) proved that replacement of milk fat with various vegetable fats considerably decreased the whipping time of ice cream.

5.5.9 Specific gravity of ice cream

The mean, SE and range with respect to the specific gravity of ice cream presented in Table 7 indicated that the specific gravity decreased as the percentage replacement of milk fat with coconut fat increased. The mean specific gravity for the control was 0.875 but for the treatment D and E it was 0.857 and 0.851 respectively which were statistically significant ($P<0.05$) from the control. This difference in specific gravity of ice cream could be correlated with the overrun in ice cream (Table 8) and as rate of incorporation of coconut fat increased the overrun also increased (Fig.8). The decrease in weight of a fixed volume of ice cream is due to the incorporation of more air in treatments D and E which had resulted in a decrease in specific gravity of ice cream.

5.5.10 Weight in grams per litre

The mean, SE and range of weight of one litre of control and experimental ice cream are presented in Table 7. It was observed that the weight gradually decreased as percentage replacement of milk fat with coconut fat increased. The control had a mean weight of 711.250 g/litre while treatment E had only 689.375 g/litre. However, statistical analysis of the data revealed no significant difference between the treatments and different treatments to control. The weight in g/litre recorded in the five groups satisfied the ISI specifications for ice cream (525 g/litre). Observations made by Al Saleh and Hammad (1992) supported the findings of this experiment. They observed that weight per gallon of ice cream decreased when milk fat was replaced with sunflower and maize oils. Slight decrease in weight in grams per litre observed for the treatments as compared to the control can also be attributed to the decreased overrun (Fig.8) in the control samples which will invariably decrease the unit weight, due to air incorporation.

5.5.11 Microscopical structure

The control and experimental ice cream were viewed under microscope to see the structural difference (Plate 1-10). The average size of the air cells were more or less uniform up to a replacement level of 75 percentage. When the replacement

level of milk fat with coconut fat increased the samples exhibited a wide range in the air cell size. The increase in thickness of cell wall membrane can be attributed to the adsorption of fat, protein and other materials to the surface of the air cells. Homogeneous distribution of particles were clearly visible in the liquid portion in the control samples, while the visibility of particles decreased as the percentage substitution of coconut fat increased. This may due to the fact that more amount of skim milk powder was added to the control samples as compared to the treatments to make up the solids in ice cream (Table 1). The structural details observed here was more or less in close resemblance to the ice cream structure reported by Rajor (1980).

5.5.12 Sensory evaluation

The sensory scores obtained for the different samples of ice cream are presented in Table 10. All the samples scored more or less uniformly for the characters like flavour, body and texture, melting quality, colour and package and bacteria. The total mean scores were 93.085, 93.992, 94.611, 95.009 and 95.084 respectively for the control and treatments B, C, D and E. Statistical analysis of the data revealed no significant difference between the treatments and control for the individual characters as well as the total score.

Effect of partial replacement of milk fat with various oils and fats such as hydrogenated oils (El Deeb *et al.*, 1983), margarine (Gonc 1988), maize oil (Rodriguz *et al.* 1991), soya oil (Sivakumar, 1991) and cottonseed oil (Sivaramakrishnan *et al.*, 1994) were studied and was proved that partial replacement of milk fat with above oils had not affected the organoleptic properties of the filled ice cream. Similarly, replacement of milk SNF with vegetable proteins and whey solids in filled ice cream studied by El Deeb *et al.* (1984), Naidu *et al.* (1986), Gabriel *et al.* (1986) and Reddy *et al.* (1987) proved that partial replacement had not impaired the organoleptic properties of ice cream. In the present investigation an important finding was that replacement of milk fat even at 100 per cent level with coconut fat produced ice cream of acceptable quality and was comparable with the control.

5.5.13 Cost estimation

The cost of 100 g each of control and experimental ice cream presented in Table 1 and Fig.9 indicated that when replacement level increased, the cost of ingredients/100 g decreased substantially. When replacement level was 100 per cent, the percentage of cost reduction was 40.57 as compared to the 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. The reduction in cost for experimental ice cream could be attributed to the lower cost of coconut fat as compared to milk fat. The findings during the present investigation is supported by the observations made by several researchers (Ramanna,1975; El Deeb *et al.*, 1984; Lautsen, 1985; Gabriel *et al.*, 1986; Reddy *et al.*, 1987; Gupta *et al.*, 1987; Das *et al.*, 1989; Umesh *et al.*, 1989; Cheema and Arora, 1991b and Jayaprakasha and Venkateshaiah, 1995) who replaced milk fat and SNF with vegetable fat and vegetable proteins and the reduction in cost was attained due to the lower cost of the ingredients used in the preparation.

5.6 Packaging material for Kera ice cream mix powder

The suitability of different packaging material for storing the Kera ice cream mix powder (E-100) with least deterioration were assessed by keeping the product for three months at room temperature. Selection of packaging material was made by analysing the results obtained for the following parameters.

5.6.1 Moisture

The initial moisture content in the powder was 1.286 and it showed an increase during the storage period of three months in different packaging materials. Highest mean moisture

percentage was observed for the powder stored in LDPE (4.668) and lowest (2.257) for the material stored in HMHDPE (Table 11) and significant ($P<0.01$) difference was observed between powder stored in the five packaging materials. The highest moisture content recorded for the powder packed in LDPE can be attributed to the higher water vapour transmission rate of this material as compared to the lowest water vapour transmission rate for HMHDPE (Appendix-V).

5.6.2 Peroxide value

With regard to the peroxide value (meq/1000 g fat) of mix powder it was observed that no peroxides could be detected in powder stored in BOPP and MET/PEST/PE (Table 11). It has been conclusively proved that presence of oxygen in food material is a factor responsible for the development of oxidative rancidity. Properties of the packaging material presented in Appendix-V indicated that OTR was least for MET/PEST/PE followed by BOPP. This might be the reason for the least peroxide value recorded for the powder stored in the above packaging material. Powder stored in LDPE showed the highest mean peroxide value (1.464) and this can be correlated to the higher OTR of that material.

5.6.3 Thiobarbituric acid value

The least mean TBA value (mg malonaldehyde) of 0.255 was recorded for the powder stored in MET/PEST/PE (material 4) and

highest for the powder stored in LDPE (Table 11) and statistical analysis revealed that material 4 was significantly ($P<0.01$) superior to the other four treatments. The lowest TBA value recorded for the powder stored in MET/PEST/PE can be attributed to the quality of this packaging material with regard to OTR and WVTR (Appendix-V). Presence of oxygen and water vapour might have resulted in a higher TBA values for the powder packed in other packaging material 1 and 2.

5.6.4 Non protein nitrogen

Lowest mean (0.363) NPN was recorded for powder packed in BOPP followed by the product stored in MET/PEST/PE (0.428) and LD/LLD (0.449) and all the treatments were statistically significant ($P<0.01$). NPN values were higher for the powder stored in LDPE and HMHDPE and this increase could be correlated to a high OTR and WVTR for the above packaging material (Appendix-V).

5.6.5 Titratable acidity

The mean, SE and range with respect to titratable acidity (percentage of lactic acid) presented in Table 11 indicated that the titratable acidity was lowest (0.682) for powder stored in MET/PEST/PE and highest in BOPP (1.153). The increased transmission of water vapour to the powder had resulted in an increased moisture content, leading to higher

water activity favourable for the growth of microbes which might have resulted in an increased acidity for the mix powder stored in BOPP.

From the foregoing analysis it was ascertained that the material 4 (MET/PEST/PE) was superior in most of the properties and this packaging material was selected for the storage of the mix powder in the subsequent experiments. The conclusion of this trial was supported by Shah *et al.* (1987) who suggested that polyethylene aluminium foil laminated pouches are good for storing spray dried acidophilus malt preparation containing live lactobacillus cells. Similarly Bhandari (1987) suggested that laminated polyester packages can keep dried ice cream mix for more than six months at 30°C. Anon (1989) and Malhotra and Mann (1989) reported that metallised polyethylene bags and metallised polyester LDPE laminate were good in storing chocolate milk powder and coffee complete powder for six months and three months respectively at room temperature. Kumar (1992) suggested that for storage of edible oil, materials with low WVTR and OTR are to be used.

