

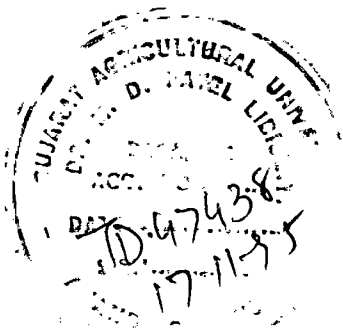
**EVALUATION OF GINGER (Zingiber officinale, Roscoe)
AS A FLAVOURING AGENT IN ICE CREAM**

**A THESIS
SUBMITTED TO THE
GUJARAT AGRICULTURAL UNIVESITY
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FOR THE AWARD OF THE DEGREE
OF
Master of Science (Dairying) in
DAIRY TECHNOLOGY**

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ANAND CAMPUS, ANAND**

1995



**DEDICATED TO
MY LATE FATHER**

ABSTRACT

EVALUATION OF GINGER (Zingiber officinale, Roscoe) AS A
FLAVOURING AGENT IN ICE CREAM

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ABSTRACT

The present investigation was planned and conducted to evaluate ginger, a herbaceous perennial, in selected forms i.e. juice, dried powder, shreds and shreds treated in sugar syrup as a flavouring agent in ice cream. The experiment was divided into two parts.

In the first part, home made ice cream was prepared in an "ice and salt" type hand freezer using ginger at selected levels i.e. juice at 3 (J1), 4 (J2) and 5 (J3) per cent levels, dried ginger powder at 0.5 (P1), 1 (P2) and 1.5 (P3) per cent levels, shreds at 4 (S1), 6 (S2) and 8 (S3) per cent levels and treated shreds at 4 (T1), 6 (T2) and 8 (T3) per cent levels. These levels were selected on the basis of preliminary trials. All the experimental samples were compared with control (C) which had vanilla as flavouring agent. The optimum level of each form of ginger (i.e. J,P,S and T) employed was selected on the basis of their sensoric quality. In the second part of this study, the preference of the different forms of ginger at selected levels adjudged from the first part was determined for home made as well as factory made

(i.e. prepared in a direct expansion batch type "Guisti" freezer) ice cream.

A basic ice cream mix having composition of 12 per cent fat, 11 per cent MSNF, 15 per cent sucrose (7.5 per cent in case of ice cream containing treated shreds), 0.25 per cent sodium alginate and 0.15 per cent glycerol monostearate was prepared. In case of ice cream containing treated shreds, 7.5 per cent (by weight of ice cream mix) of sucrose was used to prepare a boiling sugar syrup (50:50 water:sugar) and the ginger shreds were cooked in this syrup for 30 min. All the mixes were heated to 75°C, homogenized (100 kg/ sq.cm) and pasteurized (70 C for 30 min), cooled to 5 C and then aged at $5 \pm 2^\circ\text{C}$ for 24 h. Ginger juice and powder were added in the mix just prior to freezing while the shreds were added after partial freezing of the mix. Sensoric quality of the ice cream prepared was determined after 1 h of hardening. Factory ice creams having desired consistency and overrun were directly drawn into 1 lit. wax coated cartons and hardened at $-15 \pm 2^\circ\text{C}$ for 24 h. Samples of ice cream were later subjected to heat shock treatment.

The ice cream mixes were analyzed for viscosity and whipping ability. The freshly hardened ice creams were evaluated for composition, acidity, pH, overrun, melting characteristics, bacterial count and sensoric quality. Heat shocked and stored ice cream (30 d at $-10 \pm 2^\circ\text{C}$) were also evaluated organoleptically. Stored ice creams were evaluated for their bacterial count.

Addition of ginger in the form of juice, untreated shreds and treated shreds resulted in progressive decrease in compositional attributes and pH and an increase in acidity which though apparently small was found to be significant, especially at higher levels of ginger addition. Addition of powder resulted in a progressive increase in total solids and acidity and a decrease in fat and pH values. However, it did not significantly influence other components. Addition of ginger in various forms tended to increase the viscosity of ice cream mixes and melting resistance of ice creams significantly, especially at higher levels of addition. Addition of ginger in the form of juice, shreds and treated shreds decreased the whipping ability of mixes. However, incorporation of ginger powder did not influence the whipping ability of mixes significantly. Addition of ginger in any form did not influence the bacterial count of experimental mixes.

In case of ice cream prepared using ginger juice, flavourwise and body texturewise J2 (4 per cent addition) was preferred the most and order of preference was : J2 > J1 > C > J3. J2 also had the highest total score. Experimental samples had significantly lower melting quality score. However, colour scores were not affected significantly.

In case of ice cream prepared using ginger powder, the order of preference flavourwise was : P2 > P1 > C > P3. Experimental samples had significantly lower body -texture, melting quality and colour scores which declined progressively with increase in the rate of addition of ginger powder. However, all the

samples scored more than 60 per cent marks for all the attributes under study. P2 scored the highest total score among experimental samples which was at par with control.

In case of ginger shreds, the order of preference flavourwise was : S1 > S2 > C > S3. Body and texture scores increased significantly upto 6 per cent addition, beyond which the score tended to decrease. The total score of S1 was significantly higher than rest of the samples.

For treated shreds, the order of preference flavourwise was T2 > C > T1 > T3 and body - texturewise : T1 > C > T2 > T3. T2 scored significantly higher total score than the rest.

Thus, from this part of the study J2, P2, S1 and T2 were selected and used in the second part of the study.

In the second part, ice cream (home - made as well as factory made) was prepared using four different forms of ginger at the selected levels. In case of home made ice cream, the order of preference flavourwise was : T>J>S>P>C. Statistically, T and J were indistinguishable flavourwise. Body -texture wise, the order of preference was J>S>C>T>P; these scores were distinguishable statistically. Average melting quality score was in the order C>S>J>T>P. Only addition of ginger in powder form adversely affected the colour score. With respect to total score, the order of preference was J>S>T>C>P, J and S being at par with each other.

In case of factory made ice cream, addition of ginger in any

form was found to increase significantly the time required to reach 90 per cent overrun, except P. Sample T had the highest melting resistance which was followed by S, J, P and C. Incorporation of ginger in ice cream mix in different forms was found to increase the melting resistance of ice cream significantly. No significant influence of ginger on bacterial count was observed. After 30 d of storage there was a marginal increase in bacterial count of all the samples.

Flavourwise, J was preferred the most followed by T (J and T being statistically alike), S, C and P. A similar trend was noted after heat shock as well as storage of ice cream for 30 d at $-10 \pm 2^{\circ}\text{C}$. Heat shock as well as storage did not have significant influence on the flavour score of any of the product. In case of freshly hardened ice creams, body and texture preference was in the order: J>C>S>T>P, which changed to: J>S>T>C=P after heat shock treatment. The heat shock treatment adversely affected the body and texture of control, whereas ice cream containing ginger in any form could withstand the heat shock treatment and presence of ginger prevented significant change (decrease) in body and texture score. Total score of freshly hardened ice cream was in the order: J>C>T>S>P, for heat shocked products it was J>S>T>C>P and for stored products it was J>T>C>S>P. Thus, the superiority of J was statistically established on the basis of total score. Further C, S and T were equally preferred being statistically alike in all the treatments studied.

It can be concluded that ice cream containing ginger juice at

4 per cent level is preferred the most, followed by shreds at 4 per cent in case of home made ice cream. Factory made ice cream revealed that ice cream containing ginger juice at 4 per cent level is preferred the most followed by product product made using treated shreds at 6 per cent levels and untreated shreds used at 4 per cent level. Thus, the improvement in the flavour of ice cream containing ginger is established from this study. Further, ginger, which is reported to possess many medicinal properties is found to retard the adverse effect of heat shock which is generally experienced during storage and sale of ice cream.


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CERTIFICATE

This is to certify that the thesis entitled "EVALUATION OF GINGER (Zingiber officinale, Roscoe) AS A FLAVOURING AGENT IN ICE CREAM" submitted by Ms. SUNEETA V. PINTO in partial fulfillment of the requirements for the award of the degree of Master of Science (Dairying) in Dairy Technology of the Gujarat Agricultural University is a record of bonafide research work carried out by her under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : ANAND.

Date :- 01/07/1995


(M.J.SOLANKY)
Major Advisor

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(Suneeta V. Pinto)

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LIST OF ABBREVIATIONS USED

°C	degree Centigrade
CD (0.05)	Critical difference at 5 per cent level of significance
cm	centi meter (s)
CV%	Coefficient of variation (per cent)
d	day (s)
°F	degree Farenheit
g	gram (s)
h	hour (s)
IU	International Unit (s)
kg	kilo gram (s)
LA	Lactic Acid
lb.	pound (s)
lit.	liter (s)
mg	milli gram (s)
min.	minute (s)
ml	milli liter (s)
mm	milli meter (s)
MSNF	Milk Solids Not Fat
NS	Non-significant
ppm	parts per million
rpm	revolutions per minute
s	Second (s)
SEm	Standard Error of Mean
SPC	Standard Plate Count
TS	Total Solids

INTRODUCTION

CHAPTER - 1

----- INTRODUCTION -----

1.1 Ice cream is a delicious and wholesome nutritious frozen dairy food made by freezing a pasteurized mix with agitation to incorporate air and insure uniformity of consistency. The mix is composed of a combination of milk products, sugar, water with other optional ingredients, with or without egg or egg products, with harmless flavouring and with or without added stabilizer or emulsifier and all of wholesome edible material (Arbuckle, 1977). Ice cream is both a food and a refreshment. The popularity of ice cream is attributed to its refreshingly cool and delightfully sweet characteristics. It is immensely popular with people of all ages.

1.2 CONSUMPTION PATTERN

1.2.1 Milk utilization pattern in India during 1992-93 indicates that out of the milk production of about 58.8 million MT, only 0.3 per cent of the milk was utilized for ice cream making (Baxi, 1994). However, growth rate of ice cream industry in the last few years is believed to be around 25 to 30 per cent annually (Moorthy and Balachandran, 1993). The quantity of ice cream produced in the year 1992 -1993 was 22000 MT (Mahadevan, 1994). The per capita yearly availability of ice cream in India is abysmal (less than 0.6 lit.) compared with the leading ice cream consuming countries as indicated by their annual per capita availability i.e. 22 lit. for United

States of America, 18 lit. for Australia, 19 lit for New Zealand and 13.5 lit. for Sweden (Moorthy and Balachandran, 1993). Moreover, reputed multi-national ice cream companies are now also trying to penetrate the Indian market. Recently, a working group in the Ministry of Food Processing Industry in India has recommended that entry of cooperative sector in the ice cream field will be a big boon in its production and sale. As a result, the day is not far when ice cream will transform itself from an occasional treat of the elite into the daily delight of the masses. It is expected that before the end of the decade, ice cream will constitute a sizable part of the dairy industry (Thompkinson, 1995). Thus, tremendous scope exists in India for enhancing its production.

1.3 SPICES AS FLAVOURING INGREDIENT IN ICE CREAM

1.3.1 Spices, such as ginger (Zingiber officinale), are being used to a limited extent as flavourings in ice cream by small scale ice cream manufacturers as well in households, in and around Gujarat. Ginger flavoured home made ice cream, generally considered as herbal ice cream- a healthful food, is already available in Indian market. When this research work was under progress, a well reputed ice cream manufacturer in Gujarat had introduced a 'ginger flavoured ice cream'. However, there seems a need to standardize certain parameters involved in manufacturing ginger ice cream (home made as well as factory made) which would otherwise remain as secret formulation with the private entrepreneurs.

1.3.2 Ginger is consumed as a spice, as a beverage and as a food proper (Winton & Winton, 1939). The first authentic record of the use of spices and herbs may be traced back to the pyramid age in Egypt, approximately 2600 to 2000 B.C. (Rosengarten, 1973). It is normally used in culinary preparations to increase aroma, taste and appetite (Aman, 1969). The aroma of ginger is due to the volatile oil, while the pungency is due to the non-volatile constituents like gingerol, shogaol and related compounds (Shankaranarayana et al., 1988). Ginger is widely used in medicine in India and far East (Purseglove et al., 1981). The medicinal properties of ginger are fairly well documented in literature (Dastur 1962; Mathur 1965 and Aman, 1969). Around 5 per cent of dried ginger destined for industry in USA, was used in pharmaceuticals and in preparations for combating stomach disorders and throat infections (Purseglove et al., 1981).

1.4 USE OF NATURAL FLAVOURS IN ICE CREAM

1.4.1 There is a tendency among consumers to assume a higher degree of confidence in the wholesomeness and safety of natural foods and natural flavours than those based on chemicals (Heath, 1978). There is a marked prejudice against chemical additives. So the industry must consider to provide more and more quality novelty ice cream with natural flavours. Hence, it is right time to think of some new novelty ice cream with natural flavours, in India too. The demand for healthful foods is progressing even further to functional foods and

neutraceuticals. Neutraceuticals are basically foods that provide medical or health benefits including the documented prevention and treatment of certain diseases. Europe has a very strong herbal and natural food market. Future markets and future products will be influenced by the consumers growing demand for food safety, healthfulness and functional food values (Gherty, 1994).

1.5 APPOSITENESS OF THE PRESENT INVESTIGATION

1.5.1 It is clear from the aforementioned literature that the market for neutraceuticals and herbal foods is expanding day by day. Incorporation of ginger in ice cream, now available in India too, is a novel approach in this direction. However, the success of this novelty would largely depend on its overall quality as judged by the consumers. In this regard, there is a need to standardize certain technological parameters for manufacturing ginger ice cream based on scientific principles.

1.6 OBJECTIVES

1.6.1 The present investigation had been undertaken to achieve the following objectives :

1.6.1.1 To evaluate the suitability of ginger as a flavouring agent in developing 'ginger ice cream'.

1.6.1.2 To study the effect of incorporating ginger at different levels and in different forms, viz. ginger juice, ginger powder, ginger shreds and treated ginger shreds on certain physico-chemical characteristics and on the

composition of home made as well as factory made ice cream.

1.6.1.3 To select the desired level of ginger addition in different forms, in making home made as well as factory made ice cream.

1.6.1.4 To select the best form of ginger to be incorporated in 'ginger ice cream'.

1.6.1.5 To evaluate the effect of incorporating ginger on the microbiological quality of fresh as well as stored ice cream.

REVIEW OF LITERATURE

CHAPTER - 2

----- REVIEW OF LITERATURE -----

2.1 Ice cream is a palatable, nutritious and healthy frozen dairy product which is both a food and a refreshment. It is immensely popular with people of all ages. In India, ice cream is often served in weddings, in opening ceremonies and many other special occasions. The production of ice cream in India is exclusively confined to a small scale sector consisting of about 50 units with capacities of 1000 to 15000 lit. per day. The annual production from these units is estimated to be nearly 76 million lit. Within the organized sector comprising of about 10 large groups of ice cream manufacturers, the value of annual production today has exceeded Rs. 225 crore (Thompkinson, 1995). Frozen desserts like ice cream are valued mainly for their pleasing flavour, cooling effects and refreshing tastes. Vanilla, chocolate and some fruit flavours are quite prevalent in our country, but generally those materials which impart a delicate mild, natural flavour are most acceptable to the consumers. Spices such as cinnamon, clove, nutmeg, allspice and ginger are also being used to a limited extent as flavouring in ice creams, sherbets and ices. Ginger ice cream is being manufactured at household level as well as by small entrepreneurs in Gujarat. Recently, a well reputed ice cream manufacturer has also introduced 'ginger flavoured' ice cream. Scientific progress in the field of dairy processing has led to a better understanding of the chemistry of various ingredients used,

and their role in the preparation of quality ice cream. The technological innovations introduced in dairy industry such as mechanical refrigeration systems, continuous ice cream freezers and new packaging materials as well as machines have contributed to the rapid development of ice cream, as of today. The reported literature on the subject of ice cream has been briefly reviewed hereunder. The related aspects studied in the present investigation are also delineated in this section.

2.2 DEFINITION

2.2.1 Ice cream has been defined by several workers in different ways. Few standard definitions are quoted as under :

2.2.2 According to the dictionary meaning, ice cream is a type of serving of sweet mixture which is frozen and eaten cold, usually containing milk products and often eggs. It has also been termed as a frozen food containing cream or butterfat, flavouring, sweetening and usually eggs (Webster Dictionary, 1989). As early as in 1947, Turnbow et. al. defined ice cream as a whipped and frozen food made from such a mixture of dairy products as would give the desired percentages of milk fat and MSNF together with sugar, flavouring, colouring, often egg products and usually a stabilizer. Arbuckle (1977) has defined ice cream as a frozen food made by freezing a pasteurized mix with agitation to incorporate air and insure uniformity of consistency. The mix is composed of a combination of milk products, sugar, dextrose, corn syrup in

dry or liquid form, water or other optional ingredients, with or without egg or egg products, with harmless flavouring, and with or without added stabilizer or emulsifier and all of wholesome edible material. In India, as per the Prevention of Food Adulteration Act (1955), ice cream is defined as the frozen product obtained from cow or buffalo milk or a combination thereof or from cream and/or other milk products with or without addition of cane sugar, dextrose, liquid glucose and dried liquid glucose, eggs, fruits, fruit juices, preserved fruits, nuts, chocolate, edible flavours and permitted food colours. It may contain permitted stabilizers and emulsifiers.

2.3 BRIEF HISTORY

2.3.1 Ice cream was not "invented" but undoubtedly evolved from the chilled wines, and other iced beverages and foods that graced the tables of potentates of antiquity and the water ices that were popular in the early medieval period (Speer, 1978).

2.3.2 Ices were known in very ancient times, as early as 3000 years ago and it was reported that Abraham and Isaac drank frozen or chilled drinks; maybe the "milk and honey" of the Old Testament were used in this way (Hyde and Rothwell, 1973). In the fourth century B. C., Alexander The Great was reported to have been fond of iced drinks, one of which the Macedoine, is still named after him (Speer, 1978). The art of ice cream making was brought by Marco Polo from China to Italy in the

14th century and soon spread to France and rest of Europe. The first settlers took it across the Atlantic to North America, where its industrial manufacture developed in the later half of the 19th century (Blomdahl, 1982). In 1846, an American woman, Nancy Johnson invented the first hand cranked freezer. The father of the wholesale ice cream business in the United States was Jacob Fussell, a milk dealer of Baltimore, who began to manufacture ice cream in the city in 1851 (Speer, 1978). In 1913 the direct expansion freezer was introduced and the continuous freezer was patented. Further developments occurred in 1922 and 1928 when the Vogt continuous freezer was developed by Henry Vogt of Louisville, Kentucky. In 1929, Cherry Burrell Company produced continuous ice cream freezer commercially and the Creamery Package continuous freezer was introduced in 1935 (Hyde and Rothwell, 1973).

2.3.3 Thus, it is through the relentless efforts of technologists, laymen and scientists that ice cream has received new forms from time to time.

2.4 LEGAL STANDARDS

2.4.1 Ice cream is a frozen dessert food, the formulation and the manufacturing conditions under which it is made are controlled by legislation in most countries.

2.4.2 Prevention of Food Adulteration Act (1955) specifies that the amount of permitted stabilizers and emulsifiers in ice cream should not exceed 0.5 per cent by weight. The ice

cream mixture shall be suitably heated before freezing. The product shall contain not less than 10 per cent milk fat, 3.5 per cent protein and 36 per cent total solids, except that where any of the aforesaid preparations contain fruits, nuts or both, the fat content shall not be less than 8 per cent by weight. Starch may be added to the maximum extent of 5 per cent under a declaration on the label. In case of ice cream, where the chocolate or like covering portion forms a separate layer, only the ice cream portion shall conform to the standard of ice cream. The Bureau of Indian Standards (ISI, 1970) has prescribed specifications for different types of ice cream as tabulated below:

Table 2. 1 Bureau of Indian Standards (ISI, 1970) specifications for plain and fruit, nut and chocolate ice cream.

Characteristic	Type of ice cream	
	Plain	Fruit, nut & chocolate
Weight in grams per lit. , minimum	525	540
Total solids, by weight., minimum	36.0	36.0
Milk fat, % , minimum	10.0	8.0
Acidity, % (as lactic acid), maximum	0.25	-
Sucrose, % by weight, maximum	15.0	15.0
Total colony count, per g (SPC), maximum	2,50,000	2,50,000
Coliform count, per g, maximum	100	100
Phosphatase test of mix	negative	negative

2.4.3 According to the Federal Standards in the United States of America, ice cream shall contain not less than 10 per cent milk fat and 20 per cent total milk solids, except in the case of bulky flavours, the weight of fat and total milk solids shall be 8 and 16 per cent respectively. It shall weigh not less than 4.5 lb. per gallon, contain not more than 0.5 per cent stabilizer and contain not less than 1.6 lb. of food solids per gallon (Arbuckle, 1977).

2.4.4 Thus, these standards incorporate minimum level for fat and milk solids. They put restrictions on the level of emulsifiers, stabilizers, and other additives to be used in ice cream. Hence, there is a scope to consider certain natural additives which may have multifarious properties viz. that of stabilizing, emulsifying, flavouring, colouring, etc.

2.5 ICE CREAM PRODUCTION WORLD OVER

2.5.1 There is a growing demand for ice cream all over the world; the growth rate of ice cream industry is increasing at an alarming pace.

2.5.2 The growth and development of ice cream industry has been spectacular in the United States of America. It is the major producer and consumer of ice cream and related products with their production of all forms of ice cream surpassing one billion gallon mark. Some other countries ranking in order of annual production of ice cream are Japan (750 million lit.), India (513 million lit.), Canada (436 million lit.), Australia

(331 million lit.) and United Kingdom (218 million lit.). (Moorthy and Balachandran, 1993).

2.5.3 According to the figures of 1992-1993, the milk utilization pattern in India showed that only 0.3 per cent of the total milk produced was utilized for ice cream making (Mahadevan, 1994). In India, the growth rate of ice cream industry is estimated at 25 to 35 per cent per year. There were atleast 10 major ice cream manufacturers in India till 1992. There were also more than 50 sizable units, each making 1000 to 5000 lit. of ice cream per day. In all, 1267 ice cream units were registered with State Directorates of Industries. The annual production of ice cream in the organized sector is valued at more than Rs. 225 crores and in small and tiny sectors its value exceeds Rs. 200 crores (Bhushan, 1992).

2.5.4 The market for ice cream in India is still far from saturated and there is still more room in this lucrative business. Considering, the annual production of ice cream in India as 513 million lit. in 1992, the per capita availability is abysmal (less than 0.6 lit.) compared with the annual per capita availability of some leading ice cream consuming countries such as United States of America (22.0 lit.), Australia (18.0 lit.), New Zealand (19.0 lit.) and Sweden (13.5 lit.) (Moorthy and Balachandran, 1993). This clearly indicates the tremendous scope that exists for enhancing the production and supply of ice cream in India.

2.5.5 FUTURE PROSPECTS

2.5.5.1 Ice cream manufacturers face competition not only from each other, but also from the manufacturers of large number of other foods, desserts and confectioneries. Moreover, as a result of liberalized industrial policy of the Indian Government, international firms are also entering or are about to penetrate the Indian ice cream industry.

2.5.5.2 One of the best way of promoting sales of ice cream is by introducing new varieties of ice cream which will entice the consumer to buy it. As a sequel to this, there will be innovative products catering to the palate of different sections and strata of the society. The consumers are becoming more discriminatory. Health conscious consumers are always on the lookout for ways to improve nutritional traits without sacrificing psychological satisfaction (Specter and Setser, 1994). So the industry must strive to provide quality novelty. The ultimate goal in developing and marketing novelties is to sustain and keep consumers aware and interested in their products. It is also right time to think of some novelty ice cream with natural flavours or flavouring ice cream with a compatible blend of flavourings.

2.5.6 On one side, the poor per capita availability of ice cream in India seemingly hints at the good prospect for the growth and development of ice cream industry. On the other hand, many people tend to refrain from consuming ice cream fearing that it may cause cold and cough problems. Hence,

scope exists for developing a variety of ice cream containing natural ingredients possessing medicinal properties alongwith flavour and other desirable properties.

2.6 TECHNOLOGY OF ICE CREAM MANUFACTURE

2.6.1 Detailed formulations and precise methods of manufacture differ amongst countries and also amongst manufacturers and the following process outline is open to considerable interpretation depending on the plant facilities available.

2.6.2 Home made ice cream freezer consists of a small metallic cylindrical vessel housed in a wooden bucket; the intervening space being filled with ice and salt (salt being 20 to 30 per cent that of ice). The equipment is provided with a scraping-cum-beating device which is turned by a hand cranked gear wheel (Ohri, 1965 and Hyde and Rothwell, 1973). Home made ice cream mix may or may not be homogenized. The approximate composition of home made ice cream being : milk fat, 10 to 14 per cent, MSNF, 6 to 6.5 per cent, sugar, 13 to 16 per cent, stabilizer and emulsifier, 0 to 0.5 per cent, total solids, 32 to 38 per cent (Arbuckle, 1977).

2.6.3 During ice cream manufacture, various dairy as well as non dairy ingredients are chosen based on availability, cost or desired quality to supply the requisite amounts of milk fat, MSNF, sugar, stabilizer, emulsifier, flavourings, colourings with or without water. These ingredients are blended, pasteurized, homogenized, cooled and aged to form ice cream mix (Arbuckle, 1986 and Berger, 1990). After blending

the ingredients, the mix is passed through a coarse screen into the homogenizer at a pressure of 136 - 170 kg/ sq. cm with single stage, or at 170 - 204 kg/ sq. cm and 34 kg/ sq. cm with two stage homogenizer for an average mix at 69 to 71 C. This stabilizes the fat in water emulsion yielding fat globules of about 0.3 to 3.0 micro meter with an average of 0.45 - 1.0 micro meter (Berger and White, 1976). At the same time, homogenization also helps obtaining a smoother texture and aids in attaining better whipping characteristics. The homogenized bulk is maintained at this temperature for atleast 30 min. in order to effect pasteurization by batch method. Other recommended pasteurization time-temperature combinations are 79.4 °C for not less than 25 s by HTST method, 90 °C for 1 to 3 s by vacreation and 100 to 130 °C for an instant to 40 s by UHT method (Arbuckle, 1977). The mix is then cooled to around 5 °C or lower and aged for 4 to 10 h. (Iversen and Pedersen, 1982). The aged mix is then pumped into a freezer the freezing time and temperature being determined by the type of equipment used. Filtered air is incorporated under pressure towards the end of freezing and the whipping process takes place with scraped surface action on surfaces refrigerated at -20 to -33 °C. In the continuous freezers, the usual drawing temperature is 20 to 22 °F (52 to 59 per cent of water initially present in the mix is frozen), as compared with drawing temperatures of 24 to 26 °F (30 to 41 per cent of water is frozen) in case of batch freezers. In advanced countries, the frozen ice cream is passed through a pressure relief

valve and it is then either formed into blocks or filled into retail containers before passing it through an air blast tunnel for hardening which may take 40 to 60 min. at air temperatures as low as -46°C . Hardening rooms (forced air type) are commonly used for hardening of ice cream and are generally maintained at -20 to -25°C . Plate or contact hardeners and nitrogen refrigerated hardened tunnels can also be employed for the purpose. (Heath, 1978 and Berger, 1990).

2.7 DAIRY INGREDIENTS - THEIR ROLE IN ICE CREAM

2.7.1 The ingredients used in ice cream may be grouped as dairy and non dairy ingredients. The dairy ingredients group is most important as they furnish the milk fat and MSNF which have essential roles to play in ice cream. Some dairy products provide fat, others MSNF, others supply both fat as well as MSNF and still others supply bulk to the mix.

2.7.2 MILK FAT

2.7.2.1 Milk fat plays an important role in determining the quality of ice cream by imparting richness, subtle flavour characteristics and contributing to the body and smoothness of ice cream (Kilara, 1991). The milk fat in ice cream normally ranges from 2.5 to 14 per cent (Hamilton, 1990).

2.7.2.2 Many dairy ingredients such as cream, white butter, butter oil, plain condensed whole milk, sweetened condensed whole milk etc. may be used either individually or in combination as a source of milk fat in ice cream. The role of

milk fat as a constituent of ice cream has been reviewed by various workers (Turnbow et al., 1947; Sommer, 1951; Doan and Keeney, 1965; Arbuckle, 1970 and Fedali, 1976).

2.7.2.3 The role played by milk fat has been summarized here under :

2.7.2.3.1 It contributes a characteristic richness and mellowness to the flavour of ice cream (Sommer, 1951; Arbuckle and Creamers, 1954 and Fedali, 1976); this effect is accentuated when the fat particles concentrate towards the surface of the air cell during freezing (Creamers, 1954).

2.7.2.3.2 It also contributes to the smoothness of ice cream.

2.7.2.3.3 It tends to retard the rate of whipping especially when fat sources such as butter, butteroil and frozen cream are employed which results in less satisfactory dispersion of fat (Keeney, 1958 and Arbuckle, 1977).

2.7.2.3.4 It contributes to the meltdown property of ice cream (Flack, 1988).

2.7.2.3.5. The state of fat (degree of agglomeration) has a major effect on the mouthfeel, melting behavior and flavour release. The higher the agglomerated fat level, the slower the flavour release and lower is the flavour impact (Lipsch, 1986). Smaller fat globules and less clumping are less detrimental to the whipping ability. Hardened vegetable fats, used either to replace milk fat fully or partially, impart grittiness to the product.

2.7.2.4 Considering recent demand of low fat and low calorie ice creams, various ingredients like hydrocolloids (Anon, 1989 and Martin, 1987), dextran (Anon, 1979, 1990), oat bran (Inglett, 1990) and sucrose polyesters (Anon, 1990; Perotti, 1975 and McCormick, 1988) are being employed for filling up the void in solids owing to the missing contribution of fat and/ or sugar to the total solids of the mix.

2.7.2.5 Milk fat is an ingredient of major importance in ice cream and the use of correct percentage and dispersed in proper state is vitally essential not only to balance the mix properly, but also to satisfy the legal standards and to impart richness and body to the ice cream.

2.7.3 MILK SOLIDS-NOT-FAT (MSNF)

2.7.3.1 The MSNF contribute to flavour (lactose and minerals), body and texture (proteins); storage properties and are essential to the formation and maintenance of small air cells (Kilara, 1991). The MSNF per cent in ice cream normally ranges from 7 to 12 per cent (Hamilton, 1990).

2.7.3.2 Many dairy ingredients such as liquid skim milk, concentrated whole or skim milk, sweetened condensed whole or skim milk, whole or skim milk powders, caseinates, whey protein concentrates, RO concentrate / UF retentate etc. are used alone or in combination, as the source of MSNF. The role of MSNF as a constituent of ice cream has been reviewed by many workers (Price and Whittier, 1931; Dahle, 1956; Hedrick

et al., 1964; Braatz, 1969; Hall and Hedrick, 1971; Steinsholt, 1971 and Goff, 1992). The MSNF content of ice cream mix varies inversely with the fat content to ensure proper body, texture and storage properties. MSNF helps in producing a desirable body and prevents the ice cream from having a buttery taste when used in proper amounts. An excess amount of MSNF should be avoided as it tends to mask the fat taste and causes a salty taste (Turnbow et al., 1947 and Dahle, 1956). It can also lead to a soggy body or sandy textured defects. Qualitative rather than quantitative variations of MSNF have an important influence on whipping ability. MSNF increases the viscosity and resistance to melting but it lowers the freezing point of ice cream (Doan, 1958; Doan and Keeney, 1965 and Arbuckle, 1977).

2.7.3.3 Prevention of lactose crystallization is of significant importance in preventing incidence of sandiness in ice cream (Nickerson, 1962). Numerous studies have been made on factors affecting lactose crystallization (Mojonnier and Tracy, 1922; Lucas and Spitzer, 1925; Leeder and Ostroff, 1966; Arbuckle, 1972; Guy, 1980; Hassan et al., 1984, Neshawy et al., 1988 and Lindamood et al., 1989).

2.7.3.4 It has been shown that either low, medium or high heat MSNF source (liquid condensed or dried product) can be satisfactorily used in the manufacture of ice cream. Skim milk powder is generally considered to be a popular and practically viable MSNF source (Williams, 1929; Olenev and Bdulenko, 1968; Hall and Hedrick, 1971 and Steinsholt and Bredevein, 1977).

Milk UF retentates have been recently employed to replace about 25 per cent of MSNF for cost reasons (Jensen et al., 1989; and Tong et al., 1989). Hydrolyzed lactose syrups have also been used to replace MSNF (Hassan et al., 1984 and Martinez and Speckman, 1988).

2.7.3.5 Use of superheated condensed milk in preparing ice cream has been found to give several advantages over those of ordinary condensed milk; these being better whipping, greater melting resistance, superior flavour, etc. (Tracy and Hann, 1938). Recently, Shakeel-ur-Rehman (1991) on the basis of his research work, recommended full or partial replacement of plain condensed milk with 'khoa' or open pan partially desiccated milk to prepare ice cream having improved sensoric quality but suitable colours are required to overcome the off-white anomaly produced.

2.7.3.6 Replacement of MSNF by good quality sweet cream buttermilk solids upto 20 to 25 per cent has been found to give a better whipped and richer, creamier ice cream with cost benefits (Thomas and Combs, 1944; Rothwell, 1974; Mehran et al. 1976 and Rao and Atmaram, 1986). Attempts have also been made to replace MSNF by various whey products viz. liquid cheese whey upto 20 per cent MSNF (Gopalanaidu et al., 1984 and Naidu et al., 1986; Reddy et al., 1987); concentrated and dried whey upto 25 per cent of MSNF (Khalafalla et al., 1975; Mathur and Shahani, 1979 and Rothwell, 1984); whey protein concentrate upto 50 per cent of MSNF (Huse et al., 1984);

hydrolyzed whey upto 11 per cent of MSNF (Patel and Mathur, 1982) and succinylated whey proteins upto 10 per cent MSNF (Thompson et al., 1983). Guy (1980) showed that ice creams containing 2.75 per cent whey solids and 9.5 per cent skim milk powder were quite identical to control ice creams containing 11 per cent skim milk powder (no whey solids), although the ice cream containing the whey solids were slightly softer.

2.7.3.7 Partial replacement (upto 25 per cent) of dried skim milk with whey powder in ice cream mix did not affect the mix properties significantly (Steinsholt, 1971). Crowhurst (1972) suggested use of dried whey as a partial replacement of dried skim milk in mixes to be frozen in vertical freezers. Dried whey with an acidity not exceeding 0.19 per cent lactic acid is preferred as partial substitute for normal MSNF source (Khalafalla et al., 1975). Mathur and Srinivasan (1979) observed that addition of whey powder to ice cream mix at 1 per cent level improved the whipping ability and resistance to meltdown of the resultant product.

2.8 NON DAIRY INGREDIENTS - THEIR ROLE IN ICE CREAM

2.8.1 A wide range of choice of non dairy ingredients for ice cream are available. The non dairy products group include stabilizers and emulsifiers, egg products, flavours, colours, sweetener solids, special products and water. The functional properties imparted by these ingredients are quite varied and their role in ice cream is delineated here under:

2.8.2 STABILIZERS

2.8.2.1 The main function of stabilizer in ice cream is to bind water and thereby prevent the formation of large ice crystals ultimately improving the smoothness of texture, provide uniformity to the product and improve the resistance to melting (Goff and Caldwell, 1991). They also help in preventing undue growth of crystals of ice and lactose during storage of ice cream, especially when fluctuation in storage temperature is encountered (Hamilton, 1990). The type of stabilizer employed is important as it significantly influences the rate of cooling of the mix during freezing (Loewenstein and Haddad, 1972a). The role of stabilizers in ice cream industry has been reviewed by Klose and Glickman (1968); Ramzan (1972); Besset (1988) and Goff and Caldwell (1991).

2.8.2.2 Gelatin, an animal protein, has been the traditional stabilizer in the ice cream industry. Now-a-days, gelatin has largely been replaced by polysaccharide gums. The more common of these include locust bean gum and guar gum, sodium carboxymethyl cellulose (CMC), the sea weed stabilizer- sodium alginate and the bacterial gum- xanthan (Goff and Caldwell, 1991). The rate of addition may range from 0 to 0.5 per cent, but the amount generally used is from 0.2 to 0.3 per cent (Arbuckle, 1977).

2.8.2.3 The control of iciness by stabilizers has been attributed to the retardation in the growth of ice crystals

during ice cream manufacture as well as during its storage. Despite considerable scientific research in this area, the mechanism of its action has been obscure (Cottrell et al., 1979; Muhr and Blandshard, 1983; Shirai et al., 1985; Muhr et al., 1986 and Budiaman and Fennema, 1987 a,b). It has been suggested by many workers that the mobility of water in the serum phase as a function of time (which is decreased by binding of free moisture by the stabilizer) is more important in predicting stabilizer action than thermodynamic consideration regarding ice nucleation or growth (Franks, 1982, 1985; Keeney, 1982; Karel, 1985 and Levine and Slade, 1988, 1990). However, mix viscosity has not been correlated well with stabilizer action (Harper and Shoemaker, 1983 and Budiaman and Fennema, 1987a). A more practicable mode of action of stabilizer has been put forth by Buyong and Fennema (1988) recently.

2.8.2.4 Many primary stabilizers, including locust bean gum, guar gum and CMC interact with various milk proteins to cause precipitation of the reacted complex, evinced by wheying off. This reaction mechanism is not well understood. However, such phenomena can be prevented by incorporating a secondary stabilizer such as carrageenan, which also reacts with various casein components but stabilizes the proteins from being precipitated by the other polysaccharides (Goff and Caldwell, 1991).

2.8.2.5 There is a growing trend toward use of complete

customized stabilizer-emulsifier combinations for particular frozen product type (Tobias and Muck, 1981).

2.8.3 EMULSIFIERS

2.8.3.1 Emulsifiers - surface active agents, have been used in ice cream mix manufacture for many years. Their major contribution in ice cream are : improvement in the whipping quality of the mix, production of a drier ice cream necessary for moulding, fancy extrusion and sandwich manufacture, imparting smoother body and texture in finished product, attaining superior drawing qualities at the freezer, producing a product with good standup properties and melt resistance, and more accurate control of the product during freezing and packaging operations (Arbuckle, 1986). The probable mode of action of emulsifier based on partial and controlled destabilisation of fat during whipping has been put forward by Goff (1988).

2.8.3.2 Some workers are of the opinion that emulsifiers are not needed in ice cream mix to stabilize fat emulsion (Govin and Leeder, 1971 and Goff, 1988a,b) because ice cream mix contains many surface active molecules. Most of the milk proteins have components which are not truly soluble in water (i.e. surface active part) and can adsorb on to the fat globule and stabilize the globule in solution (Kinsella, 1984). There is much more protein available in ice cream to do the job, in addition to the natural fat globule membrane.

2.8.3.3 Emulsifiers are available in liquid, semisolid or powder forms and may include glycerides, lecithin, fatty acid esters, etc. Mainly two types of emulsifiers are used in the manufacture of ice cream. These are mono and diglycerides derived by chemical reaction of naturally occurring glycerides and polyoxyethylene derivatives of hexahydric alcohol, glycol and glycol esters (Arbuckle, 1977). Occasionally egg yolk solids and purified vegetable proteins from soyabean are also used as emulsifiers (Tharp, 1991).

2.8.3.4 Thus, the function of emulsifying agent in the manufacture of ice cream is mainly in improving the whipping ability of the mix, the production of a smooth texture, giving a dry stiff product at the time of drawing and a more exact control during the various manufacturing processes.

2.8.4 SWEETENERS

2.8.4.1 Many kinds of sweeteners are being used in ice cream and they represent an economical source of solids in ice cream (Anon, 1965). The sweeteners used in frozen desserts perform various functions such as: a) gives sweetness and thus palatability, b) balances the "fattiness" of added fat, c) provides bulk to the body to improve mouthfeel, d) controls ice crystallization i.e. helps to produce a smooth textured product, e) brings about suitable depression in the freezing point of mixture enabling the mix to be whipped and frozen simultaneously and thus afford the customer a delectable, refreshing food, f) enhances flavour, g) improves the shelf

life of the product, and h) increases the energy content (Jana et al., 1994). Rate of addition of sugar varies from 12 per cent to 20 per cent, while 14 to 16 per cent seems more desirable (Arbuckle, 1977). The type or mixture of sweeteners used influences the mechanical energy required to freeze the ice cream (Smith et al., 1984).

2.8.4.2 For many years, sucrose (cane or beet sugar) was the only sweetening agent added to ice cream. However, during the last forty years there has been an increasing tendency to obtain desired sweetness by blending sucrose with other sugars owing to the changing attitudes of consumers regarding sucrose consumption (Redlinger and Setser, 1987). Drusendahl (1963 a,b) and Goff et al. (1990a,b) have discussed the advantages and disadvantages of using corn syrup solids in ice cream.

2.8.4.3 An excess of sweetener may lead to masking of desirable flavour, make the product unpalatable, the product may not freeze sufficiently hard, may result in crumbly texture or chewy body, lead to faster melting rate, may contribute to shrinkage, accentuate large ice crystal formation and make the product less stable to temperature fluctuations (Tressler and Sultan, 1975 and Bray, 1991). Dahlberg and Penczek (1941) studied the relative sweetness of sugars and the effects of one sugar on the other. Various sweeteners used in ice cream include sucrose, invert sugar, dextrose, fructose, maltose, corn syrup, high fructose corn syrup, sorbitol, maltitol, xylitol, lactitol, glycerol,

saccharin, sodium cyclamate, acesulfame-K, aspartame, etc. (Nicol, 1980). In India, PFA (1955) regulation permits only use of sucrose, dextrose and corn syrups either in solid or liquid form.

2.8.5 FLAVOURING MATERIALS

2.8.5.1 Flavour is generally considered to be the most important characteristic of ice cream. Frozen desserts are valued mainly for their pleasing flavour. The performance of a flavouring material or flavouring in a frozen system like ice cream depends not only on the quality of the added flavour but also on the quality of raw materials, composition, consistency and processing; all of these together determine the ultimate quality of the perceived flavour (Lipsch, 1986). Flavouring materials are normally added to the mix at the freezer and thus do not undergo heat treatment, which the bulk of mix has undergone. Hence, it must be a product of highest bacteriological quality (Herschdoerfer, 1970). The intensity of flavour should be just strong enough to be easily recognized and delicately pleasing to taste (Arbuckle, 1977).

2.8.5.2 There is an enormous range of flavourings available for ice cream that include natural products (e.g. cocoa powder, fruit pieces, citrus fruit pastes, nuts etc.), natural extracts and essences (e.g. vanilla extract, lemon essence, etc.), imitation flavourings (e.g. imitation strawberry, raspberry, banana flavours) and synthetic chemicals (e.g. vanillin, ethyl vanillin, etc.) (Ohloff,

1972). Vanilla is no doubt the most popular and widely used flavour in ice cream worldwide (Jain and Verma, 1972; Arbuckle, 1977 and Steinitz, 1978).

2.8.5.3 The ingredients used in the basic mix play an important role in determining the nature and quantity of the flavouring to be added. For instance, a mix having a high butterfat content requires less flavouring than one having a low butterfat content (Heath, 1978). The state of fat (degree of agglomeration) has a major effect on mouthfeel, melting behavior and flavour release. The higher the agglomerated fat level, the slower is the flavour release and lower is the flavour impact (Lipsch, 1986). Similarly, variations in milk solids content and types also affect the level of added flavourings (Heath, 1978). The flavour of ice cream is also influenced by the type of sugar used and the level of sweetness in ice cream. Other major factors affecting flavour release are overrun, method of processing and storage. High overrun (> 80 per cent) often go together with a somewhat foamy dry consistency and a relatively slow melting behaviour and flavour release (Lipsch, 1986).

2.8.5.4 Natural flavours vis-a-vis synthetic flavours

2.8.5.4.1 There is a growing trend towards all natural products. Manufacturers are looking for the removal of word additives from their product label (Steinitz, 1978; Anon, 1979 and Cowle, 1985). Included among natural flavourings are fruit flavours, citrus fruit, tropical fruit flavours, sugar

free fruit flavours, natural flavours from botanicals, spices, cocoa and chocolate, coffee, natural flavourings from vanilla beans and nuts (Werry, 1984). There is a tendency to assume a higher degree of confidence in the wholesomeness and safety of natural flavours than those based on chemicals. There is a marked prejudice against imitation flavours compared to those of natural origin even where it can be demonstrated that chemically they are identical. To the layman the word "chemical" is highly emotive and is equated with "second rate", "poor quality" or "substitute" (Heath, 1978). The common man has become very health conscious and is becoming aware of the ingredients used in each and every item he consumes in his day to day life and the hazards posed by chemicals. Besides, the use of imitation flavours generally requires either a solvent or a carrier, which may be restricted by legislation or may pose problems with regard to texture in the end product (Downey and Eiserle, 1970).

2.8.5.5 However, use of natural flavours present certain problems. Natural flavours are weaker in strength/potency than artificial ones (Anon, 1979) and have to be used at a higher dosage rate to produce the desired effect in the end product. Natural flavours exhibit variations in strength and quality, the variation due to source of material, its ripeness at harvest and its subsequent handling. Furthermore, the supply of natural flavour is uncertain (Heath, 1978).

2.8.5.6 The selection of flavourings for ice cream is of

utmost importance. No matter how smooth and creamy the base product may be, it is the added flavouring which ultimately characterizes and establishes the success or otherwise of the product (Turnbow et al., 1947 and Heath, 1978).

2.8.6 COLOUR

2.8.6.1 Ice cream should have a delicate, attractive colour which is readily associated with the flavour. Only permitted colours should be used. Almost all flavours of ice cream should be adequately coloured. Yellow colour is generally added to vanilla ice cream to give it the shade of natural ice cream produced in summer months. Fruit ice creams need to be coloured because about 15 per cent fruit, the maximum commonly used produces only a slight effect on colour. Chocolate ice cream is one of the exceptions. It is rarely coloured for the required amount of cocoa (2.5 - 3.0%) usually produces sufficient colour; if required caramel is added to give the required shade. Most colours are of chemical origin and are available either in liquid or paste form (Arbuckle, 1977).

2.8.7 OTHER ADDITIVES

2.8.6.1 Use of buffered salts improves the body and texture of ice cream. Sodium citrate and disodium phosphate are effective protein stabilizers particularly when protein instability is due to high acidity, high calcium and magnesium content or salt imbalance (Arbuckle, 1977; Anon., 1991).

2.8.6.2 Use of sodium caseinate has been found to be

advantageous with regard to the whipping properties of the mix and the texture of final product (Bird et al., 1935). Nevertheless, it poses problems such as imparting slight undesirable flavour, decreases the mix viscosity, increases the rate of melting and increases the mix acidity about 0.01 per cent for each per cent of sodium caseinate used (Arbuckle, 1977).

2.8.6.3 An ice cream having 7.5 per cent MSNF, 2.2 per cent demineralized whey powder and 1.5 per cent soya flour in place of 11.2 per cent MSNF was acceptable (Rothwell, 1976). Rajor and Gupta (1982) produced a soft serve ice cream of acceptable quality containing soya and buttermilk solids (in the ratio 1.3:1), 9 per cent fat, 15 per cent sugar and 0.3 per cent sodium alginate as stabilizer.

2.8.6.4 Groundnut protein isolate can be utilized to replace about 40 per cent MSNF and 60 per cent MSNF in case of ice cream (Gabriel et al., 1986) and soft serve frozen dessert (Lawhon et al., 1980) respectively. An ice cream formula comprising of 7.8 per cent groundnut protein isolate and 5 per cent coconut powder has been developed in Thailand (Beuchat et al., 1991). Das et al. (1989) suggested the use of potato pulp to replace upto 25 per cent MSNF in ice cream, without impairing its organoleptic properties. Arrow root powder can also replace upto 40 per cent MSNF in ice cream, to give an acceptable product (Venkateshwarlu et al., 1990).

2.9 GINGER - A NOVEL HERB IN FOOD MANUFACTURE

2.9.1 The antiquity of the use of aromatic herbs and spices is well attested in ancient writings in the Old Testament, in early Greek and Roman documents, in medieval manuscripts and in more modern times, in the famous herbals of William Turner, John Gerard and John Parkinson. Spices have been treasured from the earliest times and their importance in world history has already been more interestingly covered in the literature (Clair, 1961; Parry, 1969; Purseglove et al., 1981). Ginger, is one such herb employed widely for culinary and pharmaceutical purposes (Hardman, 1973). Spices have also been used in the seasonings of foods since time immemorial (Heath, 1973).

2.9.2 BOTANICAL DESCRIPTION

2.9.2.1 Ginger, (Zingiber officinale Roscoe), is a monocotyledon, belonging to the family Zingiberaceae in the order Zingiberales. Zingiberaceae is divided into two subfamilies: Zingiberoideae and Costoideae. The subfamily Zingiberoideae includes the most important spice crop ginger, Zingiber officinale (Parry, 1969). It is a perennial horizontal root, having knots. It is tuberous and has a pungent aromatic taste. The stem is elongated with linear and sessile leaves surrounding the stem. They are dark green, 4-13 inches long and have a smooth surface. Flower spikes emerge out terminating the leafy stem upto three inches long, bracts, corolla - greenish, yellow lip, dark purple, often spotted yellow and three lobbed (Dastur, 1962).

2.9.3 VARIETIES

2.9.3.1 Ginger, mainly grows in tropical Asia and is mainly cultivated in the West Indies, India, Africa, China, Japan and the East Indies. The chief commercial varieties of ginger are Jamaica ginger, India ginger, African ginger, and the Japanese ginger. The Jamaica ginger is usually regarded as the best (Merory, 1978). There are many cultivated varieties of ginger in our country whose chemical composition varies with the variety and agroclimatic conditions (Natarajan et al., 1972). India enjoys from time immemorial, a unique position in the production and export of ginger (Peter, 1994). The major ginger producing states are Kerala, Meghalaya, Orissa and West Bengal. Out of the total production, about 30 per cent is converted into dry ginger while 50 and 20 per cent is consumed as green ginger (vegetable) and seed material, respectively (Thomas and Velappan, 1988).

2.9.3.2 Various commercial grades of dried ginger are given in Table 2.2.

Table 2.2 Commercial grades of dried ginger (Heath, 1978)

Source	Odour/ character	Average volatile oil content (% v/w)
Cochin	Strong Lemony	2.2
Jamaican	Delicately aromatic, spicy	1.0
African (Sierra Leone)	Strongly earthy, harsh	1.6
Nigerian	Strongly aromatic, camphoraceous	2.5
Chinese	Mildly aromatic, Lemony	2.5
Japanese	Weakly aromatic, Lemony	2.0
Australian	Strongly lemony	2.5

2.9.4 GENERAL COMPOSITION OF THE GINGER RHIZOME

2.9.4.1 The ginger rhizome, is a good source of crude protein, total lipids and starch (Jogi *et al.*, 1972). It contains little steam volatile oil, fixed oil (fatty oil), pungent compounds, resin, proteins, cellulose, pentosans, starch and mineral elements (Table 2.3 and Table 2.4). Of these, starch is the most abundant and comprises 40 to 60 per cent of the rhizome on dry weight basis. The crude fiber content of unpeeled ginger may be as high as 10 per cent (on dry weight

basis), but in commercial dried ginger the fiber content is usually in the range of 1.5 to 6 per cent.

2.9.4.1.1 The relative abundance of certain other constituents can vary considerably between samples of ginger in both fresh (green) and dried forms. The composition of fresh rhizome is determined by the environmental conditions of growth and the stage of maturity at harvest (Pawar and Patil, 1988). Further changes in the relative abundance of some constituents can occur post harvest during the preparation and subsequent storage of dried ginger (Purseglove et al., 1981).

2.9.4.2 Ginger is characterized by 2 major flavouring components

2.9.4.2.1 1 to 3 per cent of a yellow viscous essential oil which gives the distinct aroma to the spice, and

2.9.4.2.2 nonvolatile pungency due to highly complex mixture of especially gingerols, shagoal, paradols, etc. (Connell and Sutherland, 1969 and Connell and McLachlan, 1972)

Table 2.3 Chemical composition of fresh ginger (Aman, 1969).

Chemical constituents	Values per 100 g approximately
Carbohydrate	11.2 g
Protein	2.3 g
Fat	1.5 g
Calcium	21.1 mg
Phosphorus	61.0 mg
Iron	2.3 mg
Vitamin A	65 IU
Vitamin C	7.0 mg
Nicotinic acid	0.7 mg
Calories	75

*
Table 2.4 Average composition of dried, unpeeled ginger
(Natarajan et al., 1972)

Component %	Maximum	Minimum	Average
Volatile oil	2.7	1.0	1.8
Acetone extract	9.3	3.9	6.5
Crude fiber	9.8	4.79	7.17
Moisture	16.5	8.5	10.85
Water extract	25.8	14.4	19.6
Cold alcohol extract	9.28	3.55	6.0
Total ash	9.28	5.12	6.64
Water soluble ash	8.84	3.96	5.48
Acid insoluble ash	0.59	-	0.14
Alkalinity of ash	79.0	25.7	48.1
Crude protein N X 6.25	15.0	10.3	12.4
Starch (by hydrolysis)	59.0	40.4	53.0

* Except moisture, all values are expressed on dry weight basis. Percent alkalinity of ash is expressed as ml of 0.1 N HCl/100 g of plant material.

2.9.4.3 Components of oil of ginger

2.9.4.3.1 The volatile oil content of commercial dried gingers has been reported to be 0.5 to 4.4 per cent, but for the major types the range is usually 1 to 3 per cent (Purseglove et al., 1981). Singh et al. (1975) reported that ginger rhizome contained 5.8 to 11.4 g/100 g of total lipid, of which non polar and polar lipids varied from 3.1 to 8.9 g and 2.2 to 5.2 g respectively. A total of more than 60 compounds have been identified. Among them Zingiberene (35.6 per cent), Curcumene (17.7 per cent) and tarnescence (9.8 per cent) are the major constituents (Shankaranarayana et al., 1988). The oil of ginger is a mixture of terpenes, of which there is a relatively small proportion of sesquiterpenes and oxygenated compounds (Heath, 1978). The sesquiterpene zingiberene and cis- and trans- sesquiphellandrol are the other compounds responsible for the distinctive and identifiable profile of ginger (Bednarczyk and Kramer, 1975). The oil distilled from fresh ginger has been investigated by Krishnamurthy et al., (1970), Kami et al., (1972) and Mathew et al., (1973). It has a more pronounced spicy odour than normal dried ginger, this is attributed to the higher percentage of zingiberene and a lower percentage of sesquiterpene alcohols in the oil. The aromatic characters of the principal components of oil of ginger are given in Table 2.5.

Table 2.5 Aromatic attributes of the components of oil of ginger

(Heath, 1978)

Component	Main character	Subsidiary attributes
<u>Monoterpenes</u>		
Alpha-pinene	Pine like	Warm, resinous fresh
Camphene	Camphoraceous	Oily, terpeney
Beta-pinene	Dry, woody	Resinous, pinelike, terpeney
Sabinene	Peppery	Warm, woody, herbaceous
-3- carene	Penetrating	Sweet, irritating
Myrcene	Sweet balsamic	Resinous, lemony fresh
Beta phellandrene	Peppery	Minty, slightly citrus like
Limonene	Fresh	Light orange like
Tricyclene	Celluloid like	Sickly
<u>Sesquiterpenes</u>		
Zingiberene	Warm, woody, spicy	Sweet
<u>Oxygenated compounds</u>		
(represents about 9 per cent of the oil)		
1,8 Cineole	Camphoraceous	Fresh spicy
Borneol	Dry, woody	Peppery
Zingiberol		

2.9.5 PUNGENCY IN GINGER

2.9.5.1 The abundance of the pungent constituents, the gingerols, is in the range of 1 to 2 per cent for freshly prepared commercial dried gingers (Nambudri *et al.*, 1975). Pravatoroff (1967) has reviewed the chemistry of ginger, with special reference to its pungency and the various factors affecting it. The pungency of ginger is due to its nonvolatile constituents like gingerols, shogoal, paradol (Narayanan,

1988), zingerone (Ashurst et al., 1973 and Yamaguchi, 1983); of these, the pungency has been reported to be in decreasing order for gingerol, shogaol and zingerone (Kulka, 1967). The main pungent principle was isolated from a sample of ginger oleoresin and was identified as shogaol. During processing and storage, gingerol is decomposed to less pungent residues e.g. zingerone and aliphatic aldehydes (Connell, 1969). Eschenmoser and Schinz (1950) reported the constitution of zingiberene.

2.10 MEDICINAL PROPERTIES

2.10.1 Ginger has been used as a spice and medicine in India and China since ancient times. In India, ginger is being used from vedic period and is called 'Maha Aushidhi' (meaning - great medicine). Ancient physicians used ginger as a carminative and antifermenting medicine. Galen, a greek physician used ginger as a medicine to rectify the defective tumors of the body and to treat paralysis caused by phlegmatic imbalance of the body. Avicenna used ginger as an aphrodisiac. Pomose used ginger as a means of treating gout, centuries ago (Aman, 1969). The African and the Indians in East Africa used ginger as a remedy for headache by applying its paste on the head (Watt and Breyer, 1962). Ginger is also used externally as a rubefacient and counter irritant (Purseglove et al., 1981). Ginger has been found helpful in preventing cough and colds (Buchman, 1980). Ginger has been traditionally prescribed with anthracene purgative, rhubarb to ease any gripping action of the active principles on the

muscle of the large bowel (Hardman, 1973). The medicinal properties of ginger have been described in detail by Dastur (1962), Mathur (1965), Hussain (1965), Shariff (1968) and Buchman (1980).

2.11 GINGER PRODUCTS

2.11.1 Ginger is available in market in various forms such as fresh vegetable (green) ginger, dry ginger, ginger powder, ginger oil, ginger oleoresin, encapsulated ginger, ginger preserves, etc.

2.11.2 Fresh vegetable ('green') ginger : For preparation of vegetable green ginger, harvesting is done after planting, from the sixth month onwards. Immediately after harvesting, the green rhizomes are separated from the stem and thoroughly washed in water 2 to 3 times to remove the adhering soil, before they are marketed (Aiyadurai, 1966 and Lakshimanachar and Velappan, 1988). Fresh ginger is used for preparing crystallized ginger and ginger preserve (Natarajan et al., 1970)

2.11.3 Dry ginger : Dry ginger is available in two forms viz., unbleached and bleached. For preparation of dry ginger, harvesting is carried out after 8 to 9 months, when the leaves turn yellow in colour and start withering. The rhizomes are lifted from the soil and carefully cleaned of soil, root and stems.