5.7 Chemical composition of control and treatment mix powder

The chemical composition of control and experimental mix powder at 0 day without the addition of antioxidant are presented in Table 12 and depicted in Fig.10. The mean

moisture percentage varied from 1.036 to 1.518. The moisture percentage recorded for all groups in the present investigation was less than the specifications for moisture in dried ice cream mix prescribed (maximum four per cent) in Indian Standards (IS:7839, 1975). The values obtained in this study were near to the reported values of 1.25 per cent by Webb and Whittier (1972), 1.67 per cent by Rajor (1980), 2.5 per cent by Bhanumurthy (1986), 1.5 to 2 per cent by Sachdeva (1986) and Goyal *et al.* (1987). Balachandran (1988) reported a high value of 3.25 percent moisture for ice cream mix powder.

The mean protein percentage was 10.461 in control (A-0) mix powder and a gradual increase was observed as the percentage replacement of milk fat with coconut fat increased (12.857 for E-100). The increase in protein percentage in treatment mix powder can be attributed to a higher percentage of protein in coconut cream (Table 2) and as replacement level increased protein percentage also increased. Rajor (1980) reported a value of 16.74 percentage of protein in soya buttermilk SSI mix powder. The higher percentage of protein in buttermilk and soya milk might have resulted in the higher percentage of protein.

The mean NPN percentage remained almost same for all the treatments whereas control had the lowest mean NPN values. The lowest mean percentage of protein in control (A-0) might have reflected upon the lowest value of NPN in the control.

The mean fat percentage in both the control and experimental mix powder were almost uniform and ranged from 27.313 (A-0) to 27.645 (E-100). Indian standard specification (IS-7839, 1975) for dried ice cream mix suggested a minimum of 27 per cent fat. Webb and Whittier (1972) and Bhanumurthy (1986) reported 27 per cent fat in ice cream mix powder. Values recorded in the present investigation was close to the figures reported by Rajor (1980), Sachdeva (1986), Goyal (1987) and Balachandran (1988). They reported values of 29.76, 30-31, 30 to 31 and 29.5 per cent fat respectively. Eventhough the fat percentage was uniform the free fat content revealed an increasing trend as the replacement of milk fat with coconut fat increased (10.745 in A-0 as compared to 12.279 for E-100). The peculiar chemical nature of coconut fat might have resulted in the increased values of free fat observed in the treatment mix powder.

The mean carbohydrate percentage (calculated by difference) presented in Table 12 indicated that the highest value of 59.195 was recorded for the control, and as replacement level increased a gradual decrease in carbohydrate was observed. The carbohydrate obtained in the present experiment was the sum total of the sucrose added to the mix powder plus the carbohydrate present in the ingredients. The maximum percentage of sucrose permitted in ice cream mix powder as per IS:7839 (1975) was 40. Scientists like Webb and Whittier (1972), Rajor (1980), Bhanumurthy (1986), Sachdeva

(1986), Goyal *et al.* (1987) and Balachandran (1988) reported values of approximately 40 percent sugar in ice cream mix powder. The higher carbohydrate recorded in the present observation was mainly due to the carbohydrates other than sucrose derived from the ingredients. Increased percentage of protein in the treatment mix powder might have reflected over the decreasing trend noticed in the carbohydrate percentage.

The ash percentage in mix powder revealed a gradual increase as the percentage replacement of milk fat with coconut fat increased. The mean ash content was lowest for the control (1.846) and highest for E-100 (2.214). Rajor (1980) reported a value of 2.03 per cent ash in soya buttermilk SSI mix powder and the value obtained in the present investigation was closer to this reported value. Slight increase in ash content observed for the treatments as compared to the control in the present investigation can be correlated to the mineral content (1.020) in coconut cream (Table 2) and as replacement level increased a parallel increase in the ash content of the powder was also observed.

5.7.1 Ultra structure of the powder particle

Spray dried ice cream mix powder were subjected to scanning electron microscopy (SEM) to study the structural difference between the control and experimental mix powder.

Control A-0: SEM revealed uniform distribution of well defined spherical particles ranging in diameter from 10 to 35 µm and few had slightly wrinkled surface (Plate 11-13). Fractured particles revealed solid core with few air pockets. Bhandari *et al.* (1984) observed particles varying in diameter from 27 to 90 µm for normal ice cream mix powder. He also observed that the particles were almost spherical in shape and possessed smooth surface. The observations in this study was also similar to the findings of Buma and Henstra (1971) for whole milk powder. The particles were not as hollow as those found in whole milk powder but had few air pockets as described by Bhandari *et al.* (1984).

Treatment B-25: In this treatment the distribution of particles were not as uniform and spherical (Plate 14-16) as in the previous case and the particles appeared larger measuring between 20 and 45 µm in diameter. The surface of the particles were having wrinkles or protrusions. Particles with parallel wrinkles were observed by Bhandari *et al.* (1984) in dried ice cream mixes incorporating different stabilizers.

Treatment C-50: The powder particles under this treatment were having a diameter ranging from 20 to 45 µm (Plate 17-19). The surfaces of the particles were irregular and crinkled with pits, crevices and protrusions. The observations made in this

study was supported by the findings of Bhandari *et al.* (1984) and Pisecky (1978).

Treatment D-75: The particles were clumped and irregularly distributed, (plate 20-22) with size ranging from 25 to 50 µm. The surfaces of the particles were having crevices, craters, blobs and protuberances. Bhandari *et al.* (1984) observed numerous craters and blobs in ice cream mix powder made using sodium alginate and Tween-80. The findings of Kalab (1979) also supported the observations of this experiment.

Treatment E-100: Powder under treatment E-100 had bigger size ranging from 25 to 50 µm. The particles appeared in clumps (Plate 23-25). The surface of the particles were highly irregular and the spherical appearance of the particles were not uniformly maintained. Clustering of the particles as seen here were reported by Bhandari *et al.* (1984). The increase in diameter for the particles in treatment D-75 and E-100 might be due to longer time taken for drying, by the larger particles as compared to small particles and the latter become fused to the incompletely dried larger particles (Hall and Hedrick, 1966). The irregular surface details observed in treatments as compared to the control can be attributed to the composition of the mix. The chemical composition of the coconut cream might have influenced the drying conditions which might have resulted in the irregular shape and resulted in the rough surface of the particles. Buma and Henstra

(1971) suggested that formation of deep surface folds may be caused by casein in spray dried whole milk powder.

5.8 Physico-chemical properties of the control and treatment mix powder

The following physico-chemical properties of the control and treatment mix powder at the day of preparation were studied (Table 13) and are discussed hereunder.

5.8.1 Peroxide value

No peroxides could be detected for the control and experimental mix powder on the day of preparation. Rajor (1980) reported peroxide value of 0 for the SSI mix powder prepared from soy and buttermilk solids up to two months of storage under different packaging materials. Kumar and Murthy (1994) suggested that peroxide value when determined by iodimetric and colorimetric methods did not give a reliable indication of the milk fat oxidation in buffalo milk powder. Joshi and Thakar (1994) suggested that PV of fat from fresh as well as stored butter were too low to be estimated by iodimetric method. In this experiment fresh ingredients were used and the analysis were carried out on the day of preparation of powder, no peroxides could be detected.

5.8.2 Thiobarbituric acid value

The mean TBA values (mg malonaldehyde) for the control and treatments ranged from 0.073 to 0.085 (Table 13) and statistical analysis of the data revealed no significant difference between the treatments and control indicating that replacement of milk fat with coconut fat will not produce any difference in the TBA value on the day of preparation. Kumar and Murthy (1994) suggested that a TBA value of 0.05 be taken as the limit for TBA in dried whole milk without the development of detectable oxidised flavour. Here all the samples were having TBA value of more than what was reported by the above author but no oxidised flavour could be detected in the sample.

5.8.3 Titratable acidity

Analysis of the data with regard to the titratable acidity (percentage of lactic acid) of the mix powder revealed no significant difference between the treatments and control which ranged from 0.470 to 0.572 indicating that replacement of milk fat with coconut fat at any level will not produce any change in the titratable acidity of the mix powder on the day of preparation.

5.8.4 Solubility index

Statistical analysis of the data with regard to solubility index (ml) presented in Table 13 and depicted in Fig.11 revealed significant difference ($P<0.01$) between different treatments and control. Treatments D-75 and E-100 had a mean solubility index of 1.5 ml whereas control and B-25 had solubility index of 0.700 ml indicating that when replacement level increased beyond 25 per cent, an increase in solubility index could be observed. The value recorded in the present experiment was less than what was reported by Rajor (1980) which was 9.00 ml. Two types of infant formula developed by Rao and Mathur (1987) had a solubility index of 0.12 and 0.20 ml respectively. The solubility index recorded by Salooja and Balachandran (1988) for malted milk powder was 0.54 ml and for coffee complete powder developed by Malhotra and Mann (1989) was 0.62 ml. Solubility index (Maximum) permitted under IS:7839-1975 was 2.0 ml for dried ice cream mix powder and all the samples in this experiment had solubility index of less than 2.0 ml. The increased levels of solubility index recorded for the treatments beyond 25 per cent fat replacement can be attributed to the replacement of coconut cream which might have contained some fibrous materials that is insoluble.

5.8.5 Bulk density

Mean, SE and range with respect to bulk density (g/ml) presented in Table 13 and depicted in Fig.11 indicated that significant difference ($P<0.05$) existed between the treatments and control. The mean bulk density ranged from 0.524 to 0.535 for the treatments and control. The values recorded in the present experiment was supported by the findings of various scientists. Beckett *et al.* (1962) reported a value of 0.609 g/ml for spray dried skim milk powder, whereas Rajor (1980) reported 0.617 g/ml for soy buttermilk solids ice cream mix powder. Rao and Mathur (1987) observed the packed bulk density as 0.489 and 0.510 g/ml and loose bulk density of 0.376 and 0.410 g/ml for two different types of infant formula. Salooja and Balachandran (1988) reported 0.42 g/ml bulk density for malted milk powder and Malhotra and Mann (1989) observed a bulk density of 0.65 g/ml for ready to reconstitute coffee complete powder. The observations recorded in this trial was supported by the value (0.5 to 0.6 (g/ml) reported by Hall and Hedrick (1966). Higher BD for E-100 can be attributed to the less uniformity in particle size distribution and clumping of the particles as suggested by Hall and Hedrick (1966).

5.8.6 Average particle density

The average particle density (g/ml) presented in Table 13 indicated that replacement of milk fat with coconut fat at any level did not influence this character and it ranged from 1.033 to 1.041. The average particle density observed here was lower as compared to a value of 1.233 reported by Beckett *et al.* (1962) for spray dried skim milk powder and 1.1420 reported by Rajor (1980) for soya buttermilk solids soft serve ice cream mix powder. Hall and Hedrick (1966) suggested that the amount of entrapped air influence the particle density. In the present investigation air incorporation was enhanced by the stabilizer added and the technique of spray drying employed might have lead to an increased quantity of entrapped air in the powder.

5.8.7 Percent volume occupied by the powder particle

The mean PVPP ranged from 50.325 to 50.504 (Table 13) and there was a gradual decrease in the values for all treatments as compared to control and was statistically significant ($P<0.05$). The PVPP reported by Beckett *et al.* (1962) was 49.4 for spray dried SMP and Rajor (1980) for filled ice cream mix powder incorporating soya and buttermilk solids was 59.5230. The decreased mean range for PVPP recorded for the samples in the present observation as compared to the value reported by

Rajor (1980) can be correlated to the bulk density. As the bulk density decreases the PVPP also decreased.

5.9 Storage stability of Kera ice cream mix powder

To assess the storage stability of Kera ice cream mix powder containing various replacement levels of coconut fat with and without the addition of BHA, was stored at room temperature (30±2°C) for 180 days. The mix powder was analysed for moisture, titratable acidity, TBA, PV and NPN at two months interval. The results obtained for the above parameters are discussed below.

5.9.1 Moisture

The mean and SE with respect to moisture content in the mix powder are presented in Table 14 and Fig.12. It was apparent that the moisture percentage showed an increase during storage irrespective of addition of BHA. The result of the analysis using student's-t indicated that Kera ice cream mix powder with or with out antioxidant had significantly ($P<0.01/0.05$) higher moisture at any replacement level at 180 days indicating that addition of BHA has no effect on changes on moisture content brought about by storage.

It was reported that the shelf life of dry fat rich products depends upon factors such as temperature of storage, relative humidity, type of the packaging material and the

composition of the product. Tarassuk and Jack (1948) reported that ice cream mix powder with less than 3 per cent moisture kept well for two years at 30-40°C, when stored in gas packed tins. Rajor (1980) observed that moisture content in filled ice cream mix powder increased from 1.2911 to 4.3743 per cent when packed in polyethylene bags. Moisture increased from 1.2911 to 1.294 only when stored at 5°C in tin cans filled with nitrogen. Malhotra and Mann (1989) observed that coffee complete powder stored at 30°C in metallised polyester LDPE laminate, the moisture content increased from 2.28 to 2.40 per cent during a storage period of 90 days. Similarly Kumar and Murthy (1992) reported that moisture content in buffalo milk powder packed in polyethylene bags at 22-28°C, showed an increase when stored for a period of 12 months.

The increase in moisture content of the mix powder observed during the storage of control and treatment mix powder can be attributed to the temperature of storage (30±2°C) and high relative humidity. The packaging material used here (MET/PEST/PE) had a water vapour transmission rate of 3 and this might also have favoured the increase in moisture content of the powder.

5.9.2 Titratable acidity

The mean titratable acidity (percentage of lactic acid) ranged from 0.455 to 0.572 (Table 15) in all the samples and

showed an increase as storage period increased (Fig.13). The increase was more pronounced in samples where replacement levels were high. Analysis of the data revealed that sample with or without antioxidant had comparable titratable acidity to control up to four months of storage. Significant increase ($P<0.01/0.05$) in acidity could be observed in powder with or without antioxidant at 180 days of storage indicating that the antioxidant is not effective in reducing the acidity during the storage period.

Kumar and Murthy (1992) observed that the acidity percentage of buffalo milk powder stored in HDPE increased significantly during the storage period of 22 to 38°C. Significant increase in titratable acidity observed for the powder stored for 180 days with or without the antioxidant can be correlated to the moisture content in the powder samples because a significantly higher moisture was recorded at 180 days of storage for the powder sample.

5.9.3 Thiobarbituric acid value

Analysis of the data with respect to TBA values in mix powder presented in Table 16 and depicted Fig.14 indicated that significant difference ($P<0.01$) could be observed at 120 and 180 days without the addition of antioxidant at different replacement levels of milk fat as compared to control indicating that powder had comparable TBA up to 60 days of

storage. Analysis of the TBA value at 180 days for the powder at various replacement level with the antioxidant revealed significant ($P<0.01$) difference as compared to the control indicating that the antioxidant added powder could be stored for 120 days at any replacement level.

Sood and Srinivasan (1975) reported that TBA value of ice cream mix powder showed a greater increase under air packing than under nitrogen packing, and under air paking the product could be stored for four months. Similarly Kumar and Murthy (1994) observed that the TBA value of the buffalo milk powder increased during the storage. It has been reported that the rancidity of the milk powder is correlated with the initial acidity and the amount of moisture present. This is usually accelerated in the presence of air light and fat splitting enzymes (Kumar and Murthy, 1994). Kunkel *et al.* (1946) reported that increase in moisture content between 1 and 4.5 per cent had much greater influence on the rate of deterioration of dried ice cream mix at 60°C. The increase in TBA values recorded in the present investigation can be correlated to the increase in titratable acidity and moisture content of the powder during the storage period of 180 days. The reason for comparatively lower TBA values recorded for treatments with BHA can also be attributed to the antioxidant property of BHA. However, all the samples were having TBA value of more than 0.05, that is being prescribed as the limit for TBA in dried whole milk (Kumar and Murthy, 1994).