2.11.3.1 For the production of unbleached type, the outer skin

is peeled off using split bamboo knife or by putting the rhizomes in rotating wire mesh drums. Care is taken to remove only the thin outer skin without damaging the essential oil cell, so as to avoid any loss of oil during drying. After peeling, the material is dried in the sun to a moisture level of 10 to 12 per cent. Generally this takes 20 to 25 d under good sunshine. Sometimes the rhizomes are sliced and dried using mechanical driers in order to achieve quicker drying (Shankaranarayana et al., 1988).

2.11.3.2 The bleached ginger is produced by soaking the peeled rhizomes in 2 per cent lime water for about 6 h, followed by sundrying. This process is repeated 4 to 5 times to obtain a white coloured dry ginger. The yield of dry ginger from green ginger is 16 to 25 per cent, depending on the variety (Shankaranarayana et al., 1988). Care must be taken to use the best quality slaked lime in order to get better whiteness (Rodriguez, 1971). Dry ginger is the raw material for the manufacture of products like ginger powder, ginger oil and oleoresin (Natarajan et al., 1970).

2.11.4 Ginger powder : This is made by grinding the dry ginger to a mesh size of 50 to 60 micron. The loss of volatile oil can be minimized by cryogenic/ multistage grinding (Narayanan, 1988).

2.11.5 Ginger oil: Ginger oil is produced by steam distillation of the dried, freshly ground ginger. The dried ginger is coarsely powdered and distillation is carried out

with direct steam which takes 10 to 15 h. The yield varies from 1.5 to 3.0 per cent (Narayanan, 1988).

2.11.6 Ginger oleoresin: Oleoresin is the total extract which contains both the volatile oil and the pungent extractives. It is prepared by extraction of the powdered dry ginger employing suitable solvents like acetone, alcohol or ethylene dichloride. The solvent is then distilled off to obtain the oleoresin (Shankaranarayana et al., 1988). The approximate composition of ginger oleoresin is : volatile oil - 15 to 30 per cent, fixed oil - about 10 per cent, pungent resinous constituents, gingerol and related compounds- 20 to 30 per cent (Cripps, 1972). Commercial dried gingers have been reported to provide oleoresins in yields of 3.5 to 10 per cent and to contain 15 to 30 per cent volatile oil (Winterton and Richardson, 1965; Connell, 1970; Lewis et al., 1972; Sabel and Warren, 1973 and Naves, 1974). The pungent principle content of the oleoresins are reported to be in the range of 17 to 30 per cent for fresh extracts (Ananthakrishnan and Govindrajan, 1974 and Nambudri et al., 1975).

2.11.7 Encapsulated ginger: Due to various limitations of ginger powder such as poor hygienic quality, vulnerability to adulteration and loss of flavour on storage, it is being replaced by the oleoresin in most processed foods. Also spice extractives are highly concentrated and their application in food poses problems. Moreover, ginger powder cannot be readily incorporated into dry mixes like soup powders, gravy mixes and other convenient foods. The above disadvantages can

be overcome by converting the liquid oleoresin into powder by one of the various encapsulation techniques, the most common being spray drying (Shankaranarayana et al., 1988).

2.11.8 Ginger preserves: The major types of preserved ginger are ginger in brine (14 to 18 per cent) solution, with or without preservative (Ingletton, 1966); preserved in sugar syrup (65 to 70 Brix and pH around 3); and crystallized ginger such as ginger candy prepared from the syruped ginger by draining off the syrup, coating it with powdered sugar and drying under controlled conditions. Technological studies on methods of storage of ginger have been reported (Brown, 1969a, b, c; Leverington, 1969; Brown, 1972; Brown and Lloyd, 1972; Gupta, 1974; Seeley, 1975). The production of preserved ginger "Murabba" is a traditional product of India (Aman, 1969).

2.12 PHYSICO-CHEMICAL CHANGES IN GINGER DURING PROCESSING

2.12.1 Loss in weight, moisture, volatile oil and volatile reducing substances, and reduction in bacterial loads in spices during drying and milling operations were observed and attributed mostly to rise in product temperature during such operations (Pruthi and Misra, 1963 and Pruthi, 1964). During drying, ginger rhizomes lose about 60 to 70 per cent of their weight and attain a moisture content of 7 to 12 per cent (Pruthi, 1980). Removal of the cork skin prior to drying not only reduces the fiber content but enhances the loss of volatile oil through rupture of oil cells, nearer to the skin (Elsdon and Mayne, 1937; Gollifer, 1973 and Purseglove et

al., 1981).

2.12.2 Heat treatment (90 °C and above) of the spice and oleoresin can lead to degradation of both the volatile oil and the pungent principles (Connell, 1970). Thiessen (1970) showed that changes in the organoleptic properties became noticeable in the spice and oleoresin at 90 °C and the deterioration is pronounced at higher temperatures. Grinding solid spices in the presence of gaseous refrigerants help in retaining the essential oil content of the spice while dissipating deleterious heat (Pintauro, 1971).

2.12.3 The major storage change in the dried spice, especially in ground state, is the evaporation of some volatile oil which results in a flat odour and flavour; while the oleoresin is particularly prone to loss of pungency during storage by degradation of gingerols (Connell, 1969; Ananthakrishnan and Govindrajan, 1974 and Nambudri et al., 1975).

2.13 ANTIOXIDANT PROPERTIES

2.13.1 DuBios and Tressler (1943) reported that ginger retarded the development of rancidity in frozen ground pork and beef. Sethi and Aggarwal (1950, 1952 and 1956) indicated that ginger when heated with groundnut oil to incipient charring of the spice at 275 to 280 °C, retarded the development of peroxides and free fatty acids. Chipault et al. (1955) and Berner (1973) have also reported the weak antioxidant properties of ginger.

2.14 MICROBIOLOGICAL QUALITY

2.14.1 Natural spices are heavily loaded with microorganisms (many as spore formers) and molds (Warmbrod and Fry, 1966; Hadlok and Toure, 1973 and Staniforth, 1973). The microorganism population is often as high as 16×10^6 per g of spice. In dry spices, the microorganisms usually exist in a dormant state, but when the spices are incorporated into moist food products the spores may become activated and cause spoilage (Pintauro, 1971). In 1939, Fabian *et al.* demonstrated that spoilage of pickles was due to bacterial contamination originating from the spices used (Heath, 1978). This can be overcome by the use of ground spices which have been exposed to mixtures of ethylene oxide and carbon dioxide (or other bactericidal gases) to reduce the bacterial load to acceptable levels (Rauscher *et al.*, 1957; Gerhardt, 1969; Scudamore and Hauser, 1971 and Mayr and Suhr, 1973). A process for sterilization of spices by acid treatment was given by Scharf (1967).

2.15 LEGAL STANDARDS

2.15.1 The government of India has published "Agmark" specifications for various grades of Cochin and Calicut dried gingers, both garbled and ungarbled, non bleached and bleached, and ginger powder (Table 2.6) The US government specifications for ground ginger are given in Table 2.7.

Table 2.6 AGMARK characteristics of different grades of ginger

(Shankaranarayana *et al.*, 1988)

Grade designation	Special characteristics			
	Size of rhizome	Extraneous matter(%)	Very light pieces(%) by count max.	Lime as CaO(%)
Garbled Non-bleached Calicut/Cochin ginger NGK/NGC	Not less than 15 mm in length	2.0	-	-
Garbled bleached Calicut/Cochin ginger BGK/BGC	-do-	2.0	-	2.5
Ungarbled non-bleached Calicut/Cochin				
a. NUGC/K-special	-do-	3.0	5.0	-
b. NUGC/K-good	-do-	4.0	10.0	-
c. NUGC/K.N.S.	-do-	-	*	-
Ungraded bleached Cochin/Calicut				
a. BUGK-special	-do-	3.0	5.0	4.0
b. BUGK-good	-do-	4.0	10.0	6.0
c. BUGK-NS	-do-	-	*	*

* As may be specified in the contract with buyer.

Table 2.7 US Federal specifications for ground ginger

(US Federal Specifications, 1975)

Characteristic	

Total ash, (%) not more than	7.0
Acid insoluble ash, (%) not more than	1.0
Crude fiber, (%) not more than	8.0
Volatile oil (expressed as ml per 100 g), not less than	1.5
Moisture, (%) not more than	12.0
Starch, (%) not less than	42.0
Sieve test (for powdered ginger only) US standard sieve size	No.30
Percentage required to pass through, not less than (%)	95

MATERIALS AND METHODS

CHAPTER - 3

----- MATERIALS AND METHODS -----

3.1 The present investigation involved preparation of herbal ice cream, i.e. ice cream containing natural flavouring material viz. ginger in different forms and standardization of certain technological parameters in preparing most acceptable 'ginger' ice cream. This chapter deals with the materials and methodologies employed during present study. The various materials used during the course of this investigation are encompassed hereunder. It also describes the methods which had been used for the analysis of ginger and ice cream. All the analyses were done in duplicate and only analytical grade reagents were used in the study or otherwise as specified in the text.

3.2 INGREDIENTS / MATERIALS

3.2.1. Various ingredients used for the preparation of ice cream using different selected forms of ginger are briefly described hereunder :-

3.2.2 DAIRY INGREDIENTS

3.2.2.1 The dairy ingredients used in the manufacture of ice cream were milk, cream and skim milk powder as the source of fat and MSNF in ice cream.

3.2.2.2. Milk : Fresh, raw cow milk received at Students' Training Dairy of the College was used as the base material

for ice cream manufacture.

3.2.2.3. Skim Milk Powder : Skim milk powder of 'Sagar' brand (ISI certified), marketed by Gujarat Co-Operative Milk Marketing Federation, Anand was used in preparation of ice cream mix, as a source of MSNF.

3.2.2.4. Cream : Whole cow milk was separated in an open discharge 'Alfa-Laval' power driven mechanical cream separator, Model, C.L.O. 180520 to give about 70 per cent fat cream. The cream was then pasteurized at 72°C for 1 min. and cooled to about 20°C and the same was used as a source of fat in preparing ice cream mix.

3.2.3 NON DAIRY INGREDIENTS

3.2.3.1 The non dairy ingredients used in the manufacture of various categories of ice cream were cane sugar, stabilizer, emulsifier, vanilla flavour, whole dried ginger and fresh ginger.

3.2.3.2. Cane Sugar : Cane Sugar used was of commercial grade which was obtained from the local market at Anand.

3.2.3.3. Stabilizer : Alginate S4 ice cream stabilizer of S. Square & Co., Gwalior was used as a stabilizer in the preparation of ice cream.

3.2.3.4. Emulsifier : The emulsifier used in this study was Glycerol Mono Stearate (GMS) of Brion Fine Chem., Bombay and was of commercial grade.

3.2.3.5. Flavour : Vanilla essence No. 1 of M/S Buch Boake Allen (India) Ltd., Madras was used as the flavouring agent for control ice cream (without ginger incorporation).

3.2.3.6 Fresh Ginger : Fresh ginger was procured from the local market at Anand. The ginger was washed, peeled manually and further washed thoroughly before use.

3.2.3.7 Whole dried ginger : Whole dried ginger was procured from the local market at Anand, in bulk.

3.3 PREPARATION AND PROCESSING OF GINGER

3.3.1 The processing treatments given to ginger for the manufacture of ginger juice, ginger shreds, treated ginger shreds and ginger powder are delineated in this section.

3.3.2 GINGER JUICE

3.3.2.1 Ginger juice was prepared by passing the freshly peeled ginger (Section 3.2.3.6) through a clean and sanitized fruit and vegetable juice extractor (M/S Narangs, New Delhi). The juice collected was strained through a fine muslin cloth to remove the fibers.

3.3.3 GINGER SHREDS

3.3.3.1. The peeled ginger (Section 3.2.3.6) was finely shredded in a clean and sanitized grater attachment of Gopi Kitchen Machine (Model - Super Deluxe, Gopi Manufacturers, Ambala, Haryana). The shreds had an average length of 5 to 10

mm, width of 1 to 2 mm and thickness of 1 to 2 mm.

3.3.4 TREATED SHREDS

3.3.4.1 From the preliminary studies, the ice cream prepared with the shreds were found to possess slight pungent taste. It has been reported in literature that boiling ginger in water yields a softer product, reduces the pungency slightly and increases the shelf life of the treated shreds (Purseglove et. al., 1981). Hence, an attempt was made to treat the shreds with sugar syrup.

3.3.4.2 Out of the total quantity of sucrose (i.e. 15 per cent) to be added in ice cream, 50 per cent (7.5 per cent by weight of ice cream mix) of the sugar was added to the ice cream mix at the time of its preparation. The remaining 50 per cent (7.5 per cent by weight of ice cream mix) of sugar was made into a sugar syrup by boiling in water (equal to the quantity of sugar by weight) till it attained around 65 to 70 per cent total solids. The ginger shreds (Section 3.3.3.1) were added to the boiling sugar syrup and cooked for 30 min. Sprinkling of water was done intermittently to maintain approximately the same concentration. The mixture was then cooled to refrigeration temperature, i.e. 5 to 7 °C. The treated shreds along with the sugar syrup were added to the partially frozen ice cream mix at the freezer itself. Each lot of shreds were prepared separately. The treated shreds had an average length of 5 to 10 mm, width of 2 to 3 mm and thickness of 2 to 3 mm.

3.4 PREPARATION OF ICE CREAM MIX

3.4.1 The milk and cream used in manufacture of ice cream were analyzed for their composition, i.e. fat, total solids, MSNF, and titratable acidity. The quantity of milk, cream, skim milk powder, sucrose, alginate and glycerol monostearate required for a batch (i.e. 3 kg and 15 kg of ice cream mix for home made ice cream and ice cream to be prepared in a direct expansion type batch freezer respectively) was calculated by serum point method (Sommer, 1951). Four different categories of ice cream mixes, each for home made as well as for ice cream made in a direct expansion type, batch, "Guisti" freezer were formulated so as to contain 12 per cent fat, 11 per cent MSNF, 15 per cent sucrose, 0.25 per cent sodium alginate and 0.15 per cent glycerol monostearate. However, for ice cream containing treated shreds, only 7.5 per cent sucrose was used at this stage. The required quantities of various ingredients for each treatment were weighed, mixed and blended thoroughly. Skim milk powder was mixed with part of the sugar and added. The calculated amount of stabilizer and emulsifier were admixed with approximately 2 parts of sugar (by weight) and added only when the temperature of the ice cream mix reached 70 °C. The mixes were then further heated to 75 °C, homogenized in a clean and sanitized homogenizer at 100 kg/ sq.cm pressure and pasteurized by holding the mix at 70 °C for 30 min. (Arbuckle, 1977). The pasteurized mixes were then immediately cooled to about 5 C and aged at 5 ± 2 °C for 24 h.

The flavouring ingredients were added immediately before freezing. Each experiment was replicated thrice.

3.5 PREPARATION OF HOME MADE ICE CREAM

3.5.1 The mix was frozen in a hand operated home freezer having capacity of 5 kg. The wooden bucket was soaked in water overnight, so as to prevent the leakage of water. The metallic cylindrical vessel of the freezer and the beater cum scrapper assembly were cleaned and subsequently sanitized with a solution of NaOCl having 250 ppm of available chlorine. The prepared mix was then poured inside the cylinder till about half i.e. 2.5 kgs mix. The surrounding passage was filled with broken ice pieces and coarse salt (25 to 30 per cent of ice). After assembling the freezer, the handle attached to the beater cum scrapper assembly was revolved (30 to 35 min.) till the mix froze to the desired consistency as sensed by an increase in the load on the handle. The freezing operation was stopped at this stage. The beater-scrapper assembly was then removed from the cylinder and the machine was fully covered with a clean, wet gunny bag. The ice cream thus prepared was left for 1 h for hardening and then served for judging. The temperature of ice cream was recorded before serving.

3.5.2 The experiment was done in two parts. The first phase involved preparation of home made ice cream. This phase was divided into four parts. In the first part, ginger juice was incorporated at 3 selected levels based on preliminary screening i.e. 3, 4 and 5 per cent (i.e. J1, J2 and J3) and

compared with control (C) where vanilla was added as a flavouring agent (at the rate of 1 to 1.5 ml per kg mix). The objective was to select the optimum level of addition of ginger juice in home made ice cream. Similarly, ice cream was prepared by incorporating ginger in other forms viz. ginger powder @ 0.1, 1 and 1.5 per cent (i.e. P1, P2 and P3 levels), ginger shreds @ 4, 6 and 8 per cent (i.e. S1, S2 and S3 levels) and treated ginger shreds @ 4, 6 and 8 per cent (i.e. T1, T2 and T3 levels). In each part 4 batches of ice cream were prepared and each part was replicated thrice. From this phase of the present investigation, one level from each group, i.e. J, P, S and T was selected on the basis of sensoric quality of ice cream. Thus, the level of different forms of ginger was selected for their incorporation in preparing the herbal ice cream. The second phase comprised of testing the previously selected levels (viz. J, P, S and T) in the manufacture of herbal ice cream by 'home made' and 'factory made' methods and comparing these with the control once again.

3.6 PREPARATION OF ICE CREAM IN A DIRECT EXPANSION TYPE BATCH FREEZER

3.6.1 For preparing different batches of ice cream (control as well as experimental) in direct expansion type batch freezer, the addition of different forms of ginger at the selected level (Section 3.5.2), was done in a fashion similar to that carried out in making 'home made' ice cream (Section 3.5.1). For making vanilla ice cream (C), vanilla essence was added to

the mix @ 1 to 1.5 ml per kg mix. The aged mixes were frozen in a horizontal batch freezer (Guisti, Type FVO 902) with an arrangement for air incorporation under pressure. The temperature of the circulating refrigerant was -18 to -20 °C. After freezing the mix to a semi solid consistency, as inferred from the load on ammeter (beater load of 3 ampere) and formation of ice on the freezer door, air was whipped in the ice cream at constant pressure i.e. 0.7 kg/ sq. cm and the time taken to reach 90 per cent overrun was recorded. The frozen ice cream at the right stage of freezing, as ascertained from the consistency and overrun, was drawn directly into a wax coated one lit. paper board cartons. The temperature of ice cream at the drawing stage was recorded. The filled ice cream packs were then transferred immediately to a hardening room, maintained at -15 ± 2 °C and hardened for 24 h. The hardened ice cream were then subjected to compositional and microbiological analysis, melting quality test and organoleptic evaluation when fresh (i.e. after hardening), after heat shock (as described in Section 3.9.4.1) and after 30 days storage period at -10 ± 2 °C in a deep freeze. Three replications were conducted and from this part of the investigation, the most preferred form of ginger was ascertained.

3.7 ANALYSIS OF ICE CREAM INGREDIENTS

3.7.1 The various physico-chemical methodologies employed for analyzing the dairy ingredients as well as ginger products are described hereunder. The chemicals employed in the analysis

were of analytical grade or other wise as specified in the text.

3.7.2 MILK

3.7.2.1 The representative samples of cow milk were analyzed for the chemical parameters as described in this section.

3.7.2.2 Fat

3.7.2.2.1 The fat content of milk was estimated by Gerber method (ISI, 1977).

3.7.2.3 Total solids

3.7.2.3.1 The total solids of milk was determined by the standard procedure using a Mojonnier Milk Tester (Model D, Mojonnier Brothers Co., Chicago, USA) according to the standard procedure described in Laboratory Manual (Laboratory Manual, 1959) using 2 g sample.

3.7.2.4 Titratable acidity

3.7.2.4.1 The titratable acidity of milk was determined by the method described in the Indian Standards (ISI, 1961).

3.7.3 CREAM

3.7.3.1 The fresh cream samples were subjected to chemical analysis for fat, total solids and titratable acidity.

3.7.3.2 Fat

3.7.3.2.1 The fat content of cream was estimated by the Gerber method outlined in the ISI handbook (1989) using 5 g cream.

3.7.3.3 Total solids

3.7.3.3.1 The total solids of cream was determined by the procedure as employed for milk (Section 3.7.2.3) using 1 g sample.

3.7.3.4 Titratable acidity

3.7.3.4.1 The titratable acidity of cream was determined by the method as described in the ISI Hand Book (1989).

3.7.4 SKIM MILK POWDER

3.7.4.1 The skim milk powder samples were subjected to chemical analysis for fat, total solids, titratable acidity and solubility index.

3.7.4.2 Fat

3.7.3.2.1 The fat content of skim milk powder was estimated by the standard procedure using a Mojonnier Milk Tester (Model D, Mojonnier Brothers Co., Chicago, USA) according to the standard procedure described in Laboratory Manual (Laboratory Manual, 1959) using 1 g sample.

3.7.4.3 Total solids

3.7.4.3.1 The total solids of skim milk powder was determined

by the procedure as employed for milk (Section 3.7.2.3) using 0.5 g sample.

3.7.4.4 Titratable acidity

3.7.4.4.1 The titratable acidity of skim milk powder was determined by the method as described in the ISI Hand Book (1989).

3.7.4.5 Solubility index

3.7.4.5.1 The solubility index of skim milk powder was determined by the method as described in the ISI Hand Book (1989).

3.7.5 GINGER

3.7.5.1 With a view to ascertain the quality of ginger it was analyzed for its moisture, protein, crude fiber, non volatile ether extract and starch content.

3.7.5.2 Moisture content

3.7.5.2.1 The moisture content of ginger (dried, ground to about 500 micron size as well as of fresh ginger) was determined by the method given in ISI Hand Book of Food analysis (ISI Handbook, 1982) using 5 and 2 g of sample respectively.

3.7.5.3 Protein

3.7.5.3.1 Protein content of ginger was determined by the

Kjeldahl method as described by A.O.A.C. (1970). About 0.5 g of dried ginger or 2 g of fresh ginger was weighed and transferred to a 300 ml digestion flask. To this 20 ml of concentrated sulphuric acid and 15 g of digestion mixture consisting of copper sulphate and potassium sulphate (1:20 w/w) were added. The mixture was digested over a flame till it became transparent after cooling. The digested portion was transferred into a distillation assembly with about 100 ml of distilled water. About 20 ml of 50 per cent (w/v) sodium hydroxide solution was added to the distillation flask. The mixture was heated and the distillate collected in a conical flask containing 50 ml of saturated boric acid solution and 2 drops of mixed indicator (equal volume of saturated solution of methyl red in ethyl alcohol and 0.1 per cent (w/v) solution of methylene blue in ethyl alcohol). About 150 ml of distillate was collected and titrated against 0.1N sulphuric acid.

Calculation of protein content :

$$\text{Total nitrogen (per cent. w/w.)} = \frac{V}{W} \times 0.0014 \times 100$$

Where :

V = Volume of 0.1 N sulphuric acid required for titration

W = Weight in g of sample.

Protein (Per cent ; w/w) = Total nitrogen X 6.25.

3.7.5.4 Crude fiber

3.7.5.4.1 The crude fiber content of ginger (dried, ground to about 500 micron size as well as of fresh ginger) was determined by the method given in ISI Hand Book (1982) using 5 and 2 g of sample respectively.

3.7.5.5 Non volatile ether extract

3.7.5.5.1 The non volatile ether extract content was determined by the standard procedure using a Mojonnier Milk Tester (Model D, Mojonnier Brothers Co., Chicago, USA) according to the standard procedure described in Laboratory Manual (Laboratory Manual, 1959) using 5 g sample.

3.7.5.6 Starch content

3.7.5.6.1 The starch content of ginger (dried, ground to about 500 micron size as well as of fresh ginger) was determined by the method given in ISI Hand Book (1982) using 5 and 2 g of sample respectively.

3.8 PHYSICO CHEMICAL ANALYSIS OF ICE CREAM MIXES

3.8.1 As per the recommendation of BIS for ice cream (ISI Handbook, 1989), the ice cream containing shreds (untreated and treated) at the rate of 4, 6 and 8 per cent was comminuted to a fine homogenous mix by running it in a mixer for 3 to 5 min. until the insoluble particles (i.e. shreds) were finely divided. The mixed sample was transferred again to the refrigerator.

3.8.2 Ice cream mixes were analyzed for their total solids content, fat, protein, acidity, pH, reducing sugars, non reducing sugars, etc.

3.8.3 FAT

3.8.3.1 The fat content of ice cream was determined by the standard method suggested in ISI Handbook (1989) for ice cream mixes using 5 g ice cream mix sample.

3.8.4 TOTAL SOLIDS

3.8.4.1 The total solids of ice cream was determined by the standard procedure as described for milk (Section 3.7.2.3) using 1 g. of sample.

3.8.5 TITRATABLE ACIDITY

3.8.5.1 The titratable acidity of ice cream was determined by the standard method suggested in ISI Hand Book (1989). Twenty g of ice cream were weighed in a 250 ml beaker. To this 50 ml of freshly boiled and cooled distilled water was added and the contents mixed thoroughly. It was then titrated against 0.1 N sodium hydroxide, using 1 ml of 1 per cent phenolphthalein as indicator, till pink colour persisted for about 15 s. The reading so obtained was converted to acidity, expressed as per cent lactic acid.

3.8.6 pH

3.8.6.1 The pH of ice cream mixes was determined using a Systronic digital pH meter, Model 335, Systronic Ltd., Ahmedabad, India at 25 °C.

3.8.7 PROTEIN

3.8.7.1 The protein content of ice cream was determined by Kjeldahl method (Menefee and Overman, 1940). As per this method, the total nitrogen was determined, and the value so obtained was multiplied by a standard factor 6.38 to get the protein content.

3.8.8 REDUCING AND NON REDUCING SUGARS

3.8.8.1 The reducing and non reducing sugars of ice cream was determined using the procedure described in IS Hand Book (1989) with some modifications. 50 g of ice cream mix was weighed and volume was made to 100 ml with distilled water. After thorough mixing, 50 ml of this solution was transferred to a 250 ml volumetric flask, pH of slurry was adjusted to 4.6 with the help of 10 per cent acetic acid drop by drop till clear precipitation of proteins occurred. The volume was then made to 250 ml with hot distilled water. After thorough mixing and 5 to 7 min. holding, the contents were filtered through Whatman No. 42 filter paper. A part of the filtrate obtained was directly used for the estimation of reducing sugar whereas the remaining part was hydrolyzed for estimation of non reducing sugars as given below.

3.8.8.2 Hydrolysis of filtrate for estimation of non reducing

sugars was done in the following manner: 50 ml of the filtrate was taken in a 250 ml conical flask. To this 25 ml of 0.5 N HCl was added. The flask was then kept in boiling water bath for 1 h. The contents of the flask were cooled and the filtrate neutralized by addition of solid sodium carbonate. The contents were then transferred to a 100 ml volumetric flask and the volume was made upto 100 ml mark by addition of distilled water.

3.8.8.3 Five ml each of Fehling A and Fehling B solutions were pipetted into a 250 ml conical flask. Subsequently 20 ml of distilled water and 2 to 3 pieces of porcelain were added. The content of the flask was heated upto boiling and then the unhydrolysed filtrate from the burette was added slowly into the flask. The content of the flask was kept boiling till the end of the titration. The addition of filtrate was continued till a rust brown colour developed. At this stage 2 to 3 drops of methylene blue solution (0.1 per cent) was added and the colour was observed (i.e. changed to blue). Again the filtrate from the burette was added till rust brown colour was obtained. The volume of filtrate used in the titration was noted. By running a parallel experiment, using standard lactose solution, a factor was calculated to find out lactose concentration in the test sample. Total reducing sugar was expressed as percentage by using a factor obtained for lactose.

$$\text{Per cent total reducing sugar} = \frac{67.8}{\text{Titre value}}$$

3.8.8.4 The titration for non-reducing sugar necessitated filling the burette with hydrolyzed filtrate. The titration was performed in the same way as was done for reducing sugar and the reading (b) was noted. The unhydrolysed filtrate (a) was also titrated with Fehling A and B as mentioned earlier (Section 3.8.8.3) to get total reducing sugar. The non reducing sugar content was determined by employing the following formula:

$$\text{Non reducing sugar (per cent)} = \frac{0.0473}{10} \times \left(\frac{20,000}{b \text{ (ml)}} - \frac{10,000}{a \text{ (ml)}} \right)$$

3.8.9 ALKALINE PHOSPHATASE TEST FOR ICE CREAM MIX

3.8.9.1 With a view to ascertain the efficacy of heat treatment employed in processing of ice cream mix, the presence of alkaline phosphatase was qualitatively assessed by the test as described in the ISI Hand Book (1989).

✓ 3.8.10 VISCOSITY

3.8.10.1 The viscosity of ice cream mix was determined by the method of Loewenstein and Haddad (1972b) using a Brookefield Viscometer, Model R.V. (Brookefield Engineering Laboratories, USA). The viscosity readings were taken (a) after ageing (24 h) at $5 \pm 2^\circ\text{C}$, immediately before freezing and (b) within 2 h of addition of flavouring ingredients as described here under.

3.8.10.2 A known quantity of ice cream mix was taken in a 500

ml beaker and was raised to 7°C. The quantity of sample taken was such that the ice cream mix level was at the immersion groove cut in the spindle shaft of the viscometer. The viscosity was determined at 7°C using spindle number 2 at 30 rpm. The reading obtained on the dial was multiplied by a factor from the 'factor finder' to get the viscosity in centipoise.