5.9.4 Peroxide value

Analysis of the control and treatment mix powder for the peroxide value at various time intervals were recorded as zero. Kumar and Murthy (1994) reported that peroxide value when determined by iodimetric and colorimetric methods did not give a relative indication of the extent of milk fat oxidation. The results obtained in the present investigation was supported by the findings of Rajor (1980). He observed that the peroxide value of filled ice cream mix powder were 0 up to a period of seven months when packed in tin cans with or without nitrogen and stored at 5±2°C. When packed in polyethylene bags no peroxide could be detected up to two months of storage. In the present experiment a better packaging material was used and hence the amount of peroxides produced may be too small to be estimated by the method used in the present study.

5.9.5 Non protein nitrogen

When protein in foods undergoes degradation NPN is the resulting material, which increases progressively during the storage (Fig.15). Similar trend was observed in this experiment also. The results of the analysis of the NPN values presented in Table 17 indicated that NPN content of the powder were comparable to the control up to 120 days at any replacement level with or without BHA. At 180 days of

storage, powder without BHA at any replacement level showed significant ($P<0.01$) difference as compared to the control, whereas while antioxidant was added significant difference ($P<0.01$) could be noted at 75 and 100 per cent fat replacement levels. The effect could not be attributed entirely to the effect of antioxidant in preventing the degradation of proteins.

The NPN content recorded in the present investigation was higher than what was reported by Rajor (1980). He also observed a gradual increase in NPN content and a maximum of 0.3725 was recorded for filled ice cream mix powder stored for 12 months when packed in polyethylene bags and stored at $30\pm2°C$. The increase in NPN can be correlated to the increased acidity of the mix powder during the storage period. Increase in acidity might have a positive correlation to the NPN values because degradation will be faster in acid medium than in neutral medium.

5.10 Properties of reconstituted ice cream

The physical and organoleptic properties of the ice cream mix powder after reconstitution with potable water were studied and the results obtained are discussed hereunder.

5.10.1 Relative viscosity

Analysis of the data with regard to relative viscosity (cp) revealed no significant difference between the treatments and control (Table 18). Reconstituted product had a mean viscosity ranging from 8.331 to 8.408 cp which was lower as compared to a relative viscosity value of 35.760 to 79.593 (Table 6) of freshly prepared ice cream mix and control. The result of this experiment was supported by the findings of Sood and Srinivasan (1975) who reported that reconstituted ice cream had a lower viscosity. Similarly Rajor (1980) reported that reconstituted filled ice cream mix powder had a relative viscosity of 1.85 cp. Reconstitution of ice cream mix powder after a storage period of 10 months resulted in lower viscosity for the product (Bhandari and Balachandran, 1984). The decrease in the viscosity observed during the present investigation can be attributed to the change in the protein part of the mix resulting in reduced dispersibility (Rajor, 1980). Non ageing of the mix might also have resulted in a lower relative viscosity.

5.10.2 Specific gravity

The specific gravity of the reconstituted ice cream mix ranged from 1.051 to 1.055 for control and treatment groups (Table 18). Statistical analysis of the data conclusively proved that replacement levels of milk fat at any level did

not affect the specific gravity of the reconstituted Kera ice cream. The results obtained in this study was closer to the specific gravity value of 1.0462 reported by Rajor (1980) for reconstituted filled ice cream.

5.10.3 Overrun

Analysis of the data with regard to overrun percentage presented in Table 18 and depicted in Fig.16 revealed that the overrun gradually increased as the percentage replacement of coconut fat increased and was statistically significant ($P<0.01$). The overrun for the control was 49.637, and for treatments it ranged from 51.143 to 58.875. The overrun for freshly prepared control and experimental ice cream was in the range of 47.306 to 61.580 (Table 8). An increase in overrun was observed as percentage replacement of milk fat increased. Rajor (1980) reported a value of 42.27 for reconstituted filled SSI mix powder. The increase in overrun recorded for the treatments as compared to the control may be due to the proteins in coconut cream which had emulsification properties that might have influenced the overrun.

5.10.4 Meltdown time

The data with respect to meltdown time (minutes) presented in Table 18 and Fig.16 indicated that for the reconstituted and frozen product the time decreased as the percentage replacement of milk fat with coconut fat increased.

Control had a mean meltdown time of 61.422 min while E-R had only 52.240 min and analysis of the data revealed significant difference ($P<0.01$) between various treatments and control. A similar trend in MDT was observed for the freshly prepared control and experimental ice cream (Table 8). The lower MDT observed for the treatments can be correlated to the higher overrun percentage in these groups.

5.10.5 Organoleptic quality of reconstituted ice cream

The organoleptic qualities of reconstituted frozen control and Kera ice cream (Table 19) revealed no significant difference for the various qualities between treatments and control. Tracy and Pyension (1944) reported that reconstituted and frozen Ice cream gave good quality ice cream. No defects in flavour, body and texture, melting quality and colour and package could be detected in the reconstituted and frozen control and experimental product and that might be the reason for the high organoleptic scores for the product.

5.11 Nutritional qualities of Kera ice cream

The nutritional qualities of Kera ice cream as compared to ice cream and reference diet was evaluated by rat feeding trials, by determining the PEV and FE.

5.11.1 Protein efficiency value

Analysis of the data with respect to PEV presented in Table 20 and depicted in Fig.17 revealed significant difference ($P<0.01$) between the three diets. Reference diet (R) had a significantly higher PEV than the M and K diets. It was also revealed that ice cream diet (M) and Kera ice cream diet (K) had comparable PEV.

Bhat (1991) suggested that defatted coconut protein containing all the essential amino acids is an excellent material for the preparation of baby foods and weaning foods. Darwis (1991) reported the PER of weaning foods containing coconut protein concentrate as 2.11. PEV of rat feed incorporating tapioca starch and casein was reported to be 2.96 (Thomas, 1966) and for ground nut protein 1.49 (Francis, 1984). The PEV of reference casein diet recorded here was comparable to what is reported (2.54) by Francis (1984). The lesser PEV recorded for M and K diet may be attributed to the quality and denaturation of proteins. The reduction in the quality of proteins due to high heat treatment was reported by Fleek (1971) and Deatherage (1975).

5.11.2 Feed efficiency

Analysis of the data with regard to FE presented in Table 20 and Fig.17 revealed that the Reference diet (R) had significantly ($P<0.01$) superior FE than the M and K diets. The

results also indicated that the diet incorporating coconut fat and milk fat were having comparable FE. The feed efficiency values reported by Thomas (1966) for rat feed incorporating tapioca starch and casein was 0.30 and the values recorded here was comparable to this reported value. The decrease in feed efficiency recorded for the K diet can be attributed to the deficiency in lysine, methionine and threonine (Francis, 1984). The FE for K diet was comparable to M diet because coconut oil was having higher assimilable glycerides and digestibility coefficient as compared to butter fat (Prasad and Azeemoddin, 1994). The reference diet had significantly ($P<0.01$) higher FE and this may be attributed to the quality of proteins contained in the diet.

5.13 Serum lipid profile

At the end of the experimental period the rats fed with the four different type of diets were slaughtered and the serum lipid profile studied.

5.13.1 Total serum cholesterol

Analysis of the data with respect to serum cholesterol presented in Table 21 and Fig.18 revealed significant difference ($P<0.01$) between the control (diet C) and the other three diets such as R, M and K. Moreover the cholesterol levels in animals fed diets R, M and K were statistically at

par and was significantly higher than the animals fed with diet C.

The cholesterol (mg/100 ml) recorded in the present observation for the rats fed with R,M and K diets was higher than the range (28-76) reported by Spector (1956) and 57.1 mg/100 ml reported by Achuthan and Jose (1995). Harkness and Wagner (1989) reported values ranging from 40-130 mg/dl and the values recorded in the present experiment was within this range.

It can be reasonably believed that the type of fat, amount of fat and the fibre contained in the diet might have resulted in the higher serum cholesterol in rats fed M, K and R diets. Keys *et al.* (1957) reported that saturated fatty acids are twice as potent in raising serum cholesterol. Srivastava *et al.* (1986) also reported a similar effect. Kritchevskz *et al.* (1976) found that coconut oil fed rabbits showed similar serum lipid values compared to butter and was higher than peanut oil or corn oil. Haug and Hostmark (1987) and Van Heek and Zilversmit (1988) reported that feeding of coconut oil developed severe hyperlipedemia than fish oil or olive oil. Purushothama *et al.* (1993) reported that higher content of total saturated fatty acids in palm oil as compared to ground nut oil had not elevated serum cholesterol,but feeding at higher levels resulted in an increased blood cholesterol level.

Sindhu Rani *et al.* (1993) reported that rats fed coconut oil and groundnut oil had similar serum cholesterol and inclusion of coconut kernel along with coconut oil or groundnut oil resulted in a significantly lower serum cholesterol. Coconut oil is high in saturated fatty acids and low in unsaturated fatty acids (Kurup and Rajmohan, 1994; Prasad and Azeemoddin, 1994).

Kurup and Rajmohan (1994) reported that consumption of coconut oil with kernel to humans produced decrease in serum cholesterol. The effect was assumed to be due to the protein and dietary fibre it contained. The decreased values of serum cholesterol in rats fed with the farm diet (C) recorded in the present experiment may be due to the fact that it contained more fibre and less fat than the other diets. Rao (1993) reported that significant reduction in the level of serum cholesterol were obtained when dietary fibre was there in the diet of rats. Similarly Rajmohan (1994) reported that the proteins and the dietary fibre contained in the coconut kernel are effective in lowering serum cholesterol. Many scientists reported that high blood cholesterol cannot be correlated to atherosclerosis (Eraly, 1994; Paul and Mukkadan, 1994). Beynen *et al.* (1989) reported that type of carbohydrate and fat are the major determinants of liver cholesterol in mice. Naresh kumar and Singhal (1992) suggested that factors such as hypertension, physical inactivity, diabetes mellitus and

obesity together with a host of other factors such as age and sex can influence the development of atherosclerosis. Wick *et al.* (1992) suggested that nutritional, genetic, hormonal, infections, autoimmune and behavioral factors were all correlated to the development of atherosclerosis.

5.13.2 Triglycerides

The analysis of the data presented in Table 21 and Fig.18 revealed significant ($P<0.01$) difference in the triglyceride content in the serum of rats receiving the four diets. However the serum triglycerides of the animals receiving the R, M and K diets were statistically homogenous.

The values for the serum triglycerides reported by Harkness and Wagner (1989) was 26-145 mg/dl and the values obtained in the present observation was within this range. However, Achthan and Jose (1995) reported an average of 30.45 mg/dl for rats. The triglycerides values noted in the trial followed more or less similar trend as that of the cholesterol level.

Kritchevskz *et al.* (1976) compared coconut oil to butter fat in the serum lipid profile of rabbits and found that coconut oil fed group showed similar serum lipid values compared to butter. In this trial also animals receiving coconut oil and butter fat had more or less similar serum triglycerides and

cholesterol. Haug and Hostmark (1987) reported that coconut oil produced appreciably higher plasma triglyceride as compared to fish oil when fed to rats. Purushothama *et al.* (1993) reported that higher levels of oils in diet elevated blood serum profile and the increased level of cholesterol and triglyceride recorded in the trial may be due to the addition of oil at 10 per cent level in these diets. Contrary to this, Sindhu Rani *et al.* (1993) reported that feeding of coconut oil or ground nut oil does not elevate the triglyceride level in rats.

The results of the experiment indicated that cholesterol and triglyceride content in serum are related and the increase in cholesterol had a direct bearing on the serum triglyceride level also.

5.14 Pathological findings

Pathological examination of carcasses and tissues of animals under treatment and control groups did not reveal significant changes. The mild degenerative changes in liver, kidney and aorta of few animals in the C and R groups cannot be considered as representative of groups as changes were not consistent in all animals of the same group. These mild alterations might have been caused by some unidentified factors which unadvertendly entered their system. The scanty eosinophilic deposit was probably caused as a result of agonal

haemorrhage before the necropsy. Tissues from majority of animals were free of any pathological alteration.

All animals under K and M groups appeared healthy and their tissues showed normal histological profile (Plate 26-29). It can be surmised that dietary incorporation of Kera Ice cream and milk ice cream cause no untoward effect in organs and tissues of animals as revealed by pathological examination and there is no health hazard in using these food items. The findings of this experiment is supported by the reports of Wickremansinghe (1995) who stated that coconut oil contains medium chain fatty acids and this property make it less prone to be deposited as fat in peripheral tissues. Contrary to this Van Heek and Zilversmit (1988) reported that there is no direct relationship between plasma cholesterol and aortic cholesterol. However, when plasma cholesterol and triglycerides were high, significant correlation existed to the aortic cholesterol level. In the present experiment higher levels of cholesterol and triglycerides were noted for the diets K, M and R.

From the foregoing discussion it can be reasonably concluded that coconut fat in the form of coconut cream can be included in the preparation of ice cream replacing milk fat without any noticeable changes in the physico-chemical and organoleptic properties. The product had a better overrun and whipping ability. Cost of the product was also less when

compared to the control. Ice cream mix powder incorporating coconut fat could also be prepared and had a keeping quality for four months under normal conditions. The nutritional properties of the product were also comparable to the control.

SUMMARY

6. SUMMARY

An investigation was undertaken to assess the feasibility of incorporating coconut fat in the form of coconut cream to replace milk fat at 25, 50, 75 and 100 per cent levels for the preparation of Kera ice cream and Kera ice cream mix powder. The products prepared were analysed for physico-chemical properties, organoleptic qualities and nutritional parameters using standard analytical procedures and compared with normal ice cream.

Coconut cream was extracted from mature coconuts using screw press and analysis of the cream revealed 47.71 moisture, 38.950 fat, 5.771 protein, 6.549 carbohydrates and 1.020 ash (in percentage). Dairy ingredients such as skim milk powder and butter used in ice cream preparation were analysed for total solids and fat and the results of the constituents studied were within the normal range.

Standard procedures were followed for the preparation of Kera ice cream wherein milk fat was replaced by coconut fat at 25, 50, 75 and 100 per cent levels and the treatments were designated as B, C, D and E respectively and compared with normal ice cream designated as A. The proportionate quantity of the different ingredients to be used in the mix preparation

to meet the minimum standard for fat (10 Per cent) and total solids (36 per cent) was derived by the linear programming model (Matrix method).

Pre trials were conducted to decide on the best flavour for Kera ice cream and was found that pineapple flavour scored maximum with 7.15 points, followed by vanilla flavour with 6.35 points as evaluated by a panel of 55 consumers using nine point hedonic scale and hence pineapple favour was selected for use in the subsequent trials. Similarly pre trial for selecting a suitable stabilizer/emulsifier and or combination was carried out and was found that 1:1 combination of sodium alginate and glyceryl monosterate to make 0.5 per cent of the mix scored high. Hence this combination was selected for use in the subsequent trials.

The pysico-chemical properties of control and experimental ice cream mix and ice cream were analysed for various properties using standard procedures.

Titratable acidity (percentage of lactic acid) revealed no significant difference between the treatments and control. All the samples were having acidity of less than 0.25 per cent which is considered to be normal. pH values of the mix also indicated that replacement of milk fat with coconut fat at the different levels have no effect on the pH of ice cream mix. The mean pH values ranged from 6.641 to 6.776.

Relative viscosity (cp) of ice cream mixes revealed an increase, as fat substitution level increased from 25 to 100 percentage and was significant ($P<0.01$). Mean relative viscosity for the control (A) was 35.760 whereas for 100 per cent fat replacement (E) it was 79.593. Surface tension (dynes/cm) was highest for the control (61.919) and ranged from 54.319 (Treatment B) to 58.524 (Treatment E) and the differences were significant ($P<0.01$). Specific gravity mean of control and experimental ice cream mixes were in the range of 1.052 to 1.056 with an overall mean of 1.054 and statistical analysis revealed that replacement of milk fat with coconut fat had not produced any significant difference in specific gravity of ice cream mixes.

On comparing the overrun (percentage) obtained for the control and treatment ice cream, it was found that as the percentage replacement of milk fat with coconut fat increased a significant ($P<0.01$) increase in overrun was observed at different replacement level as compared to control. The lowest mean overrun was 47.306 for control (A) and 61.58 for Treatment E. With regard to meltdown time, a decreasing trend was observed as percentage replacement of milk fat with coconut fat increased. Mean meltdown time for the control was 59.625 minutes as compared to a time of 43.694 minutes for the treatment E and the differences were statistically significant ($P<0.01$).