3.8.11 WHIPPING ABILITY

3.8.11.1 Whipping ability was determined by the method of Neshawy et al. (1988). This test was carried out within 2 h of addition of flavouring agents to the aged mixes. The mix was cooled to 0°C in a deep freeze in the bowl of Gopi Kitchen Machine, Model Super Delux (Gopi Manufacturers, Ambala, Haryana). The mix was then agitated (to be whipped) at the maximum speed and the specific volume (cubic cm/ g) was determined after 0, 3 and 5 min. of whipping. The temperature of the mix was not allowed to rise above 7°C. The whipping ability was also determined during actual freezing of ice cream in the "Guisti" batch freezer and expressed as the time taken to reach 90 per cent overrun at constant air pressure of 0.7 kg / sq. cm pressure.

3.9 EVALUATION OF PHYSICAL CHARACTERISTICS OF ICE CREAM

3.9.1 The ice cream was examined for its physical characteristics viz., overrun, melting characteristics etc.

3.9.2 OVERRUN

3.9.2.1 During freezing of ice cream in "Guisti" batch freezer, the overrun was determined as per the method given by Sommer (1951). A known volume of ice cream mix was weighed accurately (W1) and then the same volume of ice cream was weighed (W2) and the overrun was determined as

$$\text{Per cent overrun} = \frac{W1 - W2}{W2} \times 100$$

3.9.2.2 The per cent overrun in ice cream was also determined as per the method described in ISI Hand Book (1989) for ice cream.

3.9.3 MELTING CHARACTERISTICS

3.9.3.1 The method given by Loewenstein and Haddad (1972a) as modified by Upadhyay et al. (1978) was employed for evaluating ice cream for its melting characteristics. One lit. packet of ice cream from the hardening room was taken and a slice weighing 100 g was cut in duplicate. The slices were separately placed over a wire mesh screen (250 pores per square inch) and then placed over a long stem glass funnel of 6 inches diameter. The funnel with the wire mesh containing ice cream slice was placed over a 100 ml glass cylinder. It was then kept in an incubator maintained at 37.5 °C for 40 min. After 40 min. the volume of ice cream melted was noted. It was then weighed. The melting characteristics was determined as percentage of total ice cream melted in 40 min at 37.5 °C.

3.9.4 HEAT SHOCK TREATMENT

3.9.4.1 The procedure suggested by Arbuckle (1986) was used to evaluate the freeze - thaw heat shock stability of ice cream samples. After 24 h of hardening at $-15 \pm 2^{\circ}\text{C}$, the ice cream samples were transferred to a temperature controlled area maintained at 22°C , kept for 1.5 h, and then returned to the frozen storage at $-15 \pm 2^{\circ}\text{C}$. Again after 24 h, the same samples were transferred once again to the same temperature controlled area for another 0.5 h shock and returned back to the frozen storage. The treatment was repeated every day for 6 d. At the end of the heat shock period, the ice cream samples were returned to the frozen storage for 24 h before being sensorily evaluated.

3.10 SENSORIC QUALITY

3.10.1 HOME MADE ICE CREAM

3.10.1.1. Home made ice cream was subjected to sensory evaluation as described in Section 3.5.1 using a score card suggested by Arbuckle (1977) (Appendix I and II).

3.10.2 FACTORY MADE ICE CREAM

3.10.2.1 Freshly hardened ice cream (i.e. hardened at $-15 \pm 2^{\circ}\text{C}$ for 24 h), heat shocked as well as ice cream stored in deep freeze for 30 d at $-10 \pm 2^{\circ}\text{C}$) were subjected to sensory evaluation using the score card suggested by Arbuckle, 1977.

3.10.2.2 Fresh ice cream

3.10.2.2.1 Fresh samples of ice cream after 24 h of hardening at $-15 \pm 2^{\circ}\text{C}$ in hardening room were tempered at $-7 \pm 1^{\circ}\text{C}$ before being evaluated for organoleptic characteristics by a panel of trained judges. The panel of judges consisted of 6 members selected on the basis of their consistency in scoring of various ice cream samples.

3.10.2.3 Heat shocked Ice cream

3.10.1.2.1 Sensory evaluation of such ice creams was done in a similar way as for fresh ice cream after giving heat shock treatment as described under Section 3.9.4.1

3.10.2.4 Stored Ice cream

3.10.1.3.1 Ice cream samples were stored for 30 d in deep freeze at $-10 \pm 2^{\circ}\text{C}$ and tempered to $-7 \pm 1^{\circ}\text{C}$ before being evaluated for organoleptic characteristics by the panel of judges to study the effect of storage on the quality of ginger ice cream.

3.11 MICROBIOLOGICAL ANALYSIS

3.11.1. All the ice cream samples were analyzed for Standard Plate Count (within 2 h of hardening in case of home made ice cream and after 24 h of hardening in case of factory made ice cream) by the method described by BIS (ISI, 1964).

3.11.2. STANDARD PLATE COUNT (SPC)

3.11.2.1 Eleven g of each of the sample was aseptically weighed and transferred into a 99 ml sterile phosphate buffer flasks. Further dilutions were prepared using 9 ml sterile phosphate buffer in test tubes. Suitable dilutions of each sample were transferred (1.0 ml) aseptically into a sterile petri plate and thereafter 10 to 15 ml of molten SPC agar (prepared as specified in ISI, 1962). The plates were cooled and incubated in an incubator maintained at $37 \pm 0.5^{\circ}\text{C}$ for 48 h and the number of colony forming units (c.f.u.) noted.

3.12. STATISTICAL ANALYSIS

3.12.1 The mean values of each attribute under study obtained from samples of 3 replications were subjected to analysis of variance using the method of Completely Randomized Design with equal number of observations for each treatment. The sensoric scores in general may not follow normal distribution but may have Poisson type of distribution. Under such situation, the assumptions underlying ANOVA are not satisfied. This necessitates transforming the scores to square root scale making the distribution nearer to normal thereby making ANOVA valid. Similarly, the bacterial count values were also transformed to their log values, before subjecting them to statistical analysis.

3.12.2 The statistical model described by Steel & Torrie (1980) was adopted as illustrated below :

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where:

Y_{ij} = Response due to j^{th} observation in i^{th} treatment

μ = General mean

T_i = Effect of i^{th} treatment

e_{ij} = Error associated with the j^{th} observation receiving i^{th} treatment.

RESULTS AND DISCUSSION

CHAPTER 4

----- RESULTS AND DISCUSSION -----

4.1 The dairy foods of the future promise to be healthful and functional. There is also going to be a great demand for nutraceuticals in the future. Foods of the future will contain more of natural substances (Rasmussen, 1988). Recently, Dr. R. Arnot, the health Correspondent for C.B.S. news said "Foods are the pharmacy of the 1990's", highlighting the growing demand of consumers seeking foods that enhance their health and increase their lifespan. Back in 400 BC, Hippocrates said "Let food be your medicine and medicine be your food." These words of Hippocrates and Arnot holds true for the dairy and food industry as well (Gherty, 1994). The study was undertaken to evaluate ginger, a novel natural herb, (Zingiber officinale, Roscoe) as a flavouring ingredient in ice cream, since it is well known for its medicinal and therapeutic properties. An attempt was also made to select the form of ginger to be used (viz. juice, dried ginger powder, untreated shreds and shreds treated in sugar syrup) and its acceptability level in ice cream. Ginger ice cream manufactured by few small scale ice cream manufacturers and in households in Gujarat is very popular in some localities. Recently, a well known ice cream manufacturer in Gujarat has also introduced a 'ginger flavoured' ice cream. However, there is a wide variation in the overall quality of ginger ice cream, especially in home made and to some extent in factory made too and thus needs to

be standardized. This investigation is an attempt to evaluate certain physico chemical properties of ginger ice cream when utilizing ginger in various forms. Initially home made ice cream was prepared using the various forms of ginger (Section 3.5.2) at different levels and certain physico-chemical attributes and sensoric quality of the experimental products were evaluated. Since vanilla flavoured ice cream is the most popular ice cream world over, the sensoric score of all the experimental samples was compared with vanilla ice cream which was used as a control. From this part of the study, the most preferred level for each form of ginger used was selected and these selected levels were tested in 'freezing trials' in a batch freezer to arrive at the 'ginger ice cream' which is highly acceptable in a particular form. In the second part of the investigation, factory ice cream was made in a direct expansion type batch freezer using the selected level for each form of ginger to choose the best form of ginger which could be added to the ice cream mix. This section delineates the results obtained from various experimentation during this investigation as well as discussion on these results. The data obtained during this investigation were statistically analyzed employing simple Completely Randomized Design (CRD) and were checked at 5 per cent level of probability. All the mixes showed a negative alkaline phosphatase test.

4.2 SELECTION OF LEVEL OF GINGER JUICE IN HOME MADE ICE CREAM

4.2.1 Home made ice cream was prepared using ginger juice at

three different levels i.e. 3 (J1), 4 (J2) and 5 (J3) per cent by weight of the finished ice cream respectively. Preliminary screening was carried out to arrive at the above three levels. Vanilla was used as the flavouring agent in control (C). Ginger juice was prepared by crushing fresh, peeled ginger in fruit juice maker. The yield of peeled ginger obtained from fresh ginger was in the range of 80 to 85 per cent, while the yield of ginger juice on the basis of fresh unpeeled ginger was in the range of 52 to 57 per cent. The experimentation involved making of 4 batches of ice cream i.e. C, J1, J2 and J3. Each treatment was replicated thrice. In all 12 batches of ice cream were prepared. The drawing temperatures of all the ice creams were in the range of - 4.0 C to -5.0 °C. The overall quality of ice cream would depend on the type and concentration of additive used in ice cream mix. The success of the new variety would also depend on the physico-chemical parameters which may be modified by incorporation of ingredients such as ginger. Hence, the influence of different levels of ginger juice on the compositional characteristics, acidity and pH of ice cream was studied. Further, the influence of ginger juice on certain properties of ice cream were also monitored. The samples were also screened for their microbiological status and were subjected to sensory evaluation. The score for bacteria (15) was omitted from the total score. The total scores given in Table 4.5 are out of 85 only.

4.2.1.1 According to the grading pattern recommended by ISI

for milk (ISI, 1975 a) and some of the milk products i.e. table butter (ISI, 1975 b), ghee (ISI, 1975 C), milk powder (ISI, 1981 a), sweetened condensed milk (ISI, 1981 b) and processed cheese (ISI, 1982) the samples scoring more than or equal to 90 per cent, 80 to 89 per cent, 60 to 79 per cent and less than 60 per cent marks are considered to be excellent, good, fair and poor (to be rejected) respectively.

4.2.2 EFFECT OF VARYING LEVELS OF GINGER JUICE ON THE COMPOSITIONAL ATTRIBUTES, ACIDITY AND pH OF HOME MADE ICE CREAM

4.2.2.1 The juice of a natural herb like ginger was employed in this study. It can also influence the compositional characteristics of the ice cream and create problems in meeting the relevant legal standards. Hence, the fresh control (C), and the experimental samples (i.e. J1, J2 and J3) of ice cream were analysed for their fat, protein, reducing and non reducing sugars, total solids content, acidity and pH values.

4.2.2.2 The average values of compositional attributes, acidity and pH of freshly prepared home made ice cream are presented in Table 4.1. The average total solids of ginger juice employed during the present investigation was 15.37 ± 0.59 per cent and the pH of the juice was 6.22 ± 0.057 (Appendix V). As shown in Table 4.1, the average fat, protein, reducing sugars, non reducing sugars and total solids of the experimental samples ranged between 11.32 (J3) to 11.71 (J1); 3.88 (J3) to 3.95 (J1); 5.09 (J3) to 5.22 (J1); 14.61 (J3) to

Table 4.1 Influence of varied levels of ginger juice on the average compositional characteristics, pH and acidity of home made ice cream

Level of addition of ginger juice in ice cream mix (% w/w)	Percentage of ice cream constituents				Titrate-ble acidity (% lactic acid)	pH	
	Fat	Protein	Reducing sugars	Non-reducing sugars			Total solids
0 (C)	11.94	3.99	5.28	14.90	38.23	0.196	6.34
3 (J1)	11.71	3.95	5.22	14.80	37.56	0.199	6.32
4 (J2)	11.53	3.91	5.16	14.69	37.41	0.203	6.32
5 (J3)	11.32	3.88	5.09	14.61	37.25	0.205	6.32
Statistical analyses							
SEM	0.03	0.014	0.024	0.043	0.037	0.005	0.051
CD (0.05)	0.088	0.044	0.07	0.126	0.109	NS	NS
C.V.%	0.63	0.59	1.13	0.70	0.24	3.2	1.12

14.8 (J1); and 37.25 (J3) to 37.56 (J1) per cent respectively. It is evident from the table that there is a proportionate very small decrease in per cent of fat, protein, reducing sugars, non reducing sugars and total solids in all experimental samples with increasing proportions of incorporation of ginger juice compared to control. The incorporation of ginger juice in ice cream was found to increase the acidity slightly. All the experimental samples had the same pH value, which was slightly lower than the control.

4.2.2.3 The dilution effect of ginger juice in ice cream was found to exercise significant influence ($P < 0.05$) on the fat and total solids content, both being slightly but significantly lower for experimental samples compared to the control. Further, addition of ginger in the form of juice added at the rate of 4 (J2) and 5 (J3) per cent was also found to decrease significantly the protein content, reducing sugars and non reducing sugars ($P < 0.05$). However, incorporation of ginger juice in ice cream was not found to have any significant effect on the acidity and pH of experimental samples ($P > 0.05$).

4.2.2.4 The average values of the compositional parameters, acidity and pH are well within the range of the reported literature values. The compositional attributes are well above the minimum values specified for plain ice cream either legally (PFA, 1955) or as recommended by Bureau of Indian Standards (ISI, 1970) for India. Similarly, the acidity of all

samples satisfies the requirement as specified for plain ice cream by Bureau of Indian Standards (ISI, 1970). The marginal decrease observed in the compositional values can obviously be attributed to dilution effect of ginger juice containing higher moisture content (about 85 per cent). Similarly, lower pH of ginger juice compared to that of ice cream mix may be responsible for the difference in the acidity/pH of experimental samples containing ginger juice vs. control.

4.2.2.5 On the basis of the present study, it can be said that the selection of ginger juice intended for its use in ice cream should be properly done on the basis of its compositional aspects especially total solids, acidity, pH etc. The pre-concentration of juice could ameliorate the dilution of the mix. It is advisable to take into consideration the water contained in "ginger juice" while computing several ingredients required to formulate a mix, so as to avoid dilution effect. The lower pH of experimental ice creams owing to presence of ginger juice did not have any adverse effect on the protein stability of the mixes.

4.2.3 EFFECT OF VARYING LEVELS OF ADDITION OF GINGER JUICE ON THE VISCOSITY OF ICE CREAM MIX

4.2.3.1 Viscosity has been considered an important property of ice cream mix and upto a certain extent it seems essential for proper whipping and retention of air cells. The viscosity of mix is also affected by the composition, especially fat, protein and stabilizer and the quality of ingredients used.

Table 4.2 Influence of varied levels of ginger juice on the average viscosity and whipping ability of home made ice cream

Level of addition of ginger juice in ice cream mix (% w/w)	Viscosity (in centipoise at 7°C)	Whipping ability (cubic cm/ g) after a whipping time of		
		0 min.	3 min.	5 min.
0 (C)	181.7	0.917	1.217	1.144
3 (J1)	201.6	0.922	1.185	1.127
4 (J2)	223.3	0.922	1.138	1.094
5 (J3)	241.6	0.924	1.106	1.037
Statistical analyses				
SEM	6.009	0.002	0.007	0.014
CD (0.05)	19.6	NS	0.024	0.045
C.V.%	4.91	0.40	1.09	2.15

Hence, the aged ($5 \pm 2^{\circ}\text{C}$ for 24 h) mixes (C) as well as the aged mixes containing added juice (within 2 h of addition of ginger juice) at 3, 4 and 5 per cent (i.e. J1, J2 and J3) level were subjected to viscosity test. The relevant results are described and discussed in this section.

4.2.3.2 Table 4.2 portrays the average values of viscosities of ice cream mixes as influenced by the level of addition of ginger juice. The average values of viscosity at 7°C of the control and experimental aged mixes were in the range 181.7 (C) to 241.7 (J3) centipoise. The viscosity of control was lower than those of the experimental samples (Table 4.2). It can be seen from these data that incorporation of ginger solids, in the form of ginger juice, increased the viscosity of mixes.

4.2.3.3 Such increase in the viscosity of the mixes containing ginger juice was statistically significant ($P < 0.05$) (Table 4.2). Except for the viscosity values of J2 and J3, all the remaining values were statistically different ($P < 0.05$) from each other.

4.2.3.4 Viscosity of ice cream mix is a complex property and has been found to be affected by a number of factors, viz. composition, kind and quality of ingredients, processing and handling of mix, concentration (i.e. total solids), temperature, etc. Although much has been reported about the causes and effects of viscosity there has been no final answer to the question ; how much is desired and how it can be

accurately measured. A high viscosity was believed to be essential at one time, but for fast freezing and rapid whipping in a modern equipment a lower viscosity seems desirable (Arbuckle, 1977). Sommer (1951) and Arbuckle (1977) have reported viscosity of ice cream mixes to be between 50 and 300 centipoise. The viscosity values of all the ice cream mixes were within this range. The ginger juice which was added in the experimental mixes, contained starch at levels of 8.67 ± 0.49 per cent which might be responsible for the change in viscosity (Appendix V). The starch contained in potato pulp led to increased viscosity of ice cream mixes containing added potato pulp; the starch being a hydrophillic colloid (Das et al., 1989). Cottrell et al. (1980) also indicated that polysaccharides such as starch increased the mix viscosity and restricted ice crystal growth during storage of ice cream. The acidity of ice cream mix does influence the viscosity, which in turn affects the whipping ability of mixes (Arbuckle, 1977). In the present study, the acidity of the experimental samples was higher than that of control; more so with higher levels of ginger juice addition (Table 4.1). The higher acidity of the mix might have been responsible, at least in part, for the increased viscosity of the mix and this again might be responsible for the decrease in the specific volume at 3 and 5 min. of whipping (Table 4.2). During the present investigation, the ginger juice was added to the mix at the time of freezing the mix. However, when ice cream mix containing the ginger juice was kept as such for considerable time, thickening of the mix was noticed. The inter and intra-

molecular reactions of milk solids and ginger solids might be playing some role in increasing viscosity which needs further investigations. Blanc and Odet (1981) observed that since the rheological properties of milk are not ideal unlike those of Newtonian liquids, the values published concerning viscosity are not always comparable. Further, the casein aggregates in mix can be disrupted during the measurement of viscosity and does not always give an accurate picture of consistency.

4.2.4 EFFECT OF VARYING LEVELS OF ADDITION OF GINGER JUICE ON THE WHIPPING ABILITY OF ICE CREAM MIX

4.2.4.1 The whipping ability of mixes is an important property because of its relation to quality of ice cream and profit. Whipping ability of the mixes is affected by composition of the mix, ingredients used especially surfactants/ emulsifiers, history and processing of the mix, and the freezing process. Hence, the whipping ability of aged mix as well as mix added with ginger juice were monitored. These tests were carried out within 2 h of addition of ginger juice. The relevant results are described and discussed in this section.

4.2.4.2 Table 4.2 depicts the average values of whipping ability of ice cream mixes, as specific volume (expressed as cubic cm/ g) as influenced by the level of addition of ginger juice. The average values of specific volume of the unwhipped experimental mix as well as control were in the range of 0.917 (C) to 0.924 (J3) cubic cm/ g. The specific volume of experimental unwhipped samples were marginally

higher than that of control. It can also be seen from the table that the specific volume values increased after whipping the mixes for 3 min., exceeding which (i.e. after 5 min.) it tended to decrease. However, the specific volume values of mixes after 5 min. whipping period were higher than that prevailing in unwhipped mixes. Almost similar trend was observed in all samples.

4.2.4.3 It can be observed from the statistical analysis (Table 4.2) that the values of unwhipped mixes for control as well as experimental samples were at par with each other. On whipping the mixes for 3 min. , the specific volume of control (C) rose to higher levels (viz. 1.217 cubic cm/ g) while that of experimental samples rose only to levels ranging from 1.106 (J3) to 1.185 (J1) cubic cm/ g. The slight decline in whipping ability observed after an interval of 5 min. was almost of a similar magnitude in all the samples. At this stage, the specific volume values were significantly different from each other ($P < 0.05$). After 5 min. of whipping, the small decrease in whipping ability (C vs J2, C vs J3 and J2 vs J3) was also found to be significant ($P < 0.05$).

4.2.4.4 The specific volume of mixes varies with the composition of the mix. The initial increase in the specific volume of experimental samples might be due to the difference in density of milk solids and ginger juice. Arbuckle (1977) reported that whipping ability of ice cream mix is dependent on composition, efficacy of whipping mechanism and viscosity

of the mix. Since the whipping mechanism of the experimental samples was identical, it can be stated that differences in whipping ability of mixes could be due to the higher viscosity (Section 4.2.3) of mixes containing ginger and the composition of the mix. The higher acidity of the experimental mixes probably accounting for the increased viscosity of such mixes might be responsible for the decrease in the whipping ability. Higher temperatures during whipping has been reported to adversely influence the whipping ability; the rise in temperature of the mix might be weakening the lamellae of the air cells, thereby enabling the air to escape leading to lower whipping ability (Arbuckle, 1977). The decrease in the whipping ability after 5 min. compared to at 3 min. interval could be ascribed to the rise in temperature due to longer whipping duration. The finding of the present study corroborates with reported finding (Neshawy et al., 1988).

4.2.5 EFFECT OF VARYING LEVEL OF ADDITION OF GINGER JUICE ON THE OVERRUN OF ICE CREAM

4.2.5.1 The overrun of ice cream is an important property since it directly has a relation with the yield and profit, it also affects the body, texture and palatability of the final product.

4.2.5.2 The influence of adding ginger juice to ice cream mix on the overrun of ice cream has been presented in Table 4.3. It can be seen from the table that with increase in the level of ginger juice addition, the overrun of ice cream

Table 4.3 Influence of varied levels of ginger juice on the average overrun and melting characteristics of home made ice cream

Level of addition of ginger juice in ice cream mix (% w/w)	Overrun (%)	Quantity of ice cream melted in 40 min. at 37.5 C per 100 g (g)
0 (C)	50.27	44.73
3 (J1)	45.99	37.13
4 (J2)	43.43	34.17
5 (J3)	39.29	28.87
Statistical analyses		
SEM	1.753	0.717
CD (0.05)	6.88	2.34
C.V.%	5.54	3.43

decreased. For instance, the average overrun was maximum in C (50.27 per cent) and least in J3 (39.29 per cent).

4.2.5.3 The statistical analysis (Table 4.3) indicates that the incorporation of ginger juice did not significantly affect the overrun when added upto 4 per cent level; beyond this level the overrun tended to decline significantly. All the experimental samples (J1, J2 and J3) were rated as par statistically ($P > 0.05$) with respect to overrun.

4.2.5.4 The decrease in overrun in the ice cream containing ginger juice is evident from this study. The lower overrun encountered in the experimental samples may be ascribed to the relatively higher viscosity associated with such samples. The results obtained during the present investigation corroborates with that of Das et al. (1989) who found that the increase in viscosity of ice cream mixes containing potato pulp was responsible for the adverse effect on the overrun.

4.2.6 EFFECT OF LEVEL OF ADDITION OF GINGER JUICE ON THE MELTING RESISTANCE OF ICE CREAM

4.2.6.1 Ice cream should melt down to a liquid of smooth consistency, suggestive of rich cream. Meltdown is an important property of ice cream affecting its sensoric quality. It is important from atleast two main points of view - eye appeal and mouth feel- which may differ according to the type of ice cream (Flack, 1988). It is also important that the ice cream is not too hard or should not melt quickly. Deviation in the melting property from ideal condition on

either extremes can make the ice cream defective (Sommer, 1951). Hence, the melting resistance of control as well as experimental samples were monitored. The relevant results are described and discussed in this section.

4.2.6.2 As seen from Table 4.3, the melting resistance of ice cream samples containing ginger juice increased progressively with increasing level of ginger juice addition. The control had the highest meltdown rate. The meltdown values (g of ice cream melted in 40 min. at 37.5 °C per 100 g ice cream) varied from 44.73 in C to 28.87 in J3.

4.2.6.3 From the the pertaining statistical analysis, it can be seen that experimental samples i.e. J1, J2 and J3 had significantly lower meltdown than the control. The level of ginger juice employed in this study had significant effect on meltdown property, which decreased significantly ($P < 0.05$) with increase in level of ginger juice.

4.2.6.4 In general, as the viscosity increases the resistance to melting and the smoothness increases (Arbuckle, 1977). The increase in melting resistance (i.e. decrease in meltdown values) with increase in the level of ginger juice addition to ice cream mix is quite evident from this study. The meltdown property of ice cream is generally affected by the type of raw materials employed - fat source, milk solids source, sugars, emulsifiers, stabilizers, other additives and processing conditions viz. pasteurization, homogenization, aging, freezing, hardening and overrun (Flack, 1988). These

factors affects the structure of ice cream, which in turn, governs the meltdown property (Sommer, 1951). These factors may also control the consistency / viscosity of the ice cream mix. The increase in the viscosity of ice cream mixes with incorporation of ginger juice was also observed clearly during this study and has been described and discussed earlier (Section 4.2.3). Das et al. (1989) also observed such phenomenon. Slow melting generally indicates over stabilization and such condition can be corrected by reducing the amount of stabilizer and/or emulsifier. Ginger contains certain hydrocolloids, some of which might be responsible for increasing the viscosity as discussed earlier (Section 4.2.3). This might be responsible for increasing the melting resistance of ice cream where ginger juice had been incorporated. Sample J3 was criticized for exhibiting extremely slow melting (Section 4.2.8) which could be categorized as "does not melt" defect. It is frequently accompanied by body defects such as soggy, gummy, doughy and sticky (Arbuckle, 1977).

4.2.7 EFFECT OF VARYING LEVEL OF ADDITION OF GINGER JUICE ON THE BACTERIAL COUNT OF ICE CREAM

4.2.7.1 Addition of flavouring and colouring materials to ice cream mix after pasteurization, may contaminate the mix and probably contribute to the high count in ice cream. Ginger is considered to be a spice. Notwithstanding the considerable variation in reported results, the spices possess

Table 4.4 Influence of varied levels of ginger juice on the average bacterial count of freshly prepared home made ice cream

Level of addition of ginger juice in ice cream mix (% w/w)	Average SPC per g ice cream (log cfu)
0 (C)	4.628 (42450)
3 (J1)	4.565 (36700)
4 (J2)	4.585 (38450)
5 (J3)	4.562 (36450)
Statistical analyses	
SEM	0.033
CD (0.05)	NS
C.V.%	1.22

(Figures in parentheses show actual cfu values)

antibacterial properties. Hence, standard plate count (SPC) of ice cream was performed to ascertain the probable antibacterial activity of ginger. The SPC of ice cream was determined after hardening of ice cream for about 2 h.

4.2.7.2 It can be seen from Table 4.4, that the SPC / g of all the samples varied within the range of 36,450 (J3) to 42,450 (C). Thus, the use of ginger juice was found to give marginally lower SPC in 'ginger ice creams' compared to control. However, consistent trend in this regard was not obtained.

4.2.7.3 Notwithstanding the decrease in the SPC of ice cream containing ginger juice compared to control, the decrease observed was not statistically significant ($P > 0.05$) (Table 4.4).

4.2.7.4 As early as 1939, Fabian et al. observed antibacterial effect of dried ginger when used at 5 per cent level. Such findings are substantiated by the observations made during the present study. In general, the SPC of a product is also dependent on the overall manufacturing operation. The decrease in SPC compared to control (C) was evident in this study. In sample J2 (4 per cent level of ginger juice) the SPC was found to be higher than in J1 and J3; this was however insignificant. Further, it can also be seen from the study that the SPC was far below the maximum value specified by BIS i.e. maximum 2,50,000 per gram of ice cream (ISI, 1970).

4.2.8 EFFECT OF VARIED LEVELS OF GINGER JUICE ON THE SENSORIC ATTRIBUTES OF FRESHLY PREPARED HOME MADE ICE CREAM

4.2.8.1 The fate of any food product has always rested on the acceptance of the product by the consumers. The quality of ice cream judged by consumers rests on its flavour, body and texture characteristics, melting behaviour and to some extent its colour. Keeping in view these aspects, the sensoric quality of the ice cream samples were adjudged by a panel of 6 judges using the score card recommended by Arbuckle (1977). Considering the variations expected in the sensoric scores, the root x scale was employed in statistical analysis of the data as explained earlier in Section 3.12.1. The results presented in Table 4.5 represent influence of addition of ginger juice on the organoleptic attributes of ice cream i.e. scores for flavour, body and texture, melting quality and colour; the maximum scores allotted were 45, 30, 5 and 5 respectively. The values given in the Table 4.5 represent root x scale values while the transformed average scores are given in the parentheses.