Whipping ability calculated based on the overrun percentage during the first five minutes of freezing revealed that the treatments had significantly ($P<0.01$) superior whipping ability as compared to the control. Contrary to this during the second five minutes of freezing the control had superior whipping ability ($P<0.01$).

Mean specific gravity for the control ice cream was 0.875 and it significantly ($P<0.05$) decreased as percentage replacement of milk fat with coconut fat increased. Mean specific gravity for treatment E was 0.851 indicating that specific gravity of Kera ice cream decreased as fat substitution increased. A similar trend was observed for weight in grams per litre of ice cream. Mean weight in grams per litre ranged from 689.375 to 711.250. However all the samples were having weight more than that is prescribed under the ISI specifications of 525 gram/litre.

Microscopical examination of ice cream samples revealed that Kera ice cream (E) had the highest mean air cell diameter indicating that as replacement level increased, air cell diameter also increased. It was also evident that the thickness of the air cell wall also increased when the replacement level of milk fat with coconut fat increased.

Organoleptic quality of the product was assessed by sensory evaluation with regard to characters like flavour,

body and texture, melting quality, colour and package. All samples in the four treatment groups scored more or less uniformly for the above characters and no significant difference in scores could be noted between the control and treatments. The total score obtained for all the samples were in the range of 93 to 95.

The cost of 100 g of control and experimental ice cream based on the ingredient cost revealed that as replacement level increased the cost decreased considerably. The savings in cost of ingredients (in percentage) were 10.14, 20.25, 30.43 and 40.57 when milk fat replacement was 25, 50, 75 and 100 per cent respectively. Ice cream mix powder was prepared incorporating coconut fat, replacing milk fat at 25, 50, 75 and 100 per cent levels using spray drying process following standard methods.

To evaluate the suitability of finding an ideal packaging material for storing the ice cream mix powder (without antioxidant and containing 100 per cent replacement of milk fat with coconut fat) was stored for three months in different packaging material. The packaging material was selected based on the changes in powder with respect to moisture, peroxide value, thiobarbituric acid value, non protein nitrogen content and titratable acidity. Analysis of the mix powder stored for three months in different packaging materials has revealed that metallised polyester polyethylene was superior in most of

the properties and this packaging material was selected for the storage of the mix powder in the subsequent experiments. Chemical composition of the control and treatment ice cream mix powder on the day of preparation revealed that the mean moisture percentage varied from 1.036 to 1.518, protein 10.461 to 12.857, fat 27.313 to 27.645, carbohydrate 55.978 to 59.195 and ash 1.846 to 2.214. It was observed that as the percentage replacement increased the protein and ash content in the powder increased but the carbohydrate content decreased.

Physico-chemical properties of the control and experimental mix powder was also evaluated on the day of preparation. Peroxide value was recorded as zero for the control and treatment mix powder. The mean thiobarbituric acid value (mg.malonaldehyde) varied from 0.073 to 0.085 and mean titratable acidity (percentage of lactic acid) varied from 0.470 to 0.597 indicating that these two properties of the powder was not affected significantly as the replacement level increased. With regard to solubility index (ml) it was observed that it increased significantly ($P<0.01$) as percentage replacement of milk fat with coconut fat increased. For 75 and 100 per cent replacement solubility index was 1.5 whereas for control, 25 and 50 per cent milk fat replacement it was 0.7, 0.7 and 0.9 respectively. Bulk density (g/ml) of the powder revealed homogenicity for control and treatments in which 50 and 75 per cent replacement was made. Average particle density (g/ml) did not varied significantly between

the control and treatments and the values were with in the range of 1.033 to 1.041. Per cent volume occupied by the powder particle was higest (50.504) for the control and it decreased significantly in all the treatments.

The powder particles were subjected to scanning electron microscopy to study the structural difference. Control ice cream mix powder revealed uniform distribution of well defined spherical particles of varying size ranging from 10 to 35 μm. The powder containing 25 per cent fat replacement revealed larger particles with slightly wrinkled appearance with numerous protrusions, measuring a diameter of 20 to 45 μm. When the replacement was at 50 per cent level the size of the particles ranged from 20 to 45 μm and the surface of the particles were irregularly crinkled with pits, crevices and protrusions on the outer surface. Powder containg 75 per cent milk fat replacement showed particles of pleomorphic in apperance and size ranged from 25 to 50 μm. The particles appeared clumped and irregularly distributed and surface were rough with numerous crevices, craters, blobs and protuberances. Clumping of the particles were predominant when powder contained 100 per cent substitution of milk fat with coconut fat. The particle size ranged from 25 to 50 μm. The spherical appearance of the particles was not uniformly maintained and they appeared rough, wrinkled and distorted.

To study the effect of replacement level of milk fat with coconut fat and addition of antioxidant (BHA) at the rate of 0.01 per cent on the keeping quality of Kera ice cream mix powder, the product was stored for six months at room temperature and the following properties were studied at two months interval.

It was observed that the moisture percentage increased as the storage period increased irrespective of the addition of antioxidant or the replacement level. Analysis of the data with respect to moisture at different storage period indicated that Kera ice cream mix powder with or with out antioxidant had significantly ($P<0.01/0.05$) higher moisture at 180 days of storage as compared to the control containing only milk fat.

As period of storage increased the acidity (percentage of lactic acid) also increased irrespective of the level of replacement and addition of antioxidant. Upto 120 days of storage significant difference could not be observed whereas at 180 days significant difference ($P<0.01/0.05$) in acidity could be observed for all levels of replacement as compared to its control indicating that with or without antioxidant the mix had significantly higher acidity at any replacement level at 180 days of storage.

Analysis of the data with respect to the thiobarbituric acid (TBA) value (mg.malonaldehyde) at 60 days of storage

indicated that all the samples had TBA values comparable to control upto 60 days at any replacement level with or with out antioxidant. At 120 days of storage antioxidant added powder does not revealed any significant difference as compared to the control, but significant difffernce ($P<0.01$) was observed at 180 days of storage as compared to the control. When the powder was stored without antioxidant significant difference ($P<0.01/P<0.05$) could be observed at 120 days of storage.

With respect to peroxide value no peroxides could be detected at any replacement level with or with out antioxidant even when stored for 180 days.

Analysis of the data with regard to NPN (per cent) in powder at different storage periods indicated that NPN content of the powder was comparable to the control upto 120 days at any replacement level with or with out BHA. At 180 days of storage powder without BHA in all replacement levels showed significant difference ($P<0.01$) as compared to the control, whereas on addition of antioxidant significant difference ($P<0.01$) could be noticed at 75 and 100 per cent milk fat replacement level.

Ice cream mix powder was reconstituted with water and frozen and the properties of the reconstituted and frozen product were studied. Relative viscosity (centipoise) of the control and treatment mixes ranged from 8.331 to 8.408 in

various treatments and control and no significant difference was noted between the treatments and control. It was also concluded that replacement levels of milk fat with coconut fat did not affect the specific gravity of reconstituted Kera ice cream. The specific gravity ranged from 1.051 to 1.055. With regard to overrun (percentage) it was observed that it significantly ($P<0.01$) increased as the percentage replacement of milk fat with coconut fat increased. Lowest mean overrun was observed for control (49.637) and highest (58.875) for treatment in which milk fat was completely replaced by coconut fat. With respect to meltdown time it was observed that mean meltdown time decreased as the percentage replacement of milk fat with coconut fat increased and was statistically significant ($P<0.01$). The organoleptic qualities of the reconstituted and frozen product revealed that no significant difference could be observed for various qualities such as flavour, body and texture, melting quality, colour and package between the control and the treatments indicating that coconut fat addition will not produce any difference in the sensory attributes of reconstituted Kera ice cream.

Nutritional qualities of Kera ice cream as compared to ice cream and reference diet were assessed by rat feeding experiments by determining the protein efficiency and feed efficiency values. Protein efficiency value for the ice cream diet and Kera ice cream diet were statistically at par and was significantly ($P<0.01$) different from the reference diet.

Feed efficiency also revealed a similar trend. The reference casein diet had significantly ($P<0.01$) superior feed efficiency than the other two diets. The results indicated that Kera ice cream diet and the ice cream diet had comparable protein efficiency value and feed efficiency and reference casein diet had significantly superior protein efficiency value and feed efficiency.