4.2.8.2 Flavour

4.2.8.2.1 The average flavour scores of the experimental samples were in the range of 36.61 (J3) to 38.44 (J2). Sample J2 was adjudged the best. It can be seen from the table that use of ginger juice in ice cream in place of vanilla, increased its flavour preference, when added upto 4 per cent only. Addition of the juice at 5 per cent level led to

Table 4.5 Influence of varied levels of ginger juice on the average organoleptic characteristics of home made ice cream

Level of addition of ginger juice in ice cream mix (% w/w)	Flavour (45)	Body and texture (30)	Melting characteristics (5)	Colour (5)	Total (85)
0 (C)	6.069 (36.83)	5.164 (26.66)	2.172 (4.72)	2.198 (4.83)	8.546 (73.05)
3 (J1)	6.083 (37.00)	5.244 (27.50)	2.081 (4.33)	2.211 (4.89)	8.585 (73.72)
4 (J2)	6.200 (38.44)	5.318 (28.28)	2.034 (4.14)	2.198 (4.83)	8.700 (75.69)
5 (J3)	6.051 (36.61)	5.131 (26.33)	1.957 (3.83)	2.204 (4.86)	8.463 (71.63)

Statistical analyses

SEM	0.009	0.013	0.018	0.014	0.028
CD (0.05)	0.027	0.037	0.052	NS	0.083
C.V.%	0.450	0.073	2.60	1.97	1.76

(The reported values given in parantheses show squared values i.e. actual average score)

decrease in flavour score, which was lower than that of samples J1, J2 and even C.

4.2.8.2.2 The addition of ginger juice @ of 4 per cent (J2) was found to improve the flavour score significantly over that of control ($P < 0.05$). Other levels of addition of ginger juice did not cause marked variation in the flavour profile compared to the control. Amongst the experimental samples, the levels of ginger juice employed exercised significant influence on the flavour of ice cream ($P < 0.05$). Thus, the superiority of ice cream containing 4 per cent ginger juice (J2) was established on the basis of the statistical analysis. The flavour preference decreased in the order : J2, J1, C and J3 respectively.

4.2.8.2.3 The aroma of ginger is mainly due to its volatile essential oil and the pungency is attributed to its non-volatile constituents like gingerols, shogaol, paradol, etc. (Narayanan, 1988). These might be responsible for the delectable flavour of ice cream containing ginger. The levels (i.e. lower or in excess of 4 per cent juice) were found to decrease the flavour preference. In the absence of relevant research work in this field, it may be concluded from this study that the intensity of aroma and pungency of ice cream is optimally balanced at 4 per cent level of ginger juice addition. Furthermore, it can also be seen from the flavour scores that ice cream containing juice @ 3 per cent (J1) and 5 per cent (J3) though scored less average points compared to control, the minimum score was atleast 81.36 per cent (for J3)

of the total score allotted to flavour attribute. Thus, considering the BIS guidelines for sensory evaluation and grading of products (Section 4.2.1.1), J1 and J3 can also be considered as good products flavourwise.

4.2.8.3 Body and texture

4.2.8.3.1 The average scores of body and texture presented in Table 4.5 indicate superiority of J2 ice cream over all other samples. These values also indicate that the ice cream containing ginger juice was preferred with respect to its body and texture characteristics compared to control i.e. the score increased from 26.66 (C) to 28.28 (J2) i.e. when ginger juice was added upto a level of 4 per cent. However, raising the level of the juice to 5 per cent (J3) caused a very slight decrease in score of the ice cream compared to the control. Thus the preference was in the sequence : J2 > J1 > C > J3.

4.2.8.3.2 The square root transformation employed for statistical analysis of these data indicated and confirmed the superiority of J2 over all other ice cream samples ($P < 0.05$). Even lower level of ginger juice employed i.e. J1 (● 3 per cent) was found to improve body and texture of the ice cream significantly ($P < 0.05$) compared to the control.

4.2.8.3.3 The preference of J2 over other experimental as well as control home made ice cream is clearly evident from this part of the study. The judges preferred, in general, ice cream containing 4 per cent ginger juice (J2) mainly due to its

improved smoothness and better body. Higher level of ginger juice addition resulted in product which was too cohesive and gummy which was criticized by the judges. Ginger juice was found to increase the viscosity of ice cream mix significantly, as has been delineated and discussed earlier (Section 4.2.3), which might have been responsible for improving the body of ice cream. However, decrease in score of J3 (containing 5 per cent ginger juice) was also noted. But still J3 obtained 87.77 per cent marks of the maximum allotted body and texture score (i.e. out of 30) and hence can be considered as good product as per BIS suggested grading (Section 4.2.1.1). The excessive thickening (i.e. there existed a linear increase in viscosity of ice cream mix from 181.7 centipoise for control (C) to 241.7 centipoise for J3) (Section 4.3.3) might be responsible for reducing the acceptability of J3 ice cream. At 5 per cent level of ginger juice incorporation, the overrun was found to decrease significantly compared to control (Section 4.2.5) and hence led to heavy bodied ice cream culminating in gumminess.

4.2.8.4 Melting quality

4.2.8.4.1 The incorporation of ginger juice was observed to affect adversely the melting characteristics, decreasing the score significantly ($P < 0.05$) compared to the control. Ice cream samples J1 and J2 were nondistinguishable ($P > 0.05$) in this respect. Except these, the experimental samples differed significantly from each other ($P < 0.05$).

4.2.8.4.2 The melting quality thus has been found to be affected in terms of score allotted. However, such small differences observed compared to control, i.e. 0.39 (J1 vs. c) to 0.89 (J3 vs. c) were found to be statistically significant ($P < 0.05$).

4.2.8.4.3 The experimental samples generally gave very rich consistency on melting compared to control. The increase in the melting resistance of the experimental samples compared to control was noted earlier from objective measurements (Section 4.2.6). The probable reasons for the same have also been discussed in that section. The judges generally criticized the experimental samples for their slow meltdown. The same reasons explained under section 4.2.6.2 may be considered for the lower melting quality scores obtained in this part of the study. However, as was explained earlier in this section, the very "slow melt down", is frequently accompanied by body defect like soggy, gummy, etc. (Arbuckle, 1977) and so was the case with experimental sample J3. Excessive level of stabilizer/ emulsifier has been considered partly responsible for such defects (Sommer, 1951 and Arbuckle, 1977). The hydrocolloids inherent in ginger might be acting in this regard. Hence, possibility exists to verify such phenomenon, by decreasing the level of stabilizer in ice cream containing ginger in one form or the other. Further, it can be seen from this part of the study that though all experimental samples scored less average marks compared to control, J1, J2 and J3 obtained 86.6, 82.8 and 76.6 per cent

marks (out of 5) respectively. Therefore, J1 and J2 can be considered as good and J3 as fair product from melting quality view point (Section 4.2.1.1).

4.2.8.5 Colour

4.2.8.5.1 In case of colour scores, very marginal and inconsistent changes were observed in experimental samples and these changes were not found to produce any significant effect on the colour of ice cream as evaluated by subjective methods. All the experimental samples scored more than 96 per cent marks of the total colour score (out of 5).

4.2.9 The main purpose of this part of study was to select the most preferred level of ginger juice from the various levels employed in this study which could be used in the manufacture of home made ice cream possessing the optimum flavour, taste etc. It can be seen from Table 4.5 that J2 maintained its superiority over all other samples in relation to flavour and body and texture. The colour changes were not found to have any hitch on the acceptability of J2 compared to others. On the other hand, the melting quality score tended to decrease with increased level of incorporation of ginger juice in ice cream. However, it can be seen from the total score that J2 had significantly higher score than the rest of the samples. Thus, on the basis of average total score values the ice cream containing ginger juice @ 4 per cent (J2) was preferred the most. The preference of J1 was almost similar to that of control as indicated by non-distinguishable difference in the

total score ($P > 0.05$). Hence, the level of addition of ginger juice @ 4 per cent by weight of ice cream mix was selected and employed for further study in phase II (i.e. comparing selected level of different forms of ginger in home made ice cream) and phase III (i.e. comparing selected level of different forms of ginger in factory made ice cream). All the experimental samples scored more than 84 per cent marks of the total score (out of 85) and hence can be considered as good products as per ISI grading suggested (Section 4.2.1.1).

4.3 SELECTION OF LEVEL OF DRIED GINGER POWDER IN HOME MADE ICE CREAM

4.3.1 Considering the variation in the quality of dried ginger, six samples of whole dried ginger were procured from the local market at Anand. These samples were ground to a fine powder in a grinding mill. Basic ice cream mix adopting the procedure and having the composition as described in Section 3.4.1 was prepared. In the selection of the dried ginger powder to be employed for the present study, all the ginger powders were used individually at the rate of 1 per cent in the aged ice cream mix. After thorough mixing, these samples were subjected to sensoric evaluation by the panel of six judges. Based on such preliminary screening, whole dried ginger which was preferred the most was purchased in bulk and powder was prepared from that lot and was used throughout the study. One of the dried ginger powder employed during the preliminary screening was reported to give a slight bitter

taste to the ice cream mix which clearly indicates the importance of proper selection of dried ginger intended for its use in ice cream.

4.3.1.1 In this part of the study home made ice cream was prepared using ginger powder at three different levels i.e. 0.5 (P1), 1 (P2) and 1.5 (P3) per cent. These levels were selected based on preliminary screening. Vanilla was used as the flavouring ingredient in control (C). The experiment was replicated thrice. In each replication, four batches of ice cream were prepared. The products prepared in this part of the study were subjected to analysis as mentioned in Section 4.2.1. The results obtained are delineated and discussed here under.

4.3.2 EFFECT OF VARYING LEVELS OF DRIED GINGER POWDER ADDITION ON THE COMPOSITIONAL ATTRIBUTES, ACIDITY AND pH OF HOME MADE ICE CREAM

4.3.2.1 The control (C) as well as experimental samples (P1, P2 and P3) were analysed for their fat, protein, reducing sugars, non reducing sugars, total solids, acidity content and pH values. The results were statistically analyzed and are presented in Table 4.6.

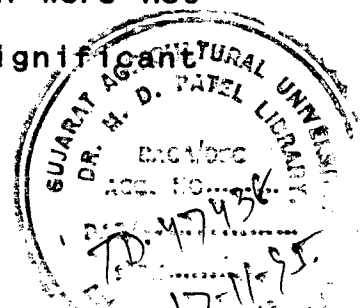
4.3.2.2. The average values of the compositional characteristics i.e. fat, protein, reducing sugars, non reducing sugars and total solids as well as acidity and pH of control (C) as well as experimental samples (P1, P2 and P3) are presented in Table 4.6. The average moisture content and

Table 4.6 Influence of varied levels of ginger powder on the average compositional characteristics, pH and acidity of home made ice cream

Level of addition of ginger powder in ice cream mix (% w/w)	Percentage of ice cream constituents			Titrate-ble acidity (% lactic acid)	pH		
	Fat	Protein	Non-reducing sugars				
0 (C)	11.89	4.12	5.22	14.90	38.25	0.199	6.35
0.5 (P1)	11.85	4.15	5.25	14.83	38.54	0.204	6.36
1 (P2)	11.72	4.16	5.25	14.75	38.85	0.201	6.33
1.5 (P3)	11.61	4.22	5.26	14.78	39.19	0.207	6.26
Statistical analyses							
SEM	0.04	0.041	0.022	0.042	0.036	0.001	0.015
CD (0.05)	0.12	NS	NS	NS	0.105	NS	NS
C.V.%	0.83	1.72	1.02	0.50	0.23	1.03	0.32

crude protein content of ginger powder used were 10.85 and 11.8 per cent respectively (Appendix IV). The average fat, protein, reducing sugars, non reducing sugars and total solids of experimental samples of ice cream ranged from 11.61 (P3) to 11.85 (P1), 4.15 (P1) to 4.22 (P3), 5.25 (P1 and P2) to 5.26 (P3), 14.75 (P2) to 14.83 (P1) and 38.54 (P1) to 39.19 (P3) per cent respectively. The acidity (as per cent lactic acid) and pH of the experimental samples ranged between 0.201 (P2) to 0.207 (P3) and 6.26 (P3) to 6.36 (P1) respectively. There was a marginal decline in fat content in the experimental samples (0.04 to 0.28 per cent) on addition of ginger powder compared to control. A similar trend was noted earlier in case of ice cream containing ginger juice. However, in comparison to the addition of ginger juice, a marginal increase was observed in protein and total solids content of ice cream containing dried ginger powders. However, the influence of addition of ginger powder was similar to the addition of ginger juice on the acidity and pH (Section 4.2.2), where marginal increase and decrease was noted respectively.

4.3.2.3 The addition of ginger powder was observed to increase the total solids content marginally but significantly ($P < 0.05$) as is revealed by the statistical values given in Table 4.6. However, the significant influence of the ginger powder addition on fat was evident at 1 per cent (P2) and 1.5 per cent (P3) level of addition only. The protein, reducing sugars, non reducing sugar content, acidity and pH were not profoundly affected as is revealed by the insignificant



changes in these values.

4.3.2.4 The addition of dried ginger powder resulted in product which had the average values for the compositional parameters, acidity and pH within the range of reported literature values. The increase in protein and total solids content and decrease in fat content of the experimental samples compared to control can be attributed to the elevated levels of the former two constituents and the lower levels of the latter component in the dried ginger powder compared to those of ice cream mix. As has been discussed earlier (Section 4.2.2.4), the composition of the dried ginger may be considered in computing the quantities of raw materials required for making ice cream mix.

4.3.3 EFFECT OF VARYING LEVELS OF GINGER POWDER ADDITION ON THE VISCOSITY OF ICE CREAM MIX

4.3.3.1 The influence of the dried ginger powder on the viscosity of ice cream mix has been described and discussed in this section. The results obtained are presented in Table 4.7.

4.3.3.2 The average values of the viscosity for experimental samples as delineated in Table 4.7 ranged from 178.3 (P1) to 195.2 centipoise (P3). The average viscosity of control was 171.7 centipoise. Similar to the earlier observations based on the addition of ginger juice (Section 4.2.3), the viscosity of ice cream mixes tended to increase with increasing level of addition of ginger powder.

Table 4.7 Influence of varied levels of ginger powder on the average viscosity and whipping ability of home made ice cream

Level of addition of ginger powder in ice cream mix (% w/w)	Viscosity in centipoise at 7°C	Whipping ability (cubic cm/ g) after a whipping time of		
		0 min.	3 min.	5 min.
0 (C)	171.7	0.915	1.254	1.203
0.5 (P1)	178.3	0.926	1.247	1.197
1 (P2)	186.7	0.927	1.249	1.187
1.5 (P3)	195.2	0.928	1.223	1.165
Statistical analyses				
SEM	2.887	0.002	0.013	0.013
CD (0.05)	9.4	NS	NS	NS
C.V.%	2.85	0.65	2.59	2.74

4.3.3.3 Incorporation of ginger powder did not increase the viscosity of ice cream mix significantly when added at 0.5 per cent level. At higher levels i.e. P2 and P3, the increase in viscosity was found to be significant. 4.3.3.4 The effect of ginger solids on the viscosity has been discussed at length in Section 4.2.3.4. However, the increase in viscosity observed in case of ice cream mixes containing ginger juice was comparatively very high (i.e. from 181.7 centipoise for C to 241.6 centipoise for J3) than that observed in ice cream containing dried ginger powder (i.e. from 171.7 centipoise for C to 195.2 centipoise for P3). The ginger juice employed in ice cream mix earlier (Section 4.2) contained only 15.37 ± 0.59 per cent total solids. The sun drying of fresh ginger in order to obtain the ginger powder might have adversely affected the water binding capacity of the starch and other hydrocolloids contained in the ginger. The form and status of ginger solids present in ginger powder might be responsible for the varying rate of increase in viscosity. The relatively lower increase in viscosity observed during this part of the study may also be attributed, again in part to the reduced solubility of ginger powder particles in the ice cream mix.

4.3.4 EFFECT OF GINGER POWDER ON THE WHIPPING ABILITY OF ICE CREAM MIX

4.3.4.1 Table 4.7 depicts the average values of the whipping ability of ice cream mixes (C, P1, P2 and P3) expressed as specific volume (cubic cm / g).

4.3.4.2 The average values of specific volume (cubic cm / g) of unwhipped samples showed a linear increase from 0.915 for C to 0.928 for P3. The trend of rise in specific volume upto 3 min. whipping and the subsequent decrease at 5 min. whipping was similar to the one observed earlier (Section 4.2.4) in case of ginger juice.

4.3.4.3 The statistical values arrived at on the basis of this data, depicted in Table 4.7 indicated no significant effect of addition of ginger powder on the specific volume and thus the whipping ability of the ice cream mix.

4.3.4.4 The effect of ginger juice, on the specific volume has been discussed earlier in Section 4.2.4.4. However, the quantitative differences observed in the specific volume in this and earlier part may be attributed to the form, status and concentration of ginger solids as has been discussed earlier in Section 4.4.3.4.

4.3.5 EFFECT OF GINGER POWDER ON THE PER CENT OVERRUN OF ICE CREAM

4.3.5.1 The effect of addition of dried ginger powder at different levels i.e. P1, P2 and P3 on the overrun of ice cream is discussed and delineated in this section.

4.3.5.2 The average values of per cent overrun of ice cream (C, P1, P2 and P3) are presented in Table 4.8. It is evident from the table that with increasing level of addition of ginger powder, the per cent overrun of experimental samples

Table 4.8 Influence of varied levels of ginger powder on the average overrun and melting characteristics of home made ice cream

Level of addition of ginger powder in ice cream mix (% w/w)	Overrun (%)	Quantity of ice cream melted in 40 min. at 37.5 °C per 100 g (g)
0 (C)	47.63	43.53
0.5 (P1)	46.10	38.50
1 (P2)	43.97	35.70
1.5 (P3)	42.90	31.37
Statistical analyses		
SEM	0.5	0.809
CD (0.05)	1.58	2.64
C.V.%	2.71	3.76

decreased from 46.1 per cent (P1) to 42.9 per cent (P3). The overrun of all the experimental samples were lower than that of control i.e. 47.65 per cent. The per cent overrun of ice cream tended to decrease from 50.27 per cent for control to 39.29 per cent for J3 (containing ginger juice at 5 per cent level).

4.3.5.3 From the statistical values displayed in Table 4.8, it can be seen that incorporation of ginger powder did not affect overrun per cent significantly ($P > 0.05$) when added at 0.5 per cent (P1) rate. However, 1 per cent (P2) and 1.5 per cent (P3) addition of ginger powder was found to adversely affect the overrun in the resultant product significantly ($P < 0.05$). P2 had significantly ($P < 0.05$) lower overrun than P1; however, it was statistically ($P > 0.05$) at par with P3.

4.3.5.4 The lower overrun in experimental samples may be ascribed to the higher viscosity of such mixes as discussed in detail in Section 4.2.5.4. It could also be partly due to the interference posed by more number of suspended ginger powder particles on the air cell lamellae of the experimental ice creams.

4.3.6 EFFECT OF GINGER POWDER ON THE MELTING RESISTANCE OF ICE CREAM

4.3.6.1 The control (C) as well as experimental samples (P1, P2 and P3) were evaluated for their melting resistance in terms of g of ice cream melted in 40 min. at 37.5°C per 100 g ice cream. The relevant results are described and discussed in

this section.

4.3.6.2 As is evident from Table 4.8, all the experimental samples had higher melting resistance compared to the control. The meltdown of experimental samples was in the range of 31.37 (P3) to 38.50 (P1) as against 45.53 (g of ice cream melted in 40 min. at 37.5 C per 100 g ice cream) for control. Comparing these values with those obtained for ice cream containing ginger juice (Table 4.3), the trend is found similar in both cases.

4.3.6.3 All the experimental samples had significantly lower meltdown values than that of control. The experimental samples i.e. P1, P2 and P3 were found to be distinguishable statistically in this respect.

4.3.6.4 The higher melting resistance of experimental samples over control could be due to the higher starch content resulting from incorporation of higher amounts of ginger powder which may have contributed to over stabilization of the ice cream mix, especially at higher levels of addition as has been discussed earlier in Section 4.4.3.4. Moreover, the increased total solids, owing to the solids contributed by ginger powder, though marginal, might be having a bearing on such property.

4.3.7 EFFECT OF GINGER POWDER ON THE BACTERIAL COUNT OF ICE CREAM

4.3.7.1 Table 4.9 depicts the average SPC per g of ice cream for control as well as experimental products.

4.3.7.2 The average Standard Plate Count (SPC) of control (C) sample was 47200 per g. The experimental samples were associated with marginally higher counts compared to control; viz. ranging from 52700 (P1) to 56600 (P2).

4.3.7.3 From the C.D. values given in Table 4.9 it can be seen that none of the ice cream samples could be distinguished statistically ($P > 0.05$) with respect to their bacterial count.

4.3.7.4 In contrast to the ice cream containing ginger juice (Table 4.4), higher SPC was encountered in the product containing ginger powder. The related aspects have been discussed earlier in Section 4.2.7.4. There are also reports in literature that natural spices in dried forms are heavily loaded with microorganisms and molds, many in spore forms (Fabian et al., 1939; Warmbrod and Fry, 1966; Pintauro, 1971; Hadlok and Toure, 1973; Staniforth, 1973 and Heath, 1978). This, at least in part, could be ascribed to the increase in bacterial load in experimental samples. The sundrying could have led to destruction of some constituent of ginger which otherwise exhibited antibacterial activity as was evinced from Section 4.2.7 (for ginger juice). Further, the exposure of ginger to the atmosphere for drying purpose might have been

Table 4.9 Influence of varied levels of ginger powder on the average bacterial count of freshly prepared home made ice cream

Level of addition of ginger powder in ice cream mix (% w/w)	Average SPC per g ice cream (log cfu)
0 (C)	4.674 (47200)
0.5 (P1)	4.722 (52700)
1 (P2)	4.753 (56600)
1.5 (P3)	4.746 (55700)
Statistical analyses	
SEM	0.042
CD (0.05)	NS
C.V.%	0.82

(Figures in parentheses show actual cfu values)

responsible for manifestation with spore forming air-borne microorganisms.

4.3.8 EFFECT OF GINGER POWDER ON THE SENSORIC ATTRIBUTES OF FRESHLY PREPARED HOME MADE ICE CREAM

4.3.8.1 For selecting the preferred level of ginger powder to be added to the ice cream mix from the 3 levels employed in this study, the sensoric evaluation of all the samples was performed. The results obtained upon use of ginger powder are encompassed in this section. The results depicted in Table 4.10 represent the influence of addition of ginger powder at various levels: 0.5 (P1), 1 (P2) and 1.5 (P3) per cent on the organoleptic attributes of ice cream as adjudged by the panel of 6 judges in terms of flavour, body and texture, melting quality and colour scores. The values given in Table 4.10 represent the root X values, while the transformed average scores are placed in the parentheses.

4.3.8.2 Flavour

4.3.8.2.1 The average flavour score for control was 36.83. As is evident from Table 4.10, the flavour of experimental ice cream containing 1 per cent added ginger powder was preferred the most while the other two levels employed were found to result in a slightly inferior product on the basis of the average flavour scores.

4.3.8.2.2 All the ice cream samples, except C and P1, could be distinguished statistically ($P < 0.05$). From the statistical

Table 4.10 Influence of varied levels of ginger powder on the average organoleptic characteristics of home made ice cream

Level of addition of ginger powder in ice cream mix (% w/w)	Flavour (45)	Body and texture (30)	Melting characteristics (5)	Colour (5)	Total (85)
0 (C)	6.069 (36.83)	5.153 (26.55)	2.160 (4.66)	2.192 (4.80)	8.535 (72.84)
0.5 (P1)	6.051 (36.61)	5.088 (25.89)	2.088 (4.36)	2.081 (4.33)	8.437 (71.19)
1 (P2)	6.142 (37.72)	5.033 (25.33)	2.068 (4.28)	2.054 (4.22)	8.459 (71.55)
1.5 (P3)	6.009 (36.11)	4.989 (24.89)	2.020 (4.08)	2.033 (4.13)	8.319 (69.21)

Statistical analyses

SEM	0.009	0.016	0.019	0.022	0.026
CD (0.05)	0.026	0.046	0.055	0.064	0.078
C.V.%	0.44	0.95	2.76	3.17	1.98

(The reported values given in parantheses show squared values i.e actual average score)

analysis of the flavour scores obtained during this part of the investigation, the superiority of P2 (i.e. ice cream containing 1 per cent level of ginger powder) is confirmed, which was even preferred over control containing vanilla as the flavouring agent.

4.3.8.2.3 Amongst experimental samples P1 was criticized for lacking in the desired ginger flavour whereas P3 was criticized for having harsh, strong, excessive pungent flavour and intense spicy after taste. None of the levels of ginger powder employed in this study was found to adversely affect the perception of sweetness in ice cream.

4.3.8.2.4 Thus, addition of ginger powder at 1.0 per cent could be selected from the three levels tested in this study, on the basis of flavour characteristics. It can also be seen that though P1 and P3 scored lower average marks for flavour compared to control, the minimum flavour score was at least 80.2 per cent (in P3) of the total score allotted to flavour (i.e. maximum score of 45). Thus considering the ISI guidelines for sensory evaluation and grading of products (Section 4.2.1.1), P1 and P3 can also be graded as good products flavourwise.

4.3.8.3 Body and texture

4.3.8.3.1 In the case of ginger powder, the body and texture scores tended to decrease marginally with increasing level of ginger powder addition. These results are in contrast to the earlier study (Table 4.5) where there was an increase in body

and texture scores when ginger juice was added upto 4 per cent level; further addition led to decline in the body and texture scores.

4.3.8.3.2 From the relevant statistical analysis it can be seen that control had significantly higher body and texture scores than any of the experimental samples; even such a marginal decrease in the body and texture score was found to be significant at each level of addition, except amongst P2 and P3, which were rated at par with each other ($P > 0.05$).

4.3.8.3.3 Thus, incorporation of ginger powder in ice cream was found to be slightly detrimental to the body and texture characteristics. The decrease in body and texture scores in experimental samples was mainly attributed to the presence of coarse ginger particles as well gummy body. The coarseness associated with the experimental samples was ascribed to the undissolved powder particles which was detrimental to 'eating quality'. The body and texture was not uniform through out the ice cream mass which may be due to the uneven distribution of ginger powder. The scope of mixing ginger powder in ice cream mix at elevated temperature for its efficient mixing may need further investigations. P3 which had minimum body and texture score, obtained 83 per cent marks of the maximum body and texture score (i.e. 30) and hence can be considered a good product as per suggested ISI grading (Section 4.2.1.1).

4.3.8.4 Melting quality

4.3.8.4.1 The average melting quality score for control was 4.67 while that of experimental samples ranged from 4.08 (P3) to 4.36 (P1) (Table 4.10). There was a progressive decrease in the melting quality scores with increasing rate of addition of ginger powder. Similar trend was also observed in case of ice cream made utilizing ginger juice (Table 4.5).

4.3.8.4.2 The average melting quality score of the control was significantly higher than any of the experimental samples as is evident from the C.D. values given in Table 4.10. The melting quality scores of P1 vs P2 and P2 vs P3 were statistically alike ($P > 0.05$). Even such a steady and marginal decrease in melting score observed for experimental samples compared to control was found to be statistically distinguishable ($P < 0.05$) (Table 4.10).

4.3.8.4.3 The decrease in melting quality score of experimental samples was owing to the delayed melting which was also evident from their lower melting rates (Section 4.3.6). The delayed melting could be due to the over stabilization contributed by the increased total solids and starch content provided by the ginger powder, as discussed in detail earlier in Section 4.2.8.4. The settling of ginger powder particles however led to a curdy meltdown in specific portion of ice cream, especially at higher level of addition of ginger powder. Even though all the experimental samples scored lower average marks compared to control, P1, P2 and P3

obtained 87.2, 85.6 and 81.6 per cent marks respectively of the total melting quality scores and thus could be considered as good product with respect to melting quality scores as per suggested ISI grading (Section 4.2.1.1).

4.3.8.5 Colour scores

4.3.8.5.1 The mean colour scores of ice cream containing 0.5, 1.0 and 1.5 per cent ginger powder presented in Table 4.10 indicates that the experimental ice creams scored less marks compared to control. There was a proportionate decrease in colour score of experimental samples with increasing level of addition of ginger powder; the colour score decreased from 4.33 (P1) to 4.13 (P3). However, the overall magnitude of decrease observed was only 0.67.

4.3.8.5.2 The critical difference calculated (Table 4.10) indicate that addition of ginger powder had a very slight but significant ($P < 0.05$) effect on the colour scores. However, the colour scores of P1, P2 and P3 were indistinguishable statistically ($P > 0.05$).

4.3.8.5.3 All the experimental samples were criticized for their dull, brownish colour as against control which was white and glossy. The panel objected to the presence of suspended brown particles which resulted in the dulling of the colour in all the experimental samples; higher levels of ginger powder addition culminated in exerting a more adverse effect. Addition of requisite brown colour to the mix could probably enable overcoming such shortcoming. The efficient mixing of

ginger powder particles in ice cream mix during its pasteurization treatment or with the aid of any such similar thermal treatment may also be helpful. P1, P2 and P3 scored 86.6, 84.4 and 82.6 per cent marks respectively of the maximum colour score (i.e. 5) and hence, as per ISI guidelines for grading the product can be graded as good products (Section 4.2.1.1).

4.3.9 The primary goal of this part of the study was to develop an ice cream using specific level of ginger powder so as to obtain optimum taste and other characteristics. It is evident from these observations (Table 4.10) that ice cream made from mix containing 1 per cent ginger powder resulted in superior flavoured product amongst the experimental samples. Also, it can be seen from the C.D. calculations of the total score that the score of sample P2 was not distinguishable from that of control ($P > 0.05$). Addition of ginger powder at 1 per cent level also did not have any adverse effect on the compositional attributes, pH and acidity of ice cream. Nevertheless, it led to dulling of the colour and the product tended to whey-off during melting. Probably incorporation of caramel as brown colouring agent and carrageenan at 0.01 per cent could be added to prevent wheying off. All the experimental samples scored more than 81 per cent marks of the total score (out of 85) and hence can be considered as good products as per suggested ISI grading (Section 4.2.1.1). Hence, ice cream made with 1 per cent ginger powder was selected for further use in the investigation.

4.4 SELECTION OF LEVEL OF UNTREATED GINGER SHREDS IN HOME MADE ICE CREAM

4.4.1 Fresh, green ginger was procured from the local market at Anand. Care was taken to select ginger which had reasonably lower fibre content. The ginger was peeled, washed and shredded finely in a shredder attachment of Gopi mixer. Preliminary trials were conducted to select the levels of ginger shreds to be employed in this investigation. Based on such preliminary trials, three levels of addition of ginger shreds were selected i.e. 4 (S1), 6 (S2) and 8 (S3) per cent. The shreds were added at the freezer to the partially frozen mix for ensuring its even distribution without disintegration. In each replication, four batches of ice cream were prepared i.e. C, S1, S2 and S3. In all, three replications were attempted preparing finally i.e. in all 12 batches of ice cream. The products prepared during this part of the study were subjected to certain physico-chemical and sensory analysis as described earlier in Section 4.2.1.

4.4.2 EFFECT OF ADDITION OF GINGER SHREDS ON THE COMPOSITIONAL ATTRIBUTES, ACIDITY AND pH OF HOME MADE ICE CREAM

4.4.2.1 The significance of studying the effect of addition of ginger as juice and powder in ice cream on the compositional attributes, acidity and pH has already been delineated earlier in Section 4.2.2 and 4.3.2 respectively. Similarly, the effect of using ginger in the form of shreds is covered in this

Table 4.11 Influence of varied levels of ginger shreds on the average compositional characteristics, pH and acidity of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Percentage of ice cream constituents				Titrate-ble acidity (% lactic acid)	pH	
	Fat	Protein	Reducing sugars	Non-reducing sugars			
0 (C)	11.90	4.07	5.24	14.91	38.18	0.197	6.38
4 (S1)	11.62	3.98	5.16	14.83	37.50	0.199	6.38
6 (S2)	11.42	3.95	5.07	14.77	37.12	0.204	6.38
8 (S3)	11.18	3.89	4.99	14.71	36.73	0.207	6.37
Statistical analyses							
SEM	0.039	0.057	0.033	0.023	0.062	0.003	0.031
CD (0.05)	0.11	NS	0.1	0.07	0.19	NS	NS
C.V.%	0.82	0.61	1.60	0.37	0.41	2.02	0.68

section. The sample of ice cream mix or ice cream containing ginger shreds was given special treatment for ensuring uniform distribution of as has been described earlier (Section 3.8.11).

4.4.2.2 The average fat, protein, reducing sugars, non reducing sugars, total solids, acidity and pH of control as well as experimental samples have been presented in Table 4.11. It can be seen that there was a marginal decrease in fat, protein, reducing sugars, non reducing sugars and total solid content and pH values and a marginal increase in the acidity of the experimental samples. The differences in these values of experimental samples widened with increasing rate of addition of ginger shreds. A similar trend was also noted earlier in ice cream containing different levels of ginger juice.

4.4.2.3 Notwithstanding the marginal differences, the incorporation of ginger shreds significantly decreased ($P < 0.05$) the compositional attributes except for protein content. Further, it can be seen from the calculated statistical values (Table 4.11) that the levels of ginger shreds employed had also statistically distinguishable ($P < 0.05$) effect on the compositional parameters in general. No significant differences in acidity and pH values was evident between control and experimental samples. Nevertheless, acidity was marginally higher and pH was slightly lower in experimental samples compared to control as was evident previously also (Section 4.2.2 and 4.3.2).

4.4.2.4 The compositional attributes of all the experimental samples satisfies the legal standards (PFA, 1955) as well as BIS standards. Similarly, the acidity of all the samples were well within the limits specified by BIS (IS, 1970) for plain ice cream. Discussion on the probable reasons for the change in compositional attributes has already been detailed earlier under Section 4.2.2.4.

4.4.3 EFFECT OF ADDITION OF GINGER SHREDS ON THE VISCOSITY OF ICE CREAM MIXES

4.4.3.1 The influence of addition of ginger shreds at different levels i.e. S1, S2 and S3 on the viscosity of ice cream mixes is discussed and delineated in this section.

4.4.3.2 Table 4.12 indicates the average values of viscosity of ice cream mixes as influenced by the level of addition of ginger shreds. The average viscosity of control mix (C) was 174.2 centipoise. The viscosity of experimental mixes progressively increased with increasing level of addition of ginger shreds and reached a maximum at 8 per cent level of addition (i.e. S3). Similar trend was observed earlier in ice cream samples containing ginger in the form of juice (Section 4.2.3.2) and powder (Section 4.3.3.2). However, in this case the rate of increase over control was considerably higher (95 to 128.3 centipoise) than that observed earlier in case of ginger juice (19.9 to 59.9 centipoise) or ginger powder (6.6 to 23.5 centipoise).

Table 4.12 Influence of varied levels of ginger shreds on the average viscosity and whipping ability of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Viscosity in centipoise at 7 °C	Whipping ability (cubic cm/ g) after a whipping time of		
		0 min.	3 min.	5 min.
0 (C)	174.2	0.918	1.222	1.173
4 (S1)	269.2	0.922	1.167	1.142
6 (S2)	283.3	0.927	1.145	1.110
8 (S3)	302.5	0.929	1.122	1.047
Statistical analyses				
SEM	5.017	0.004	0.006	0.007
CD (0.05)	14.81	NS	0.016	0.021
C.V.%	4.77	0.30	1.16	1.57

4.4.3.3 It is evident from the relevant statistical analysis that incorporation of ginger shreds significantly ($P < 0.05$) increased the viscosity of experimental samples. Except for the viscosity values of S1 and S2, all the remaining values were statistically different from each other ($P < 0.05$).

4.4.3.4 The probable reasons for the increased viscosity of experimental mixes has already been discussed earlier in Section 4.2.3.4 and Section 4.3.3.4. However, higher rate of increase observed in this case may be due to presence of ginger shred containing fibres in the mix.

4.4.4 EFFECT OF ADDITION OF GINGER SHREDS ON THE WHIPPING ABILITY OF ICE CREAM MIXES

4.4.4.1 The influence of addition of ginger shreds at different levels i.e. S1, S2 and S3 on the whipping ability, expressed as specific volume (cubic cm / g), of the aged ice cream mixes was monitored within 2 h of addition of shreds. The relevant results are discussed and described hereunder in this section.

4.4.4.2 Table 4.12 depicts the average values of whipping ability of ice cream mixes expressed as specific volume as influenced by the varying levels of addition of ginger shreds in ice cream mix. The specific volume of all the experimental unwhipped samples were marginally higher than that of control. It is also evident from the table that the specific volume values increased after whipping the mixes for 3 min., followed by a decrease at 5 min. on further whipping. This trend was

similar to that observed in case of ginger used either in the form of juice or powder.

4.4.4.3 The statistical values, determined on the basis of these data depicted in Table 4.12 indicate no significant effect of addition of ginger shreds on the whipping ability of unwhipped samples. However, the specific volumes after 3 and 5 min. whipping period were statistically distinguishable. Similar trend was also observed in case of ginger juice (Section 4.2.4).

4.4.4.4 The use of ginger, either in the form of juice, powder or shreds exhibited similar pattern with regard to specific volume. The effect of ginger added in the form of ginger juice, on the specific volume has already been discussed earlier in Section 4.2.4.4 and the same may hold true for shreds as well.

4.4.5 EFFECT OF ADDING GINGER SHREDS AT PREDETERMINED LEVELS ON THE OVERRUN OF ICE CREAM

4.4.5.1 The influence of addition of ginger shreds at different levels i.e. 4, 6 and 8 per cent (i.e. S1, S2 and S3) on the overrun of ice creams is discussed and delineated in this section.

4.4.5.2 The data presented in Table 4.13 represent the average values of overrun in ice cream samples expressed as per cent overrun, as influenced by the level of addition of ginger shreds. The average overrun per cent in control was maximum

Table 4.13 Influence of varied levels of ginger shreds on the average overrun and melting characteristics of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Overrun (%)	Quantity of ice cream melted in 40 min. at 37.5 C per 100 g (g)
0 (C)	42.58	42.82
4 (S1)	40.86	30.58
6 (S2)	39.66	23.68
8 (S3)	37.97	21.28
Statistical analyses		
SEM	0.585	1.19
CD (0.05)	1.73	3.52
C.V.%	3.56	9.85

(i.e. 42.6 per cent). The tabulated results reveal that addition of ginger shreds decreased the overrun in resultant ice cream; the effect being marked with higher levels of addition.

4.4.5.3 The overrun of control was at par with that of S1 whereas S2 and S3 had significantly lower overrun than control.

4.4.5.4 The probable reasons for the lower overrun associated with the experimental samples have been already discussed earlier in Section 4.2.5.4 and Section 4.3.5.4. Moreover, the shreds may themselves be responsible to some extent in decreasing the overrun by weakening the air cell lamellae.

4.4.6 EFFECT OF GINGER SHREDS ON THE MELTING RESISTANCE OF ICE CREAM

4.4.6.1 The influence of incorporation of varying levels of ginger shreds on the melting resistance of ice cream is discussed in this section.

4.4.6.2 The melting resistance of ice cream samples containing ginger shreds increased progressively with increasing rate of addition of ginger shreds. The results obtained in this part of the study followed a similar trend as has been witnessed earlier in case of ginger juice (Section 4.2.6.2) and ginger powder (Section 4.3.6.2). However, the increase in melting resistance was comparatively higher in this case compared to that noted earlier in Section 4.2.6.2 and Section 4.3.6.2.

4.4.6.3 All the experimental samples containing ginger shreds had significantly lower meltdown values as compared to control ($P < 0.05$). Amongst experimental samples, ice cream samples S2 and S3 were statistically undistinguishable ($P > 0.05$) with regard to the melting resistance.

4.4.6.4 Thus, it can be seen that the use of ginger in any form i.e. juice, powder or shreds was found to cause increased melting resistance of ice cream (i.e. lower melting rate values). The comparatively higher melting resistance evinced in case of samples containing ginger shreds compared to use of juice or powder stems from the fact that shreds led to profound increase in the mix viscosity as is evident on comparing Table 4.12 with Tables 4.2 and 4.7.

4.4.7 EFFECT OF GINGER SHRED ADDITION ON THE BACTERIAL COUNT OF ICE CREAM

4.4.7.1 Table 4.14 depicts the average Standard Plate Count per g of ice cream as influenced by the level of addition of ginger shreds in ice cream. gin

4.4.7.2 The experimental samples showed marginally lower counts compared to control.

4.4.7.3 None of the ice cream samples could be distinguished statistically ($P > 0.05$) for the Standard Plate Count.

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4.5.7.4 A similar trend was observed earlier in ice cream containing ginger juice (4.2.7). The related aspects have

Table 4.14 Influence of varied levels of ginger shreds on the average bacterial count of freshly prepared home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Average SPC per g ice cream (log cfu)
0 (C)	4.574 (37500)
4 (S1)	4.524 (33400)
6 (S2)	4.5390 (34600)
8 (S3)	4.561 (36400)

Statistical analyses

SEM	0.022
CD (0.05)	NS
C.V.%	1.18

(Figures in parentheses show actual cfu values)

already been discussed earlier in Section 4.2.7.4.

4.4.8 EFFECT OF ADDITION OF GINGER SHREDS AT DIFFERENT LEVELS ON THE SENSORIC QUALITY OF HOME MADE ICE CREAM

4.4.8.1 To select the preferred level of ginger shreds in ice cream from the three levels tested sensoric evaluation was done. The results obtained are encompassed hereunder. The results presented in Table 4.15 depicts the influence of addition of ginger shreds on the organoleptic attributes of home made ice cream.

4.4.8.2 Flavour

4.4.8.2.1 It can be seen from Table 4.15 that S1 (containing 4 per cent shreds) was preferred the most scoring 38.44 marks followed by S2, C and S3.

4.4.8.2.2 From the statistical analysis it can be seen that flavourwise C, S2 and S3 were indistinguishable. 4.4.8.2.3 Sample S1 had the optimum flavour of ginger whereas S2 and S3 were often criticized for excessive pungency and harsh flavour; the effect was marked with increased rate of addition of shreds. With respect to flavour score, S1 (i.e. 4 per cent shred) was found to be the most acceptable. During sensoric evaluation, the judges reported and criticized the chewy, fibrous character of the shreds which was especially evident when present at higher levels. Furthermore, pungency of shred in ice cream was also objected to some extent by the judges especially at higher levels. It can also be seen from

Table 4.15 Influence of varied levels of ginger shreds on the average organoleptic characteristics of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Flavour (45)	Body and texture (30)	Melting characteristics (5)	Colour (5)	Total (85)
0 (C)	6.069 (36.83)	5.164 (26.67)	2.172 (4.72)	2.198 (4.83)	8.574 (73.05)
4 (S1)	6.200 (38.44)	5.244 (27.50)	2.081 (4.33)	2.211 (4.89)	8.669 (75.16)
6 (S2)	6.083 (37.00)	5.318 (28.28)	2.034 (4.14)	2.198 (4.83)	8.617 (74.25)
8 (S3)	6.051 (36.61)	5.132 (26.34)	1.957 (3.83)	2.204 (4.86)	8.464 (71.64)

Statistical analyses

SEM	0.009	0.013	0.018	0.014	0.19
CD (0.05)	0.027	0.037	0.052	NS	0.058
C.V.%	0.45	0.73	2.60	1.97	1.93

(The reported values given in parantheses show squared values i.e. actual average score)

the flavour score that S3, though scored less marks compared to C, scored 81.4 per cent of the total score awarded to flavour (i.e. 45). Thus, considering ISI guidelines for grading of products, it can be considered as good product flavourwise (Section 4.2.1.1).

4.4.8.3 Body and texture

4.4.8.3.1 Incorporation of the shreds in ice cream was found to improve body and texture when added upto a level of 6 per cent only; beyond which it hampered the score to values less than control.

4.4.8.3.2 Statistical analysis of the data indicated a significant improvement in the body and texture characteristics of ice cream when shreds were added upto a level of 6 per cent ($P < 0.05$) samples while C and S3 were rated at par ($P > 0.05$) with respect to their body and texture characteristics.

4.4.8.3.3 S1 and S2 had smoother body compared to control where as S3 was criticized for having gummy body owing to the excess quantum of shreds in S3 it led to more chewy and fibrous product. Still S3 obtained 87.8 per cent marks of the maximum body and texture score (i.e. 30), and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.4.8.4 Melting quality

4.4.8.4.1 The melting quality score for control was maximum, being 4.72 out of 5. The scores for melting quality of the experimental samples decreased very slightly (i.e. from 4.33 for S1 to 3.83 for S3) as the rate of addition of ginger shreds increased.

4.4.8.4.2 Notwithstanding a very marginal differences in the score, the samples were distinguishable statistically except for samples S1 and S2 which were found to be statistically similar ($P > 0.05$).

4.4.8.4.3 The experimental samples were generally criticized by the judges for their delayed meltdown. The discussion on this attribute has already been dealt earlier in Section 4.2.8.4.3.

4.4.8.5 Colour

4.4.8.5.1 The mean colour score of the ice cream samples varied within a very narrow range of 4.83 for C and S2 to 4.89 for S.

4.4.8.5.2 No significant differences in colour scores amongst any of the samples were observed ($P > 0.05$).

4.4.8.5.3 Addition of untreated ginger shreds did not have any adverse effect on the colour score of the ginger ice cream and judges did not object to the presence of shreds in ice cream.

4.4.9 From this part of the study, it is evident that amongst

all the levels tried, S1 (containing 4 per cent ginger shreds) resulted in a product having superior flavour score. The preference of ginger shreds in ice cream was in the order: S1 > S2 > S3. Additionally the total score of S1 was significantly higher than rest of the samples ($P < 0.05$). Hence, ice cream made with 4 per cent untreated ginger shreds was selected for further use in this study. All the experimental samples scored more than 84.3 per cent marks of the total score (out of 85) and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.5 SELECTION OF LEVEL OF TREATED GINGER SHREDS IN HOME MADE ICE CREAM

4.5.1 Considering the comments and criticisms of the untreated shreds in ice cream, an attempt was made to treat the shreds in boiling sugar syrup (Section 3.3.4), so that the chewiness of the shred particles could be reduced. Furthermore, the pungency imparted by the shreds in ice cream can also be brought down to an acceptable level. The treated, cooled (room temperature) shreds were incorporated in ice cream mix at 4, 6 and 8 per cent (i.e. T1, T2 and T3) levels respectively. The treated shreds were added to the partially frozen mix at the freezer itself. In all, 3 replications were done. In each replication, 4 batches of ice cream were manufactured i.e. C, T1, T2 and T3. The products prepared during this part of the investigation were also subjected to similar analyses as has been described in earlier sections.

4.5.2 EFFECT OF ADDITION OF VARIED LEVELS OF TREATED GINGER SHREDS ON THE COMPOSITIONAL ATTRIBUTES, ACIDITY AND pH OF HOME MADE ICE CREAM

4.5.2.1 The average compositional values, acidity and pH of control (i.e. C) as well as experimental samples (i.e. T1, T2 and T3) are presented in Table 4.16.

4.5.2.2 As evident from Table 4.16, there was a marginal decrease in the fat, protein, reducing sugar, non reducing sugar, total solids content and pH; and a slight increase in the acidity of experimental samples containing treated ginger shreds. Such difference were marked with increasing level of addition of treated ginger shreds. Similar trend was observed earlier in case of ice cream containing ginger juice and shreds (i.e. Section 4.2.2 and Section 4.3.2 respectively).

4.5.2.3 Incorporation of the treated ginger shreds tended to decrease significantly the fat and total solids of ice cream. The reducing sugars and non reducing sugars were also tended to decrease significantly at and above 6 per cent of ginger shreds in ice cream. On the other hand, protein which decreased slightly but was not significantly affected by addition of the treated shreds in the experimental ice cream samples. As observed earlier, there was a slight increase in acidity and decrease in pH values of experimental samples compared to control, but this difference was statistically indistinguishable ($P > 0.05$).

Table 4.16 Influence of varied levels of treated ginger shreds on the average compositional characteristics, pH and acidity of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Fat	Protein	Reducing sugars	Non-reducing sugars	Total solids	Titrate-ble acidity (% lactic acid)	pH
0 (C)	11.87	4.15	5.33	14.83	38.25	0.201	6.37
4 (T1)	11.57	4.06	5.23	14.75	37.78	0.205	6.36
6 (T2)	11.32	3.96	5.14	14.66	37.48	0.206	6.36
8 (T3)	11.07	3.92	5.06	14.58	37.04	0.206	6.36
Statistical analyses							
SEM	0.04	0.098	0.036	0.034	0.059	0.001	0.015
CD (0.05)	0.12	NS	0.11	0.10	0.18	NS	NS
C.V.%	0.85	3.43	1.68	0.56	0.38	1.04	0.34

4.5.2.4 The standards specified in our country for ice cream are met by all the experimental samples. However, care should be taken while formulating the basic ice cream mix to take into account the slight decrease in fat and total solid content which occurs when incorporating the treated shreds.

4.5.3 EFFECT OF TREATED GINGER SHREDS ON THE VISCOSITY OF ICE CREAM MIX

4.5.3.1 The influence of addition of treated ginger shreds at various levels on the viscosity of ice cream mix is discussed in this section.

4.5.3.2 The viscosity of experimental samples was considerably higher compared to that of control.

4.5.3.3 As evident from the Table 4.17, all the samples could be statistically distinguished from each other on the basis of their viscosity ($P < 0.05$). Similar increase in the viscosity of ice cream containing other forms of ginger (ie. juice, powder and untreated shreds) was also noticed earlier in Sections 4.2.3, 4.3.4 and 4.4.3 respectively. However, the increase in viscosity was most pronounced in ice cream containing treated ginger shreds.

4.5.3.4 The average starch content of ginger shreds used was 11.1 ± 0.26 per cent (Appendix V). Heating of ginger shreds in sugar syrup must have gelatinized the starch which might have led to the steep increase in viscosity as evinced in the experimental mixes. Since the average viscosity of

Table 4.17 Influence of varied levels of treated ginger shreds on the average viscosity and whipping ability of home made ice cream.

Level of addition of ginger shreds in ice cream mix (% w/w)	Viscosity in centipoise at 7 C	Whipping ability (cubic cm/ g) after a whipping time of		
		0 min.	3 min.	5 min.
0 (C)	184.2	0.913	1.230	1.173
4 (T1)	286.7	0.921	1.147	1.127
6 (T2)	330.2	0.926	1.113	1.095
8 (T3)	349.5	0.928	1.100	1.070
Statistical analyses				
SEM	9.199	0.001	0.006	0.004
CD (0.05)	27.2	0.002	0.015	0.013
C.V.%	8.54	0.14	1.06	0.94

experimental sample rose to as high as 330.2 centipoise when treated ginger shreds were incorporated at 8 per cent level, the possibility of reducing the stabilizer content of basic mixes may be more promising in this case.

4.5.4 EFFECT OF TREATED GINGER SHREDS ON THE WHIPPING ABILITY OF ICE CREAM MIX

4.5.4.1 The average values of whipping ability of ice cream mixes (i.e. C, T1, T2 and T3) as influenced by the addition of treated ginger shreds are given in Table 4.17.

4.5.4.2 The same trend of rise in the specific volume of unwhipped samples with increasing level of ginger, either in the form of juice, powder or untreated shred was also observed here. In addition, an increase in specific volume after whipping for 3 min. followed by a decrease after 5 min. was noticed as general phenomena, in all the forms of ginger used.

4.5.4.3 The whipping ability values (expressed as specific volume, in terms of cubic cm/ g) obtained in this part of the study i.e. in non whipped samples after 3 min. and 5 min. were statistically distinguishable in their groups, except for T2 and T3 after 3 min. whipping which were statistically alike ($P > 0.05$).

4.5.4.4 The effect of ginger on whipping ability has been already discussed earlier in Sections 4.2.4 and 4.3.4.

4.5.5 EFFECT OF ADDITION OF TREATED GINGER SHREDS ON THE OVERRUN OF ICE CREAM

4.5.5.1 The average values of per cent overrun of C, T1, T2 and T3 ice cream samples are given in Table 4.18.

4.5.5.2 The average values of overrun tended to decrease with increasing rate of addition of shreds as can be observed (Table 4.18). This trend remained same irrespective of the form of ginger used, throughout the study. The decrease in overrun in this case was highly pronounced when compared with other forms used earlier (i.e. juice, powder and untreated shreds).

4.5.5.3 The addition of treated ginger shreds, akin to other forms of ginger tended to decrease the overrun significantly ($P < 0.05$). All the samples could be statistically differentiated from each other ($P < 0.05$) in this regard.

4.5.5.4 The factors related to the decrease in overrun in experimental ice cream samples containing ginger have been discussed earlier (Section 4.2.5.4). The marked adverse effect of treated shreds on the overrun may be ascribed to the localized depression in freezing point, in the vicinity of the shreds which was coated with sugar syrup. This influences the amount of water frozen in the freezer at a particular temperature (mix would be slacker) and thereby affect the overrun adversely.

Table 4.18 Influence of varied levels of treated ginger shreds
the average overrun and melting characteristics of
made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Overrun (%)	Quantity of ice cream melted in 40 min. at 37.5 C per 100 g (g)
0 (C)	45.47	41.20
4 (T1)	37.20	29.00
6 (T2)	34.02	22.58
8 (T3)	31.08	18.00
Statistical analyses		
SEM	0.436	0.641
CD (0.05)	1.29	1.89
C.V.%	2.97	5.66

4.5.6 EFFECT OF TREATED GINGER SHREDS ON THE MELTING RESISTANCE OF ICE CREAM

4.5.6.1 The influence of treated ginger shreds on the melting resistance of ice cream, as affected by the addition of different levels of treated ginger shreds is discussed in this section.

4.5.6.2 The melting resistance of control (C) was the lowest as is evident from Table 4.18. The experimental samples had increased melting resistance as compared to control. Thus, a similar trend in melting resistance prevailed throughout the study. The extent of increase in melting resistance was observed to be of a greater magnitude in this case than when using juice, powder or untreated shreds as flavouring agent.

4.5.6.3 As observed earlier, the addition of ginger in the form of treated shred also influenced the melting rate characteristics significantly. The melting rate of all the samples were statistically distinguishable ($P < 0.05$), from each other.

4.5.6.4 The significant increase in melting resistance in the experimental samples could be ascribed to the state of starch present (i.e. pregelatinized) owing to the treatment meted out to the shreds in boiling sugar syrup, resulting in a highly viscous mix.

4.5.7 EFFECT OF ADDITION OF TREATED GINGER SHREDS ON THE BACTERIAL COUNT OF HOME MADE ICE CREAM

4.5.7.1 The influence of addition of treated ginger shreds at various levels on the bacterial count (i.e. SPC per g) of home made ice cream is discussed in this section.

4.5.7.2 The incorporation of ginger in the form of treated shreds was observed to cause little decrease in the SPC of experimental samples as is evident from Table 4.19.

4.5.7.3 Notwithstanding a decrease in SPC/g of 2950 (maximum) in experimental samples compared to the control, none of the ice creams could be distinguished statistically for their SPC ($P > 0.05$).

4.5.7.4 Addition of treated ginger shreds did not have much influence the SPC of ice cream.

4.5.8 EFFECT OF TREATED GINGER SHREDS ON THE SENSORIC QUALITY OF HOME MADE ICE CREAM

4.5.8.1 The data relating to the the scores of different sensoric attributes i.e. flavour, body and texture, melting quality and colour for different ice cream samples (i.e. C, T1, T2 and T3) were statistically analyzed. The relevant results are delineated and discussed hereunder. The results presented in Table 4.20 represent the influence of addition of treated ginger shreds on the organoleptic attributes of home made ice cream.

Table 4.19 Influence of varied levels of treated ginger shreds on the average bacterial count of freshly prepared home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Average SPC per g ice cream (log cfu)
0 (C)	4.617 (41400)
4 (T1)	4.599 (39700)
6 (T2)	4.584 (38350)
8 (T3)	4.591 (39000)
Statistical analyses	
SEM	0.021
CD (0.05)	NS
C.V.%	1.11

(Figures in parentheses show actual cfu values)

Table 4.20 Influence of varied levels of treated ginger shreds on the average organoleptic characteristics of home made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Flavour (45)	Body and texture (30)	Melting characteristics (5)	Colour (5)	Total (85)
0 (C)	6.078 (36.94)	5.175 (26.78)	2.172 (4.72)	2.198 (4.83)	8.560 (73.27)
4 (T1)	6.064 (36.77)	5.191 (26.94)	2.108 (4.44)	2.185 (4.78)	8.539 (72.93)
6 (T2)	6.155 (37.89)	5.126 (26.23)	2.047 (4.19)	2.166 (4.69)	8.545 (73.01)
8 (T3)	6.037 (36.44)	5.110 (26.11)	2.020 (4.08)	2.128 (4.53)	8.436 (71.16)
Statistical analyses					
SEM	0.011	0.009	0.019	0.016	0.025
CD (0.05)	0.032	0.025	0.055	0.045	0.074
C.V.%	0.55	0.5	2.76	2.17	0.97

(The reported values given in parantheses show squared values i.e. actual average score)

4.5.8.2 Flavour

4.5.8.2.1 The flavour preference of ice cream followed the pattern: T2 > C > T1 > T3. A small decrease in flavour score of ice cream was noticed when treated shreds were incorporated at 8 per cent level in ice cream.

4.5.8.2.2 Incorporation of treated ginger shreds at 6 per cent level was most beneficial flavourwise. The lowest level used resulted in a product (T1) that was rated at par with control ($P > 0.05$). However, use of shred at 8 per cent level in ice cream was observed to decrease the flavour preference of the product.

4.5.8.2.3 With respect to the flavour score, T2 was preferred the most. T3 was criticized for having excessive amount of shreds giving intense ginger flavour, whereas T1 was criticized for lacking in the desired optimum flavour. Still T1 and T3 obtained 81.7 and 81.0 per cent marks of the maximum flavour score (i.e. 45) and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.5.8.3 Body and texture

4.5.8.3.1 Addition of treated shreds was found to increase the body and texture scores of ice cream marginally when added at 4 per cent level. However, increasing the quantum of treated shreds (i.e. T2 and T3 levels) was found to affect the body and texture score adversely.

4.5.8.3.2 The average body and texture scores of C and T1

were statistically at par ($P > 0.05$). But addition of the treated shreds at elevated levels i.e. 6 per cent (T2) and 8 per cent (T3) was found to reduce the score significantly ($P < 0.05$).