Serum lipid profile of rats under the above feeding trials and farm diet were also estimated. It was shown that animals receiving the reference diet, ice cream diet and Kera ice cream diet were having significantly higher ($P<0.01$) serum cholesterol and triglyceride than the rats receiving the farm diet.

At the end of the feeding trial the animals under the four groups were slaughtered and gross pathology and histopathology of the organs were studied. No gross lesions were detected in any organ of the animals under the control and treatment groups. Histological changes were not present in tissues of most of the animals in any group. It can be surmised that dietary incorporation of Kera ice cream and ice cream cause no untoward effect in organs and tissues of animals as revealed by pathological examination.

From the overall assessment of the data during the course of the present investigation, it can be reasonably concluded

that coconut fat in the form of coconut cream can be incorporated in the preparation of ice cream with added advantage of increased overrun and cost reduction. The product had comparable organoleptic properties as compared to normal ice cream. The keeping quality of the mix powder can be enhanced for two months by the addition of antioxidant. Pathological examination of tissues of animals fed with Kera ice cream revealed normal profile.

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* Originals not seen

APPENDICES

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10 'SIMPLEX LINEAR PROGRAMMING ( MATRIX METHOD ) FOR ICE CREAM MIX
20 CLEAR
30 DIM C(20, 40), D(20, 40), VALY(20), Y(20), PRDT(20), AMT(20), VALX(20), X(40)
, RVLX(40)
40 DIM X1$(40), Y1$(40), CON$(40), ING(20), Q(20), ING$(20), RES(20), OM(20, 40)
, VALO(20)
50 PRINT "       LINEAR PROGRAMMING FOR OPTIMUM MIX ": PRINT
55 INPUT "Level of cream replacement (percent)  ", L: LL = L / 10
60 INPUT "Intermediate Tables to be printed ? (Y/N) ", A$
70 READ N, M, VP
80 PRINT : PRINT "INGREDIENTS = "; M - N, "  CONDITIONS = "; N
100 FOR I = 1 TO N: FOR J = 1 TO M: READ C(I, J): OM(I, J) = C(I, J): NEXT J: NE
XT I
110 FOR J = 1 TO M: READ VALX(J): VALO(J) = VALX(J): NEXT J
120 FOR I = 1 TO N: READ PRDT(I): NEXT I
150 FOR J = 1 TO M: READ X1$(J): NEXT J
160 FOR I = 1 TO N: READ CON$(I): NEXT I
190 PRINT : PRINT SPC(35); "INGREDIENT  COMPOSITION": PRINT
210 PRINT "CONDITIONS", "OPTIMUM LEVEL"; : FOR J = VP TO M: PRINT SPC(2); X1$(J)
; : NEXT J: PRINT : PRINT
220 FOR I = 2 TO N-2: PRINT CON$(I), : PRINT USING "#####.##"; PRDT(I); : PRINT
SPC(4); : FOR J = VP TO M: PRINT USING "#####.##"; C(I, J)*100; : NEXT J: PRINT
: NEXT I
230 PRINT"PRESS F5 TO CONTINUE":STOP
240 F = C(2, VP)
242 PRDT(N) = LL / F
250 FOR I = 1 TO N: VALY(I) = VALX(I): NEXT I
260 FOR J = 1 TO M: X(J) = J: NEXT J
270 NN = NN + 1: PRINT : PRINT "TRIAL  - "; NN
280 FOR J = 1 TO M: SUMP = 0: FOR I = 1 TO N: P = VALY(I) * C(I, J): SUMP = SUMP
 + P: NEXT I
290 RVLX(J) = VALX(J) - SUMP
300 NEXT J
310 ZMAX = 0: FOR J = 1 TO M: IF (RVLX(J) - ZMAX) >= 0 THEN 330
320 ZMAX = RVLX(J): K2 = J
330 NEXT J
340 IF ZMAX >= 0 THEN 640
350 FOR I = 1 TO N: IF PRDT(I) >= 0 THEN 370
360 PRINT "PRDT", I, PRDT(I): STOP
370 IF C(I, K2) > 0 THEN 390
380 AMT(I) = -1: GOTO 400
390 AMT(I) = PRDT(I) / C(I, K2)
400 NEXT I
410 I = 1
420 IF AMT(I) >= 0 THEN 450
430 I = I + 1: IF (I - N) <= 0 THEN 450
440 PRINT "AMT"; I; AMT(I)
445 PRINT "UNFEASIBLE SOLUTION ": END
450 ZMIN = AMT(I): K1 = I
460 I = I + 1
470 IF (I - N) > 0 THEN 500
```