4.5.8.3.3 With higher levels of addition of treated ginger shreds, the samples were criticized for being heavy bodied (due to lower overrun as is evident from Section 4.5.5) and especially sample T3 was said to possess too cohesive and gummy body. The comparison of the viscosity data also indicates an excessive increase in viscosity specially in T2 and T3. The comparison of these data also indicate preference in body and texture of ice cream made from a mix possessing around 280 centipoise viscosity. Compared to the untreated shreds, the ice cream containing treated shreds was reported by the judges to possess less chewiness and less pungency. All the experimental samples scored more than 87 per cent marks of the total body and texture score (i.e. 30) and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.5.8.4 Melting quality

4.5.8.4.1 Melting quality scores of experimental samples were lower than that of control and decreased progressively with increasing level of addition of treated ginger shreds; the same trend has been noted earlier also (Section 4.2.8, 4.3.8 and 4.4.8).

4.5.8.4.2 The control had significantly higher melting quality scores than those of the experimental samples.

4.5.8.4.3 The incorporation of ginger in the form of treated shreds also led to "delayed meltdown" compared to control as was the case with other forms of ginger studied earlier. Further, the experimental samples were also reported to have very thick consistency upon melting. All the experimental samples scored more than 81.6 per cent of the total melting quality score (i.e. 5) and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.5.8.5 Colour

4.6.8.5.1 The addition of ginger as treated shred was found to have a very slight effect on colour score which nevertheless decreased progressively with increasing level of addition of ginger shreds.

4.5.8.5.2 The effect of addition of treated ginger shreds was found to have a small but significant ($P < 0.05$) influence on the colour, only at the highest level of shred used i.e. 8 per cent (T3). All other samples were statistically rated at par ($P > 0.05$) with each other.

4.5.8.5.3 Boiling of shreds in sugar syrup imparted a dull brown color to the shreds which was disliked by the judges, especially at the maximum (i.e. 8 per cent) level of shred addition. However, except at this level the colour of the product was not significantly influenced. Addition of

compatible colour in ice cream containing ginger may overcome the colour constraint, if any. Use of sulphur compound in sugar syrup (i.e. SO₂) while treating the shreds might prevent the shreds from becoming brown. However, its legal implications would have to be solved. Yet T3 obtained 90.6 per cent marks of the total colour score of 5 and hence can be considered as good product as per suggested ISI grading (Section 4.2.1.1).

4.5.9 From this part of the study it can be seen that amongst the experimental samples, T2 had the highest flavour score which was significantly higher than all the other samples including control ($P < 0.05$). The total score of T2 was the highest, however it was not significantly different from control or T1. Addition of treated ginger shreds at T2 level also did not affect the compositional attributes and were well within the values specified by legal standards (PFA, 1955). Therefore, incorporation of treated ginger shreds at T2 level (i.e. @ 6 per cent) was selected for further studies. All the experimental samples scored more than 83.7 per cent marks of the total score (i.e. 85) and hence can be considered as good product as per suggested ISI grading system (Section 4.2.1.1).

4.6 PREFERENCE OF FORM OF GINGER IN HOME MADE ICE CREAM

4.6.1 Home made ice cream was prepared using four different forms of ginger at the levels selected earlier i.e. juice at 3 per cent (J), powder at 1 per cent (P), shreds at 4 per cent (S) and treated shreds at 6 per cent (T). Vanilla was used as

the flavouring material for control. This part of the experimentation was done to select the most preferred form of ginger in the manufacture of home made ice cream.

4.6.2 Table 4.21 represents the average flavour, body and texture, melting quality and colour scores of C, J, P, S and T ice creams made using a ice and salt freezer, which are delineated and discussed hereunder.

4.6.2.1 Flavour

4.6.2.1.1. The average flavour score of the product containing treated shred (@ 6 per cent w/w, T) was the highest, which was very closely followed by J. The third preference was for ice cream containing untreated shreds (i.e. S). The product containing ginger powder though preferred over control was least preferred in home made ice cream from amongst the different forms of ginger employed during the study.

4.6.2.1.2 From the statistical point of view, the most preferred form of ginger in home made ice cream on the basis of its flavour profile was found to be the one containing treated ginger shreds @ 6 per cent (T). However, the preference of the products containing the following two form of ginger viz. treated shreds and ginger juice was significantly established over that of control ($P < 0.05$); both these forms were non-distinguishable amongst themselves on the basis of their flavour score. Flavourwise, C and P could not be distinguished statistically ($P > 0.05$). All samples other than these two combinations (i.e. C vs P and J

Table 4.21 Influence of varied forms of ginger at selected levels on the average organoleptic characteristics of home made ice cream

Form of ginger used and level of addition in ice cream mix (% w/w)	Flavour (45)	Body and texture (30)	Melting characteristics (5)	Colour (5)	Total (85)
0 (C)	6.041 (36.49)	5.172 (26.75)	2.179 (4.75)	2.187 (4.78)	8.531 (72.77)
4 (J)	6.190 (38.32)	5.309 (28.19)	2.015 (4.06)	2.207 (4.87)	8.686 (75.44)
1 (P)	6.052 (36.63)	5.037 (25.37)	1.951 (3.81)	2.031 (4.12)	8.362 (69.93)
4 (S)	6.134 (37.63)	5.244 (27.50)	2.091 (4.37)	2.148 (4.61)	8.609 (74.11)
6 (T)	6.227 (38.78)	5.111 (26.12)	1.983 (3.93)	2.091 (4.37)	8.556 (73.20)
Statistical analyses					
SEM	0.018	0.017	0.035	0.034	0.026
CD (0.05)	0.053	0.051	0.106	0.103	0.079
C.V.%	0.57	0.65	3.43	3.20	0.97

Figures in parentheses show squared values.

vs T) were statistically different from each other ($P < 0.05$).

4.6.2.1.3 Thus, it can be concluded from this study that on the basis of flavour score, home made ice cream containing treated shreds @ 6 per cent w/w of mix was preferred the most which was very closely followed by J containing 4 per cent ginger juice, both of which were statistically alike. These two were followed by sample S product containing shreds @ 4 per cent and P (containing ginger powder @ 1 per cent). Further, it can also be concluded that all the forms of ginger employed during the course of investigation were preferred over control on the basis of its flavour profile.

4.6.2.2 Body and texture

4.6.2.2.1 The average body and texture scores, delineated in Table 4.21 was in the order J (28.19) > S (27.5) > C (26.75) > T (26.12) > P (25.37). Thus, the body and texture score varied within a very short range of 25.37 to 28.19. It can be seen from these values that home made ice cream containing juice or shreds (untreated) were preferred over control. The score of treated shred containing product (T) was very slightly lower (by 0.63) than that of control while that of P was the lowest (1.38 marks lower than C).

4.6.2.2.2 Notwithstanding very small differences in the body and texture scores, all the products could be distinguished statistically ($P < 0.05$). Thus statistically, the body texture preference of the product was in the order: J > S > C > T > P.

4.6.2.2.3 It can be seen from this part of the investigation that body and texture of home made ice cream containing juice (J) was preferred the most, followed by that of ice cream containing shreds (S), while the product T (containing treated shreds) and P (containing ginger powder) were slightly but significantly disliked in comparison with control. Thus, comparing the individual and compiled body and texture scores (Table 5, 10, 15, 20 and 21) almost similar trend is visualized. The probable reasons have been already described earlier in the relevant sections (Section 4.2.8, 4.3.8, 4.4.8 and 4.5.8). According to the reports of the judges, J and S were found to possess more smoothness compared to C whereas T was reported to have a gummy and sticky/ cohesive body impairing its acceptability. The visible presence of small brown particles and their associated mouthfeel made the sample P subject to criticism for its coarseness and grittiness and hence was the least preferred one. However, the latter two samples (i.e. P,T) could be considered acceptable body texture wise having scored more than 60 per cent marks (Section 4.2.1.1). Product T and P obtained about 87 and 84.6 per cent marks respectively out of the maximum marks of 30 assigned to body and texture score.

4.6.2.3 Melting quality

4.6.2.3.1 The range of melting quality score was found to be very narrow (3.81 to 4.75) differing by 0.94 only. The melting quality of control was preferred the most, followed by S, J, T

and P.

4.6.2.3.2 The statistical analysis performed on these data indicate that though control was having only a slight positive edge over the experimental samples, the former was significantly preferred over the later ($P < 0.05$). Amongst the experimental samples, except P vs. S and S vs. T; which were statistically distinct ($P < 0.05$) with respect to the melting quality all others were found to be at par with each other ($P > 0.05$).

4.6.2.3.3 It can be seen once again in this comparative study that all the samples scored more than 60 per cent marks of total ascribed to melting quality characteristics (i.e. 5). Though the control obtained highest score, the per cent marks obtained by P, T, J and S respectively were about 76, 79, 81 and 87. The reported literature on the aspects and probable factors affecting the melting quality attribute of home made ice cream have been discussed earlier (Section 4.2.8, 4.3.8, 4.4.8 and 4.5.8).

4.6.2.4 Colour

4.6.2.4.1 The data on the average colour scores displayed in Table 4.21 are discussed in this section.

4.6.2.4.2 The variation in colour scores found was very marginal to the tune of 0.75 only. The order of preference obtained was: $J > C > S > T > P$.

4.6.2.4.3 The calculated C.D. values indicates that amongst all home made ice creams, only P (containing ginger powder) scored significantly lower marks than control. Amongst the experimental samples, J could be distinguished from P and T, while P could only be differentiated from S. All other products were rated at par with each other. Again considering colour attribute, all the samples scored more than 82 per cent of total marks and hence could be considered highly acceptable keeping in view the recommendation of ISI (Section 4.2.1.1). Thus, colourwise the experimental samples were highly acceptable except for sample P. Even the slight shortcoming, if any, in the colour of the product can be tackled by incorporating desired shade of colour in the ice cream containing a particular of ginger.

4.6.3 It can be seen from Table 4.21 that the product flavoured with ginger juice at 4 per cent level i.e. J was superior to all the other samples with respect to total score. From C.D. calculations, it can be seen that the total score of J was at par with S. The order of preference with respect to total scores was: $J > S > T > C > P$. Even though T had higher flavour score over S, its total score was lower because of its relatively inferior body and texture, melting quality and colour scores. Hence, it may be worth experimenting to try to decrease the amount of stabilizer in T in order to improve upon the body and texture and melting quality. Even though P scored lower total score than C, it scored 82.3 per cent of the total score (i.e. 85) and hence can be considered as a

good product as per suggested ISI grading (Section 4.2.1.1).

4.7 SELECTION OF FORM OF GINGER IN FACTORY MADE ICE CREAM

4.7.1 Though the influence of different forms of ginger at various levels employed in this study was studied in case of home made ice cream in the preceding sections, the comparative influence of the selected levels of such different forms of ginger on factory made ice cream was also attempted since the latter process produces a very smooth textured ice cream. The finer air cell incorporation as a result of whipping under pressure and the freezing at a very rapid pace are probably the main reasons for the smoother texture. Moreover, in the compressed state the desired volume of air can be incorporated with extreme fineness without having the air cells becoming continuous and merging; when the pressure is released the air expands, the lamellae becomes thinner and since no vigorous beating follows, the lamellae can exist at a thinness that would be impossible where the same final volume of air is incorporated by vigorous beating at atmospheric pressure. The overall quality and physico-chemical characteristics of ice cream made employing horizontal direct expansion type batch freezer (factory made ice cream) would deviate slightly from those of home made ice cream. The former is generally characterized by high overrun, light body and smooth texture. Hence, the various selected forms of ginger i.e. juice at 4 per cent, powder at 1 per cent, shreds at 4 per cent, and treated shreds at 6 per cent levels were employed in factory made ice cream also. The main aim here was

to arrive at the order of preference of the form of ginger in factory made ice cream and thereby identify the most preferred form of ginger on the basis of its sensoric profile. The physico-chemical characteristics of factory made ice cream were monitored in a manner similar to those evaluated for home made ice cream. The compositional attributes, acidity, pH, viscosity and whipping ability of ice cream mixes employed in making factory made ice cream have been given in Appendices VI and VII. The aged ice cream mixes were frozen in a 'Guisti', horizontal batch freezer as described earlier in Section 3.6 and whipping was done so as to obtain about 90 per cent overrun in the final product. The factory made ice cream was also evaluated for the time required to reach 90 per cent overrun, melting resistance, effect of thermal shock and storage ($-10 \pm 2^{\circ}\text{C}$) of ice cream for 30 d on the sensoric and microbial quality of ice cream. The results obtained during this part of the study are described and discussed hereunder.

4.7.2 TIME TO REACH 90 PER CENT OVERRUN FOR FACTORY MADE ICE CREAM AS INFLUENCED BY DIFFERENT FORMS OF GINGER ADDED AT SELECTED LEVELS

4.7.2.1 The whipping ability of ice cream mixes was determined during freezing of ice cream in the freezer and expressed as time taken to reach 90 per cent overrun at a constant air pressure of 0.7 kg/ sq.cm and ammeter reading of 3 ampere.

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4.7.2.1 The whipping ability of ice cream mixes was determined during freezing of ice cream in the freezer and expressed as time taken to reach 90 per cent overrun at a constant air pressure of 0.7 kg/ sq.cm and ammeter reading of 3 ampere.

Table 4.22 Influence of various forms of ginger at selected levels on the time required to reach 90 per cent overrun and the melting characteristics of factory made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Time required to reach 90 % overrun (s)	Quantity of ice cream melted in 40 min. at 37.5 C per 100 g (g)
0 (C)	180	31.04
4 (J)	199	21.63
1 (P)	186	24.53
4 (S)	215	20.72
6 (T)	236	12.68
Statistical analyses		
SEM	3.476	0.839
CD (0.05)	10.5	2.53
C.V.%	3.34	5.16

4.7.2.2 Table 4.22 represents the average values of time (in seconds) required to obtain 90 per cent overrun in factory made ice cream containing different forms of ginger (.e. J, P, S and T) as well as for control (C). Addition of ginger in any form necessitated more time i.e. P (186 s), J (199 s), S (215 s) and T (236 s) in order to reach 90 per cent overrun compared to control (180 s). Thus, different forms of ginger was found to considerably affect this attribute.

4.7.2.3 The tabulated results reveal that in case of J, S and T there was a significant ($P < 0.05$) increase in the time required to reach 90 per cent overrun compared to control. On the other hand, the time required to reach 90 per cent overrun for P was at par with C. Moreover, all the experimental samples, except for J vs. P varied significantly from each other in terms of time required to reach 90 per cent overrun.

4.7.2.4 It can also be seen that the two tests used for assessing the whipping ability viz. 'laboratory test' (Appendix VII) and overrun during freezing employed in this part of the study almost led to similar inferences. Viscosity of ice cream mix is considered to be an important property and a certain quantum of it seems essential for proper whipping and subsequent retention of whipped air. For fast freezing/rapid whipping in modern equipment, a lower viscosity seems desirable. In general, as the viscosity increases, the rate of whipping decreases (Arbuckle, 1977). The increased viscosity of ice cream mix necessitated more time in attaining 90 per cent overrun; such effect is in accordance with the reported

literature, though the desirable viscosity level and its correlation with better whipping has not been fully established. The whipping property in general is dependent on the lamellae formed around the air bubble, its strength and thus stability. The presence of ginger in any form might be reducing the stability of the air cell lamellae and thereby leads to significantly prolonged period required to reach 90 per cent overrun in the ice cream.

4.7.3 EFFECT OF ADDITION OF VARIOUS FORMS OF GINGER AT SELECTED LEVELS ON THE MELTING CHARACTERISTICS OF FACTORY MADE ICE CREAM

4.7.3.1 The data presented in Table 4.22 are the average figures of ice cream melted (g/ 100g ice cream) in 40 min. at 37.5 C as affected by different forms of ginger used in ice cream.

4.7.3.2 As seen in Table 4.22, there was a decrease in the melting rate of all the experimental samples compared to control. The melting resistance tended to decrease in the order: T > S > J > P > C. Thus, the wide melting range observed was from 12.68 (T) to 31.04 (C) g/ 100 g ice cream.

4.7.3.3 As indicated by relevant C.D. values (Table 4.22), the melting rate of all the experimental samples was significantly lower than that of control. Among the experimental samples, T had the lowest melting rate, which was found to be significantly lower than that of J, P or S ($P <$

0.05). Among the experimental samples, except for J vs. S, all others could be distinguished significantly ($P > 0.05$) from each other.

4.7.3.4 Discussion on the probable reasons for the increased melting resistance of products containing different forms of ginger has already been detailed under Sections 4.2.6, 4.3.6, 4.4.6 and 4.5.6. Thus, from this study it can be concluded that ice cream containing treated shreds (@ 6 per cent) gives minimum melt (i.e. highest melting resistance) compared to all other samples which is only 40.9 per cent of the melt value of control. The melting rate of J, S and P was 69.7, 66.8 and 79.0 per cent respectively of the melt value of control.

4.7.4 SPC PROFILE OF FRESH AND STORED FACTORY MADE ICE CREAM CONTAINING DIFFERENT FORMS OF GINGER ADDED AT PREDETERMINED LEVELS

4.7.4.1 Considering the reports of several spices on their bactericidal effect, the SPC of fresh ice cream (after 24 h hardening) and after storage of 30 d at $-10 \pm 2^{\circ}\text{C}$ temperature was monitored.

4.7.4.2 The average SPC of control as well as experimental samples compiled in Table 4.23 reveal that at 0 d (fresh ice cream) in comparison to control, the SPC was slightly lower in J, S and T but slightly higher in P. However, during storage of ice cream ($-10 \pm 2^{\circ}\text{C}$) for 30 d, the counts were found to increase in each case.

Table 4.23 Influence of various forms of ginger at selected levels on the average bacterial count of freshly prepared and stored (30. d) factory made ice cream

Level of addition of ginger shreds in ice cream mix (% w/w)	Average SPC per g ice cream (log cfu)	
	(Freshly hardened for 24 h)	(Stored for 30 d)
0 (C)	4.633 (43000)	4.737 (54600)
4 (J)	4.578 (37900)	4.685 (48400)
1 (P)	4.685 (48400)	4.785 (60950)
4 (S)	4.602 (40000)	4.700 (50100)
6 (T)	4.634 (43050)	4.725 (53050)
Statistical analyses		
SEM	0.021	0.018
CD (0.05)	NS	NS
C.V.%	0.92	0.76
(Figures in parentheses show actual cfu values)		

4.7.4.3 Irrespective of the form of ginger utilized in the study, it did not produce any significant effect on the microbial status of ice cream (SPC), either in fresh or in the stored product ($P > 0.05$).

4.7.4.4 Thus, no bactericidal effect of the ginger used in any form and at the level used was evident from this study. The higher counts in ice cream associated with the use of ginger powder has already been discussed in relation to home made ice cream earlier (Section 4.3.7). Further, there was an increase in the counts of all the stored samples. A similar rise in the bacterial count of ice cream during storage was also observed by Lloyd (1969) and Pawar and Vyas (1977).

4.7.5 EFFECT OF ADDITION OF DIFFERENT FORMS OF GINGER AT SELECTED LEVELS ON THE SENSORIC PROFILE OF FACTORY MADE ICE CREAM

4.7.5.1 The sensoric quality of freshly hardened, heat shocked and stored products was adjudged by a panel of 6 judges using the score card recommended by Arbuckle (1977). Heat shock occurs primarily during the distribution and storage of ice cream. Heat shock is considered responsible for the growth of ice crystals in ice cream. Several such heat shock cycles may alter the properties of milk proteins, stabilizers and other solids present in the ice cream matrix, viz. decreased water binding capacity, decrease in stability of air cells, etc. and subsequently may affect the flavour or body and texture characteristics of the ice cream. Hence, 7 heat shock cycles

(i.e. keeping ice cream in a temperature controlled area at 22 C for 1.5 h for the first day and for 0.5 h everyday for 6 subsequent days) (Section 3.9) were simulated and the overall sensoric quality of the treated ice cream was adjudged. The sample evaluation was divided into 3 phases. Initially freshly hardened (at $-15 \pm 2^{\circ}\text{C}$ for 24 h) product was evaluated. The second phase comprised of the hardened ice cream meted out with heat shock treatment. The third phase involved sensoric evaluation of the stored product (i.e. at $-10 \pm 2^{\circ}\text{C}$ for 30 d) (Section 3.10.1.3). Statistical analysis of data was done as explained earlier in Section 3.12.

4.7.5.2 Flavour

4.7.5.2.1 The results portrayed in Table 4.24 represent the influence of addition of ginger in various forms (i.e. J, P, S and T) as well as control on the flavour score of freshly hardened, heat shocked and stored ice cream.

4.7.5.2.2 As seen from the table, ice cream containing powder (@ 1 per cent) had the minimum flavour score (38.58) closely followed by control (39.92). The order of preference flavourwise for the fresh product was: $J > T > S > C > P$ implying the dominance of product J (flavour score of 41.58). The same order was also evident in heat shocked product. In case of heat shocked product, a very slight decrease in the score of C, J and P was observed, whereas slight improvement was noted in case of S and T. A decrease in the score was evident in the samples stored for 30 d. However, the

difference in the score of each product either fresh, heat shocked or stored was found to be very small in magnitude. However sample T was found to have a slight positive edge over J in case of stored products.

4.7.5.2.3 From the statistical point of view, the most preferred ice cream flavourwise was J which was very closely followed by T; the flavour scores these two being statistically alike. Likewise C and P were rated at par with each other ($P > 0.05$). Though the flavour score of S was significantly lower than that of J or T, yet it was preferred significantly over control. A similar trend was also noted after the heat shock treatment, but in heat shocked ice cream the flavour preference was similar statistically for sample S and T. In case of stored products, only C and P were non distinguishable statistically on the basis of their flavour preference. For others, i.e. J, S and T the trend was found similar in all three conditions. The heat shock treatment and storage did not exert any significant influence on the flavour score, irrespective of the type of product made i.e. C, J, P, S or T ($P > 0.05$).

4.7.5.2.4 It can be seen from these observations that heat shock employed during this study did not create any significant adverse effect on the flavour. Ice creams containing treated shreds and juice were preferred the most in all groups i.e. fresh, heat shocked and stored products; both (i.e. S and J) being rated statistically alike. A slight but non significant reduction in the flavour intensity during

storage and after thermal shock treatment has been observed by Conforti (1994). Thus, the results obtained here are in agreement with this report. The flavour of S and T after heat shock treatment was found to improve slightly, which however was non-significant.

4.7.5.3 Body and texture

4.7.5.3.1 Table 4.25 shows the influence of incorporation of ginger in various forms at selected levels (i.e. J, P, S and T) as well as control on the body and texture scores of freshly hardened, heat shocked as well as stored samples.

4.7.5.3.2 Ice cream containing ginger juice (@ 4 per cent) scored the highest average body and texture score followed by C, S, T and P in freshly hardened as well as in stored samples. In case of heat shocked products, there was a noticeable decline in the body and texture score of C. A marginal decrease in the average body and texture score of J, S, and T was also observed. Sample P exhibited a slight improvement in body and texture score after heat shock treatment. However, in case of heat shock treated products the body and texture preference was changed to $J > S > T > C = P$. Thus, addition of ginger in the form of juice or shreds- either treated or untreated was found to maintain the body and texture of the respective heat shocked products, while in case of control heat shock treatment had significant decrease in the body texture score.

Table 4.25 Influence of various forms of ginger at selected levels on the body and texture scores of freshly hardened, heat shocked and stored ice cream (out of 30)

Level of addition of ginger in ice cream mix (% w/w)	Body and texture scores of			SEM	CD	CV%
	Freshly Hardened ice cream	Heat shocked ice cream	Stored ice cream (30 d)			
0 (C)	5.307 (28.16)	5.204 (27.08)	5.291 (27.99)	0.015	0.045	0.62
4 (J)	5.342 (28.54)	5.331 (28.42)	5.344 (28.56)	0.024	NS	0.71
1 (P)	5.196 (27.00)	5.204 (27.08)	5.187 (26.90)	0.021	NS	0.83
4 (S)	5.268 (27.75)	5.260 (27.67)	5.271 (27.78)	0.025	NS	0.71
6 (T)	5.244 (27.50)	5.228 (27.33)	5.262 (27.69)	0.017	NS	0.52

Statistical analyses

SEM	0.013	0.015	0.012
CD (0.05)	0.038	0.044	0.035
C.V.%	0.6	0.71	0.87

(The reported values given in parantheses show squared values i.e. actual average score)

4.7.5.3.3 In the freshly hardened ice creams, the superiority in the average body and texture score of J over C was not significant ($P > 0.05$). Further, the presence of ginger in the form of S, T or P was found to adversely affect the body and texture scores. Amongst experimental fresh samples, significant ($P < 0.05$) variation was observed, except for S and T which were statistically alike ($P > 0.05$). In comparison with control, the presence of ginger in the form of juice (@ 4 per cent) and shreds (@ 4 per cent) was found to yield ice creams with better body and texture characteristics, even after heat shock treatment as indicated by higher score of the later (S and J) over that of control. The improved body and texture score of P and T over that of control was not much apparent ($P > 0.05$). In case of the experimental heat shocked samples, only T was rated at par with P and S, whereas all others differed significantly from each other ($P < 0.05$). In case of stored products, the average body and texture scores of J was found to be significantly higher and that of P significantly lower than that of control. Sample S and T were preferred as much as control sample ($P > 0.05$) with respect to their body and texture characteristics. Further, it can also be seen from the table that out of the various treatments (i.e. heat shock, storage) meted out to ice cream samples, only heat shock could significantly affect the body and texture characteristics, decreasing the average score to a level which was significantly lower than control ($P < 0.05$). Though, the presence of ginger in any form (i.e. J, P, S and T) helped in maintaining the body and

texture score especially during storage, the treatments employed did not make significant variation in the body and texture score when compared to the body with the texture score of the respective fresh samples.

4.7.5.3.4 This study shows that use of ginger (as J, S and T) in ice cream is advantageous in many respects. The heat shock treatment, which is generally experienced during storage of ice cream in varying degree, affected adversely the body and texture characteristics of the control while the ice cream containing ginger in the form of juice (J), shreds (S) or treated shreds (T) helped in combating the ill-effects of heat shock cycle. The control subjected to heat shock treatment was criticized for development of iciness. Heat shock treatment was found to give rise to growth in the size of originally small ice crystals due to partial thawing and refreezing cycle leading to iciness/ coarseness in the resultant product (Sommer, 1951; Arbuckle, 1977 and Conforti, 1994). This problem is intimately concerned with the sale of ice cream by the manufacturers. On the other hand, none of the experimental heat shocked samples were criticized for iciness indicating probable protective effect of ginger in the ice cream against adverse storage conditions. Stabilizers do not stabilize the texture perfectly, but they are an important aid, without which ice cream would have suffered much more as a result of temperature fluctuations usually encountered in retail cabinets. Ginger does possess certain hydrocolloids which might be providing stabilizing action in the ice cream

as has been discussed earlier (Section 4.7.5.1). Polysaccharides such as starch is reported to restrict ice crystal growth during storage (Cottrell et al., 1980). Storage of ice cream for 30 d at $-10 \pm 2^{\circ}\text{C}$ was not found to have any significant adverse effect on the body and texture characteristics of the control and experimental ice creams. Incorporation of ginger in any of the forms used manifested in gummy body in resultant product (Section 4.2.8, 4.3.8, 4.4.8 and 4.5.8) as has been also evident during this part of the study, especially for freshly hardened ice creams (S, T and P). Some of these related aspects have been delineated and discussed earlier in sections 4.2.8, 4.3.8, 4.4.8 and 4.5.8.

4.7.5.4 Melting characteristics

4.7.5.4.1 The melting characteristics of freshly hardened, heat shocked and stored ice cream samples are presented in Table 4.26.

4.7.5.4.2 In terms of melting characteristics, C scored the maximum which was followed by J, S, T and P; irrespective of the treatment employed i.e. heat shock or storage.

4.7.5.4.3 Statistically, control sample was significantly preferred ($P < 0.05$) over the experimental ones; be it fresh, heat shocked or stored. The different forms of ginger employed at selected levels was found to exert marked influence on the melting quality scores, except for the stored S and T samples which were more or less identical.

Table 4.26 Influence of various forms of ginger at selected levels on the melting quality scores of freshly hardened, heat shocked and stored ice cream (out of 5)

Level of addition of ginger in ice cream mix (% w/w)	Melting quality scores of		SEM	CD	CV%
	Freshly Hardened ice cream	Heat shocked ice cream (30 d)			
0 (C)	2.208 (4.88)	2.198 (4.83)	0.032	NS	1.02
4 (J)	2.141 (4.58)	2.148 (4.61)	0.021	NS	0.87
1 (P)	1.957 (3.83)	1.946 (3.79)	0.047	NS	1.31
4 (S)	2.082 (4.33)	2.072 (4.29)	0.013	NS	0.32
6 (T)	2.021 (4.08)	2.010 (4.04)	0.214	NS	0.28
Statistical analyses					
SEM	0.015	0.017	0.015		
CD (0.05)	0.043	0.05	0.045		
C.V.%	1.74	2.01	2.11		

(The reported values given in parantheses show squared values i.e. actual average score)

However, the heat shock treatment or storage employed did not exert any significant influence on the melting characteristics, irrespective of the type of product under study i.e. C, J, P, S or T.