```
481!IF AMT(I) < 0 THEN 460
490 IF ZMIN - AMT(I) > 0 THEN 450 ELSE 460
500 Y(K1) = X(K2)
510 Y1$(K1) = X1$(K2)
520 VALY(K1) = VALX(K2)
530 FOR I = 1 TO N: PRDT(I) = PRDT(I) - ZMIN * C(I, K2): NEXT I
540 PRDT(K1) = ZMIN
550 FOR J = 1 TO M: FOR I = 1 TO N:
560 D(I, J) = C(I, J) - C(K1, J) * (C(I, K2) / C(K1, K2)): NEXT I: NEXT J
570 FOR J = 1 TO M: D(K1, J) = C(K1, J) / C(K1, K2): NEXT J
580 FOR J = 1 TO M: FOR I = 1 TO N: C(I, J) = D(I, J): NEXT I: NEXT J
590 IF A$ = "Y" THEN 600 ELSE 270
600 FOR I = 1 TO N: PRINT Y(I), : PRINT USING "###.###"; PRDT(I): NEXT I
610 GOTO 270
620 PRINT
630 PRINT
640 PRINT "FINAL RESULTS"
650 PRINT "            ICE CREAM INGREDIENT COMPOSITION (Per cent) "
655 PRINT "            ========================================="
656 PRINT " Level of MILK fat replacement"; L; "%"
660 PRINT "ITEM", "g/100g"; SPC(5); "Fat contri. %"; SPC(5); "FAT %"; SPC(3); "S
NF%";"     Cost/kg"
665 PRINT "======================"
670 FOR I = 1 TO N
690 K = Y(I): ING(K) = Y(I): ING$(K) = Y1$(I): Q(K) = PRDT(I)
710 NEXT I: K = 1: FOR I = VP TO M: QK(K) = Q(I): PRINT ING$(I),
715 PRINT USING "###.##"; Q(I); : K = K + 1: FAT = OM(2, I) * 100: FATC = Q(I) *
 FAT / 10:SNF=OM(4,I)*100
716 PRINT SPC(5); : PRINT USING "###.##"; FATC; : PRINT SPC(8); : PRINT USING "#
#####.##"; FAT; SNF;VALO(I)
717 NEXT I
720 FOR I = 1 TO N: FOR J = VP TO M
740 RES(I) = RES(I) + OM(I, J) * Q(J)
760 NEXT J: NEXT I
765 PRINT
770 PRINT "Calculated chemical composition"
780 FOR I = 1 TO N - 2: PRINT CON$(I), : PRINT USING "####.##"; RES(I): NEXT I
790 ZVAL = 0: FOR I = 1 TO N: ZVAL = ZVAL + PRDT(I) * VALY(I): NEXT I
800 PRINT
810 COST = ZVAL / 100
820 PRINT "COST OF ICE CREAM (Per kg)=  Rs."; : PRINT USING "###.##"; COST
830 DATA 08,14,09
840 DATA 1,0,0,0,0,0,0,0,01,1,1,1,1,1
850 DATA 0,1,0,0,0,0,0,0,0.3500,0.0050,0,0,0,0.8000
860 DATA 0,0,1,0,0,0,0,0,0,0,1,0,0,0
870 DATA 0,0,0,1,0,0,0,0,0.1000,0.9800,0,0,0,0.0500
880 DATA 0,0,0,0,1,0,0,0,0,0,0,1,0,0
890 DATA 0,0,0,0,0,1,0,0,0.5500,0.015,0,0,1,0.1500
892 DATA 0,0,0,0,0,0,1,0,0,0,0,0,0,1
894 DATA 0,0,0,0,0,0,0,0,1,1,0,0,0,0,0
900 DATA 1000000,1,1,1,1,1,1,1,25,45,12,120,0.1,100
910 DATA 100,10,15,11,0.5,63.5,30,5
920 DATA D1,D2,D3,D4,D5,D6,D7,D8,COC.CR,S.M.P,SUGAR,STABI.,WATER,BUTTER
930 DATA QUANTITY=,FAT% =,SUGAR% =,SNF% =,STABI% =,MOISTURE% =,BUTTER=,COC.CR.=
940 END
```

Appendix-II

Ice cream score card

Examined by.....Date.....Time.....
Kindly indicate your choice as follows.

	Samples				
	1	2	3	4	5

---

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Neither like nor dislike
6. Like slightly
7. Like moderately
8. Like very much
9. Like extremely

Remarks:-

Signature

Appendix-III

Ice cream score card
(Modified)

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

Perfect score	Criticisms	Samples 1	2	3	4	5
Body & Texture-85	No Criticisms 84-85					
Normal range 80-85	Coarse or icy					
	Crumbly					
	Fluffy					
	Sandy					
	Soggy					
	Weak					
Melting quality 15	No Criticism 15					
Normal range 13-15	Curdy					
	Does not melt					

Date :
Time : Signature:

Appendix IV

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				
		1	2	3	4	5
Flavour 45	No Criticism 40-45					
Normal range 31-40	Cooked					
	Lacks fine flavour					
	Too high flavour					
	Lacks flavouring					
	Lacks freshness					
	Lacks sweetness					
	Too sweet					
	Metallic					
	Old Ingredient					
	Oxidized					
	Rancid					
	Salty					
	Storage					
	Syrup flavour					
Body & texture 30	No Criticism 29.5-30					
Normal range 25-30	Coarse or icy					
	Crumbly					
	Fluffy					
	Sandy					
	Soggy					
	Weak					
Melting quality 5	No Criticism 5					
Normal range 4-5	Curdy					
	Does not melt					
Colour & package 5	No Criticism 5					
Normal range 3-5	Colour uneven					
	Colour unnatural					
Bacteria 15	Allowed perfect in contest					
Total 100	Total score of each sample					

Date :
Time :

Signature :

Appendix V

Properties of the packaging materials

Property	Type of film				
	LDPE	HMHDPE	BOPP	MET/PEST/PE	LD/LLD
Thickness (mm)	0.0718	0.047	0.0375	0.0625	0.08125
Tensile strength(kg/sqcm) MD	200	400	2000	500	180
CD	-	-	1200	450	115
Elongation at break(%) MD	500	550	50	60	300
CD	-	-	140	75	740
Heat seal strength(kg/sqcm)	-	-	-	150	120
Water vapour transmission rate (g/sqm/24hrs at 90% RH and 38°C)	5.0	1.2	7	3.0	3.2
Oxygen transmission rate (cc/sqm/24hrs/1 atmos	6500	2900	2000	21	2500
Overall migration residue test	----------within the limits----------				

MD- Machine direction
CD- Cross direction / Transverse direction

Appendix - VI

Composition of vitamin and salt mixture

Vitamin A	5,00,000 iu
Vitamin D 3	1,02,500 iu
Vitamin B 2	0.13 g
Vitamin E	87.5 units
Vitamin K	0.1 g
Calcium pantothenate	0.25 g
Vitamin B 1	0.75 mg
Choline chloride	6% W/W
Calcium	85 g
Manganese	2.75 g
Iodine	0.1 g
Zinc	1.5 g
Iron	0.75 g
Copper	0.2 g
Cobalt	0.045 g

Appendix VII

Composition of rat feeds

1. Reference diet (R)

Ground nut oil	-	10 g
Sugar	-	14 g
Vit. and salt mix.	-	4 g
Casein	-	12.1 g
Corn starch	-	59.9 g
Energy value	-	4.71 K cal/g

2. Ice cream mix powder diet (M)

Ice cream mix powder	-	33.36 g
Vit. and salt mix.	-	4 g
Casein	-	7.48 g
Corn starch	-	52.16 g
Energy value	-	4.67 K cal/g

3. Kera ice cream mix powder diet (K)

Kera ice cream mix powder	-	36.36 g
Vit. and salt mix.	-	4 g
Coconut protein isolate	-	6.23 g
Corn starch	-	53.41 g
Energy value	-	4.71 K cal/g

4. Farm diet (C)

Bengal gram	-	26 g.
Wheat	-	20 g.
Gingly oil cake	-	25 g.
Black gram husk	-	20 g.
Fish	-	5 g.
Vit. and salt mix.	-	4 g.

Note:- Fat and sugar in Kera ice cream mix powder and ice cream mix powder were 27.5 and 41 per cent respectively

Protein in casein	- 82.880 per cent
Protein in coconut protein isolate	- 85.560 per cent
Protein in ice cream mix powder	- 10.461 per cent
Protein in Kera ice cream mix powder	- 12.857 per cent

ABSTRACT

An experiment was conducted to assess the suitability of incorporating coconut fat in the form of coconut cream in preparing ice cream and ice cream mix powder replacing milk fat at 25, 50, 75 and 100 per cent levels (treatments) so as to reduce the cost of preparation of ice cream. The product developed was named as Kera ice cream and the qualities were compared with normal ice cream (control).

Kera ice cream was prepared with pineapple flavour and a combination of sodium alginate and glyceryl monosterate as stabilizer since it was found to be the most suitable. It was found that replacement of milk fat with coconut fat at any level does not influence the acidity, pH and specific gravity of Kera ice cream mix. The relative viscosity of Kera ice cream was increased as fat substitution level increased. Higher surface tension was observed for the control, and among treatments it showed a gradual increase as replacement level increased. It was observed that the overrun percentage increased as replacement with coconut fat increased. Contrary to this a decreasing trend in meltdown time was observed as percentage replacement with coconut fat increased. Whipping ability was lowest for the control during the first 5 min of freezing but it significantly increased during the second five min of freezing. Structural details of the ice cream revealed that as replacement

level increased the air cell diameter and cell wall thickness increased. Organoleptic quality of Kera ice cream were comparable to normal ice cream. The savings in cost of production for Kera ice cream with 100 per cent replacement was calculated as 40.57 per cent compared to control.

The properties of the reconstituted ice cream revealed more or less similar trend in characters like acidity, pH, specific gravity, overrun, meltdown time and organoleptic properties as that of the freshly prepared ice cream. The ultra structure of the Kera ice cream mix powder particle were studied and it revealed that as replacement level increased the particle size also increased. Clumping of the particles and irregular surface were more evident at 75 and 100 per cent level whereas particles of the control and 25 per cent replacement had smooth surface. Solubility index of the powder increased as percentage replacement increased. Significant difference could be noted with regard to bulk density and percent volume occupied by the powder particle.

Storage studies were conducted with different packaging material and metallised polyester polyethylene was found to be the best. The moisture and titratable acidity of Kera ice cream mix powder with and without antioxidant were significantly higher at any replacement level at 180 days of storage. The thiobarbituric acid value showed a significant difference for the powder without antioxidant at 120 days of storage and with

antioxidant the difference could be noted at 180 days of storage. Peroxide value was recorded as zero at different periods of storage upto 180 days of storage. At 180 days of storage, powder without BHA at any replacemnet level showed significant difference whereas in antioxidant added powder difference could be noted at 75 and 100 per cent replacement levels.

Nutritional qualities of Kera ice cream was evaluated by rat feeding trials and was found that protein efficiency value and feed efficieny were comparable to ice cream diet. The cholesterol and triglyceride level in animals fed with Kera ice cream and ice cream were also not different.

Pathological examination of carcas**es** and tissues of animals under treatment and control groups did not reveal significant changes indicating that incorporation of coconut fat cannot cause any untoward effect in organs and tissues of animals. It can be concluded that coconut fat can be incorporated in the prepartation of ice cream and mix powder with out any noticeable changes in the quality. Addition of antioxidant prolongs the keeping quality of the powder by two months. There is no health hazard in consuming the Kera ice cream as revealed by the pathological examination of tissues from the experimental animals fed with Kera ice cream.