4.7.5.4.4 A similar trend was observed earlier in case of home made ice cream (Section 4.2.8, 4.3.8, 4.4.8 and 4.5.8). The relevant discussion has already been covered earlier (Section 4.2.8, 4.3.8, 4.4.8 and 4.5.8).

4.7.5.5 Colour scores

4.7.5.5.1 The average colour scores of freshly hardened, heat shocked and stored ice cream samples are presented in Table 4.27 alongwith the relevant statistical analysis.

4.7.5.5.2 As seen from the table, the average colour scores varied within a narrow range of 4.12 (P) to 4.80 (C), 4.08 (P) to 4.83 (C) and 4.09 (P) to 4.76 (C) for fresh, heat shocked and stored product respectively. Thus, the colour of ice cream was not found to be affected much either by incorporating ginger in various forms or by subjecting it to adverse storage conditions.

4.7.5.5.3 No significant differences in the colour scores of C, J, S and T could be observed ($P > 0.05$) in case of freshly hardened, heat shocked as well as stored ice cream samples. However, colour score of P though marginally lower than C, J, S and T was statistically significant throughout this part of the study. Heat shock treatment as well as storage of samples

Table 4.27 Influence of various forms of ginger at selected levels on the colour scores of freshly hardened, heat shocked and stored ice cream (out of 5)

Level of addition of ginger in ice cream mix (% w/w)	Colour scores of		SEM	CD	CV%
	Freshly Hardened ice cream	Heat shocked ice cream (30 d)			
0 (C)	2.190 (4.80)	2.198 (4.83)	0.031	NS	1.02
4 (J)	2.187 (4.78)	2.181 (4.76)	0.021	NS	1.21
1 (P)	2.031 (4.12)	2.021 (4.08)	0.032	NS	1.32
4 (S)	2.150 (4.62)	2.147 (4.61)	0.025	NS	1.58
6 (T)	2.152 (4.63)	2.150 (4.62)	0.011	NS	1.11
Statistical analyses					
SEM	0.015	0.017	0.016		
CD (0.05)	0.044	0.052	0.049		
C.V.%	1.73	1.25	1.78		

(The reported values given in parantheses show squared values i.e. actual average score)

did not have any adverse effect on the average colour scores of control as well as experimental samples as evident from Table 4.27.

4.7.5.5.4 Thus, it can be concluded on the basis of this study that the colour of ice cream is not adversely affected by incorporation of ginger either in the form of juice (J), shreds (S) or treated shreds (T). However, ginger powder was found to significantly decrease the colour score. Addition of compatible colour in ice cream containing ginger powder may ameliorate the said drawback.

4.7.6 The main aim of this part of the study was to select the best form of ginger and to arrive at the order of preference of the various forms of ginger used in factory made ice cream. It is evident from the total scores presented in Table 4.28 that J was preferred the most and it had significantly higher total score than rest of the samples, either in case of freshly hardened, heat shocked or stored products. The order of preference obtained in case of fresh products was: J > C > T > S > P, that of heat shocked products was: J > S > T > C > P and that of stored product was: J > T > C > S > P. Thus, the superiority of ice cream containing ginger juice at the rate of 4 per cent (i.e. J) was established on the basis of the total score under normal or even adverse storage conditions. Samples C, S and T were more or less equally preferred; the total score of these being at par with each other, ($P > 0.05$) in all the treatments studied. However, incorporation of ginger powder @ 1 per cent was found to exercise adverse

Table 4.28 Influence of various forms of ginger at selected levels on the total scores of freshly hardened, heat shocked and stored ice cream (out of 85)

Level of addition of ginger in ice cream mix (% w/w)	Total scores of Freshly Hardened ice cream	Total scores of Heat shocked ice cream	Total scores of Stored ice cream (30 d)	SEM	CD	CV%
0 (C)	8.818 (77.76)	8.751 (76.58)	8.790 (77.26)	0.019	0.058	1.15
4 (J)	8.916 (79.50)	8.904 (79.28)	8.892 (79.07)	0.048	NS	1.12
1 (P)	8.633 (74.53)	8.624 (74.37)	8.601 (73.98)	0.061	NS	1.63
4 (S)	8.791 (77.28)	8.793 (77.32)	8.777 (77.04)	0.072	NS	1.52
6 (T)	8.801 (77.46)	8.791 (77.28)	8.814 (77.69)	0.081	NS	1.51

Statistical analyses

SEM	0.018	0.021	0.020
CD (0.05)	0.056	0.063	0.059
C.V.%	1.89	0.97	1.15

(The reported values given in parantheses show squared values i.e. actual average score)

effect on all the sensoric attributes, irrespective of the treatments meted out them during this part of the investigation. Hence it was preferred the least in all the cases. The flavour profile data presented in Table 4.24 clearly indicates the preference of all the experimental samples, except the one containing powder (P) over that of control. However, incorporation of different forms of ginger was found to produce ice cream with gummy characteristics and delayed melting which was attributed to the probable effect of the hydrocolloids inherent in ginger showing to effect similar to the one that is generally experienced in ice cream containing excessive stabilizer. Limited preliminary work on reduction of level of stabilizer in the ice cream containing treated ginger shreds was found to improve the body and texture and melting quality characteristics of ice cream. However, systematic study on this aspect is necessary to check/ confirm the efficacy of ginger in providing stability, i.e. to provide at least in part, the properties of a stabilizer used in ice cream.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

5.1 The dairy foods of the future will contain more of healthful, functional foods i.e. nutraceuticals. Ice cream is a frozen dairy product which is both a food and a refreshment. Frozen desserts like ice cream are valued for their pleasing flavour and cooling and refreshing effects. There is an enormous range of flavouring materials available for ice cream which may be of natural or chemical origin. Ginger is one such natural herb which is valued for its medicinal and therapeutic properties since time immemorial. Ginger has also been used as a flavouring ingredient in ice cream. Such a product could be classified as a nutraceutical i.e. food which provides medicinal or health benefits including treatment of diseases. Ginger ice cream is being prepared in house holds using salt and ice type batch freezers as well as by small scale ice cream manufacturers in and around Gujarat. Recently, a well known ice cream manufacturer in Gujarat has also introduced ginger flavoured ice cream. However, there is a wide variation in the overall quality of ginger ice cream being manufactured. Therefore, this investigation was an attempt to evaluate certain physico-chemical properties of ginger ice cream using selected forms of ginger employed at different levels and to assess their preference on the basis of sensoric quality.

5.2 Ginger is a relatively new flavour used in ice cream. The

information regarding various aspects on ice cream as well as ginger has been reviewed in Section 2.

5.3 In the present investigation, ginger - a natural herb, was used as a flavouring agent in ice cream manufacture and was incorporated in mix or ice cream in various forms. Certain physico-chemical characteristics and sensoric quality of experimental samples were evaluated. The experiment was divided into two parts.

5.3.1 In the first part, preliminary trials were conducted to select various levels of ginger juice, powder, untreated shreds and treated shreds in home made ice cream, using hand (ice and salt type) operated freezer. From the three different levels selected for each form of ginger, the most preferred level for a particular form of ginger was selected on the basis of overall sensoric quality. All the experimental samples were compared with vanilla flavoured ice cream which served as control.

5.3.2 In the second part, factory made ice cream was prepared using a direct expansion type batch "Guisti" freezer. The selected levels of various forms of ginger from the first part of this study were employed in factory made ice cream as well as home made ice cream with a view to obtain their sensoric preference.

5.3.3 A basic ice cream mix having 12 per cent fat, 11 per cent milk SNF, 15 per cent sucrose (7.5 per cent in case of ice cream containing treated ginger shreds), 0.25 per cent

sodium alginate and 0.15 per cent glycerol monostearate was prepared. In case of ice cream containing treated ginger shreds, 7.5 per cent (by weight of ice cream mix) of sucrose was used to prepare a boiling sugar syrup in which the ginger shreds were cooked in this syrup for 30 min. so as to attain a sugar concentration of 65 to 70 per cent. All the mixes 2 were heated to 75 °C, homogenized at 100 Kg/cm followed by pasteurization at 70 °C for 30 min., cooling to 5 ± 2 °C and finally aged for 24 h at the same temperature.

5.3.4 Four different forms of ginger were employed during this study, viz. ginger juice (J), ginger powder (P), ginger shreds as such (S) and treated ginger shreds (T). Ginger juice was employed @ 3, 4 and 5 per cent w/w of ice cream mix, ginger powder was used at @ 0.5, 1.0 and 1.5 per cent w/w of ice cream mix, whereas untreated ginger shreds and treated ginger shreds were employed at @ 4, 6 and 8 per cent by wt. of gcm. Ginger juice and powder were added to the mix just prior to freezing while the shreds were added later at the freezer after partial freezing of the mix.

5.3.5 Appropriate physico-chemical and microbiological methodologies were adopted and experiments were designed suitably to permit statistical interpretation of the data as detailed in Chapter 3.

5.4 RESULTS OF THE INVESTIGATION

5.4.1 Various results obtained during this investigation as

given in Chapter 4 are presented here under in summarized form.

5.4.2 SELECTION OF LEVEL OF GINGER JUICE IN HOME MADE ICE CREAM

5.4.2.1 Home made ice cream was made containing 3 different levels of juice (3, 4 and 5 per cent designated as J1, J2 and J3). Control (C) had vanilla as a flavouring ingredient and the whole experiment based on 3 replications (i.e. totally 12 lots of ice cream) were statistically analyzed by CRD design throughout this study. The effect of incorporation of ginger juice on different attributes of ice cream has been summarized here under.

5.4.2.2. Composition

5.4.2.2.1. Notwithstanding the marginal differences in composition between the control and experimental samples, the addition of ginger juice decreased the fat and total solids content significantly. The decrease in protein, reducing sugars and non reducing sugars content was found significant at 4 and 5 per cent level of addition of ginger juice only. Acidity increased and pH decreased, but these marginal changes were not distinguishable statistically ($P > 0.05$). However, the standards specified in our country for ice cream were fulfilled by all the samples studied.

5.4.2.3 Viscosity

5.4.2.2.1. Addition of ginger juice significantly increased

the viscosity ($P < 0.05$) of all the experimental samples over that of control. The average viscosity of control, J1, J2 and J3 were 181.7, 201.6, 223.3 and 241.6 centipoise respectively.

5.4.2.4 Whipping ability

5.4.2.4.1. The specific volume expressed as cubic cm./ g of unwhipped ice cream mixes revealed that experimental mixes had marginally higher specific volume compared to control though the differences were not significant ($P > 0.05$). However, after 3 min. of whipping, all the experimental samples had slightly lower specific volume compared to control but was significant. There was a slight decline in the specific volume of all the samples after 5 min. of whipping, which was almost of a similar magnitude in all of the samples. The specific volume of unwhipped control was 0.917 and that of experimental samples varied between 0.922 (J1) and 0.924 (J3). In ice cream mixes whipped for 3 min. these respective values were 1.217 (C) and 1.106 (J3) to 1.185 (J1), while after 5 min. whipping these values were 1.144 (C) and 1.037 (J3) to 1.127 (J1).

5.4.2.5 Overrun

5.4.2.5.1. A decrease in per cent overrun in ice creams containing ginger juice was noticed. However, only the highest level of ginger juice employed (i.e. 5 per cent) significantly decreased the overrun ($P < 0.05$). The overrun obtained in C, J1, J2 and J3 were 50.27, 45.99, 43.43 and 39.29 per cent respectively.

5.4.2.6 Melting resistance

5.4.2.6.1. All the experimental samples had significantly lower meltdown (expressed as g ice cream melted at 37.5 C for 40 min. per 100 g ice cream) than control indicative of delayed meltdown. There was a significant decrease in meltdown with increase in the level of ginger juice. These values for C, J1, J2 and J3 were 44.73, 37.13, 34.17 and 28.87 g respectively.

5.4.2.7 Bacterial count

5.4.2.7.1. Though multiple factors are involved in deciding the total population of microorganisms in ice cream, limited study indicated no significant influence of the ginger juice on the SPC of ice cream.

5.4.2.8 Sensoric profile

5.4.2.8.1 All the samples were judged for their organoleptic quality using a score card given by Arbuckle (1977).

5.4.2.8.2 Flavour scores: Flavourwise J2 was preferred the most and its preference was also confirmed statistically. The order of preference observed was: J2 > J1 > C > J3, the latter three being statistically alike. The flavour score obtained by C was 36.83 (out of 45) and that by experimental samples varied between 36.61 (J3) to 38.44(J2).

5.4.2.8.3 Body and texture scores: Addition of ginger juice improved slightly but significantly the body and texture

scores when added upto 4 per cent level. Thereafter, a very small and nonsignificant decrease in score was observed. Body and texturewise the order of preference was: J2 > J1 > C > J3. J2 had a rich taste and smooth body which was appreciated by the judges and was preferred the most. Control scored 26.66 out of 30 while J1, J2 and J3 scored 27.5, 28.28 and 26.33 average marks for their body and texture attributes respectively.

5.4.2.8.4 Melting quality scores: Use of ginger juice in ice cream was observed to give delayed meltdown and hence experimental samples obtained marginally lower marks than the control. However, this small decrease were observed to be significant statistically. The average scores of melting quality were 4.83, 4.89, 4.83 and 4.86 for C, J1, J2 and J3 respectively.

5.4.2.8.5 Colour scores: Though a marginal differences in colour scores was noticed, the differences were statistically indistinguishable ($P > 0.05$). The ice cream samples obtained average marks for colour in the range of 4.89 (J1) to 4.83 (C and J2).

5.4.2.9 Ice cream made with 4 per cent addition of ginger juice (J2) had the highest total score and was also preferred flavourwise and body and texture wise. The superiority of J2 was also confirmed statistically and hence was selected and used further in comparing different forms of ginger in home made as well as factory made ice creams.

5.4.3 SELECTION OF LEVEL OF DRIED GINGER POWDER IN HOME MADE ICE CREAM

5.4.3.1 Home made ice cream was made using 3 different levels of ginger powder (0.5, 1 and 1.5 per cent designated as P1, P2 and P3 respectively). The ginger powder used in this study was selected from 6 different lots of powder based on preliminary screening. The effect of incorporation of ginger powder on different attributes of ice cream has been summarized hereunder.

5.4.3.2 Composition

5.4.3.2.1 The marginal decrease in fat content of experimental samples was found significant at P2 and P3 level of addition of ginger powder. However, no significant differences in fat content was noted between experimental samples. There was also an increase in total solids content with increasing level of addition of ginger powder which was found to be significant at each stage of addition. Addition of powder did not influence significantly the protein, reducing or non reducing sugars, acidity as well as pH values of ice cream. The compositional attributes of all experimental samples were well within the range specified by PFA and BIS standards for plain ice cream.

5.4.3.3 Viscosity

5.4.3.3.1 Addition of ginger powder tended to increase the

viscosity of ice cream which was found to be significant beyond 0.5 per cent level of addition of powder. However, P2 and P3 were statistically alike. The average viscosity of C, P1, P2 and P3 were 171.7, 178.3, 186.7 and 195.2 centipoise respectively when assessed at 7 C.

5.4.3.4 Whipping ability

5.4.3.4.1 No significant effect of addition of ginger powder on the specific volume and hence whipping ability of ice cream mixes were observed after 3 and 5 min. whipping of ice cream mixes. The range of whipping ability in unwhipped, whipped samples for 3 min. and 5 min. were 0.915 (C) to 0.928 (P3), 1.223 (P3) to 1.254 (C), and 1.165 (P3) to 1.203 (C) cubic cm/g respectively.

5.4.3.5 Overrun

5.4.3.5.1 Incorporation of ginger powder did not have any significant influence on overrun upto 0.5 per cent (P1) level of addition. However, increased levels (i.e. 1 (P2) and 1.5 (P3) per cent was found to decrease the overrun significantly; however, they were rated at par in this respect. The average overrun obtained in C, P1, P2 and P3 were 47.63, 46.1, 43.97 and 42.9 per cent respectively.

5.4.3.6 Melting resistance

5.4.3.6.1 All the experimental samples had significantly lower meltdown values in comparison to the control indicating higher resistance to meltdown. The experimental samples i.e.

P1, P2 and P3 were also found to be distinguishable statistically. The respective meltdown values (in terms of g of ice cream melted in 40 min. at 37.5 C) for C, P1, P2 and P3 were 43.53, 38.5, 37.5 and 31.37 g respectively.

5.4.3.7 Bacterial count

5.4.3.7.1 No consistent trend was noticed in the bacterial count of ice creams. Addition of ginger powder did not have any influence on the bacterial count of experimental mixes. The samples had SPC in the range of 47,200 (C) to 55,700 (P3) per g of product.

5.4.3.8 Sensoric profile

5.4.3.8.1 All the samples were judged for their organoleptic quality using a score card given by Arbuckle (1977).

5.4.3.8.2 Flavour scores: The flavour of ice cream containing 1 per cent ginger powder (i.e. P2) was preferred the most, the score of which was significantly higher than that of P1 and P3. P1 could not be distinguished from C statistically. However, beyond 1 per cent level of addition, flavour score decreased significantly. The order of preference in terms of flavour score was: P2 > C > P1 > P3. However, P1 and P3 obtained 81.4 and 80.2 per cent of the maximum marks allotted to the flavour score.

5.4.3.8.3 Body and texture scores: There was a decrease in the body and texture score with increase in level of ginger powder

addition compared to the control. The decrease in body and texture scores was found to be significant at each level of addition. The experimental samples were criticized for having coarseness and gummy body; the former defect arose from the presence of undissolved powder particles. C, P1, P2 and P3 obtained 88.5, 86.3, 84.4 and 83 per cent of the maximum body and texture marks.

5.4.3.8.4 Melting quality scores: A decrease in the melting quality score similar to that observed earlier in case of ginger juice (Section 5.3.3.8.4) was observed with increase in the level of ginger powder addition which was small but significant (i.e. C vs. P1, P2 and P3). All the experimental samples were criticized for their delayed and uneven curdy meltdown; which was especially so at higher levels of addition of ginger powder. C scored 4.67 (out of 5) while P1, P2 and P3 scored 4.36, 4.28 and 4.08 average marks for their melting quality attributes respectively.

5.4.3.8.5 Colour scores: There was also a proportionate decrease in the colour score with increasing levels of addition of ginger powder. Colour scores of all the experimental samples were slightly lower than control. The average per cent colour scores out of the maximum score obtained by P2 and P3 were 86.6, 84.4 and 82.6 per cent respectively.

5.4.3.9 Ice cream made with 1 per cent addition of ginger powder (P2), had the highest total score amongst experimental

samples (P1, P2 and P3) and was preferred the most flavourwise. Though it had a very marginally lower total score than the control it was statistically indistinguishable. Hence, it was selected and used further during subsequent investigation. All the experimental samples scored more than 81 per cent marks of the total score.

5.4.4 SELECTION OF LEVEL OF GINGER SHREDS IN HOME MADE ICE CREAM

5.4.4.1 Different levels of ginger shreds selected on the basis of preliminary screening i.e. at 4 (S1), 6 (S2) and 8 (S3) per cent were used in preparation of home made ice cream alongwith control which employed vanilla as flavouring agent. The effect of incorporation of ginger shreds on different attributes of ice cream is summarized here below:

5.4.4.2 Composition

5.4.4.2.1 Compositional analysis of ice creams revealed that the levels of ginger shreds employed had a very slight but statistically distinguishable ($P < 0.05$) effect on the compositional parameters in general which tended to decrease marginally. Although acidity was marginally higher and pH slightly lower in experimental samples compared to control, these differences were not statistically distinguishable. However, the compositional attributes of all experimental samples satisfied the legal (PFA, 1955) standards.

5.4.4.3 Viscosity

5.4.4.3.1 Incorporation of ginger shreds significantly increased the viscosity of all the experimental samples. Except for S1 and S2, all the remaining samples had viscosity values which were statistically different from each other. The average viscosity of C, S1, S2 and S3 were 174.2, 269.2, 283.3 and 302.5 respectively.

5.4.4.4 Whipping ability

5.4.4.4.1 The specific volume of all the experimental samples were marginally, though not significantly higher than that of control. The effect of ginger shreds was almost similar to the pattern exhibited by juice. The specific volume of all samples after 3 and 5 min. of whipping were statistically distinguishable.

5.4.4.5 Overrun

5.4.4.5.1 The average overrun obtained in C, S1, S2 and S3 were 42.58, 40.86, 39.66 and 37.97 per cent respectively. The overrun of control, though lower was at par with S1 whereas it had significantly higher overrun than that of S2 and S3.

5.4.4.6 Melting resistance

5.4.4.6.1 There was a significant decrease in meltdown values with increasing level of addition of ginger shreds. The increase in melting resistance was comparatively higher than that noted earlier in case of juice (Section 5.4.2.6) or

powder (Section 5.4.3.6). The meltdown values for C, S1, S2 and S3 were 42.82, 30.58, 23.68 and 21.28 g/ 100 g ice cream respectively.

5.4.4.7 Bacteriological status

5.4.4.7.1 None of the ice cream samples could be distinguished statistically for their SPC which ranged between 33,400 (S1) to 36,400 (S3) per g of sample.

5.4.4.8 Sensoric profile

5.4.4.8.1 All the samples were judged for their organoleptic quality using a score card given by Arbuckle (1977).

5.4.4.8.2 Flavour profile: The order of preference flavourwise was : S1 > S2 > C > S3. Flavour score of S1 was significantly higher than the rest. Statistically with regard to flavour, C was at par with S2 and S3 ($P > 0.05$). The flavour scores of S1, S2, C and S3 were 38.44, 37.0, 36.83 and 36.61 respectively.

5.4.4.8.3 Body and texture scores: Incorporation of ginger shreds was found to significantly improve the body and texture score when added upto 6 per cent level beyond which (i.e. S3), there was a decrease in body and texture score. Yet S3 obtained 87.8 per cent marks of the maximum body and texture score i.e. 30.

5.4.4.8.4 Melting quality characteristics: There was a very slight decrease in the melting quality score of product upon

incorporation of shreds i.e. 4.33 (S1) to 3.83 (S3) compared to the control (4.83). All the samples, except for S1 and S2 were distinguishable statistically.

5.4.4.8.5 Colour aspect: Addition of ginger shreds did not influence the colour scores significantly. The ice cream samples scored average marks for colour in the range of 4.83 (S2) to 4.89 (S1) as against 4.83 for control.

5.4.4.9 Ice cream made with 4 per cent addition of ginger shreds (S1) scored the highest total score as well as flavour score. The superiority of S1 was confirmed statistically also. S1, S2, C and S3 obtained 75.16, 74.25, 73.05 and 71.64 out of 85. Hence, S1 was selected and used further in the second part of experimentation i.e. comparing different forms of ginger in home made and factory made ice cream.

5.4.5 SELECTION OF LEVEL OF TREATED GINGER SHREDS IN HOME MADE ICE CREAM

5.4.5.1 Home made ice cream was prepared containing 3 different levels of treated ginger shreds (i.e. at 4, 6 and 8 per cent designated as T1, T2 and T3) and compared with control (C) where vanilla was used as a flavouring agent. Ginger shreds were treated in a boiling sugar syrup so as to reduce their pungency and chewiness which otherwise reduced their acceptability. The effect of incorporation of treated ginger shreds on different attributes has been summarized hereunder:

5.4.5.2 Composition

5.4.5.2.1 A marginal decrease in all of the compositional attributes under study was observed which was found to be significant specially at higher levels of incorporation of treated shreds. However, there was no significant effect on the protein content, acidity and pH values of the samples when used upto moderate levels. All the samples fulfilled the legal standards specified for nut ice cream in our country.

5.4.5.3 Viscosity

5.4.5.3.1 A steep increase in viscosity of experimental samples was observed which was found to be significant at each level of addition of ginger shreds. The increase in viscosity was more pronounced here compared to when juice, powder or untreated shreds were used. The average viscosity of experimental samples ranged between 286.7 (T1) to 349.5 (T3) centipoise when assessed at 7°C.

5.4.5.4 Whipping ability

5.4.5.4.1 The effect on whipping ability was found to follow a similar pattern as noted earlier in case of ginger juice (Section 5.4.2.4) and shreds (Section 5.4.4.4).

5.4.5.5 Overrun

5.4.5.5.1 A decrease in overrun was observed in experimental samples which was more pronounced in this case when compared with other forms of ginger i.e. juice, powder or shreds. The

average per cent overrun attained in C, T1, T2 and T3 were 45.47, 37.2, 34.02 and 31.08 respectively.

5.4.5.6 Melting resistance

5.4.5.6.1 An increase in melting resistance similar to that observed in case of juice, powder and shreds was noticed. The melting rates in terms of g ice cream melted in 40 min. at 37.5 C per 100 g ice cream for C, T1, T2 and T3 were 41.2, 29, 22.58 and 18 g respectively.

5.4.5.7 Bacterial count

5.4.5.7.1 Limited study indicated that none of the ice cream samples could be distinguished statistically for their SPC.

5.4.5.8 Sensoric profile

5.4.5.8.1 All the samples were judged for their organoleptic quality using the score card given by Arbuckle (1977).

5.4.5.8.2 Flavour profile: Flavourwise, T2 was preferred the most and its preference was also confirmed statistically. The order of preference was $T2 > C > T1 > T3$. The flavour score obtained by C was 36.94 (out of 45) and that of experimental samples varied between 36.44 (T3) to 37.89 (T2).

5.4.5.8.3 Body and texture scores: A marginal increase in body and texture score was evident when treated shreds were added upto 4 per cent level such scores being at par with control ($P > 0.05$). However, addition at higher levels decreased the body and texture scores significantly. The body and texture

score of T1, C, T2 and T3 were 26.94, 26.78, 26.23 and 26.11 respectively. All the samples scored more than 87 per cent of the maximum body and texture score.

5.4.5.8.4 Melting quality scores: Use of treated ginger shreds in ice cream was observed to give delayed meltdown and hence experimental samples obtained lower marks than control which was observed to be statistically significant. The average melting quality scores for C, T1, T2 and T3 were 4.72, 4.44, 4.19 and 4.08 respectively.

5.4.5.8.5 Colour score: Addition of treated shreds led to a product having brown colour which decreased their colour scores. Colour score of T1 and T2 were at par with C statistically. The average colour score of C, T1, T2 and T3 were 4.83, 4.78, 4.69 and 4.53 respectively out of a maximum score of 5.

5.4.5.9 Ice cream containing 6 per cent treated ginger shreds (i.e. T2) had the highest flavour score which was significantly higher than the rest. Also the total score of T2 was highest, however such score was at par with C and T1. Samples C, T2, T1 and T3 obtained 86.2, 85.9, 85.8 and 83.7 per cent of the maximum total score being 85. Hence, T2 was selected and used in the second part of the study.

5.4.6 PREFERENCE OF FORM OF GINGER IN HOME MADE ICE CREAM

5.4.6.1 Home made ice cream was prepared using 4 different forms of ginger at pre-selected levels i.e. J (4 per cent

ginger juice), P (1 per cent ginger powder), S (4 per cent ginger shreds) and T (6 per cent treated ginger shreds) and compared with C to select the most preferred form of ginger in the manufacture of home made ice cream. All the samples were judged for their organoleptic quality using the score card given by Arbuckle (1977).

5.4.6.2 Sensoric profile

5.4.6.2.1 Flavour score: Ice cream containing treated shreds @ 6 per cent was preferred the most flavourwise and its score was at par with J. The order of preference flavourwise was :T > J > S > P > C. The flavour scores obtained by T, J, S, P and C were 38.78, 38.32, 37.63, 36.63 and 36.49 respectively.

5.4.6.2.2 Body and texture scores: The average body and texture score was in the order : J (28.19) > S (27.5) > C (26.75) > T (26.12) > P (25.37). The body and texture score of all the products could be distinguished from each other statistically. Though T and P had lower body and texture scores than control, they obtained 87 and 84.6 per cent marks out of the maximum marks i.e. 30.

5.4.6.2.3 Melting quality scores: The average melting quality scores was in the order C (4.75) > S (4.37) > J (4.06) > T (3.93) > P (3.81). The per cent marks out of the maximum marks obtained by P , T, J and S were 76, 79, 81 and 87 respectively.

5.4.6.2.4 Colour scores: The order of preference obtained was

J > C > S > T > P. Only P scored significantly lower marks than C. All the samples scored more than 82 per cent of the total marks for their colour score.

5.4.6.3 With respect to total score, J was superior to all other samples. However, J and S were at par statistically. Order of preference was: J (75.44) > S (74.11) > T (73.2) > C (72.77) > P (69.93).

5.4.6.4 Thus, it is evident from this part of the study that flavourwise all the experimental samples scored higher marks (Preference cycle being T=J>S>P=C) than the control, preference of T, J and S being statistically confirmed over control. However, incorporation of treated shreds (@ 6 per cent) and powder (@ 1 per cent) adversely affected body and texture of ice cream giving gummy, sticky and cohesive body characteristics. Incorporation of ginger was also found to affect melting quality adversely leading to delayed melting. However, scope exists to check these adverse effects of the ginger in ice cream by decreasing the level of stabilizer added in making ice cream mix.

5.4.7 PREFERENCE OF FORM OF GINGER IN FACTORY MADE ICE CREAM

5.4.7.1 Factory made ice cream was prepared in a direct expansion type "Guisti-make" batch freezer, using selected levels of various forms of ginger designated as J, P, S and T. The results obtained are summarized hereunder.

5.4.7.2 Time required to reach 90 per cent overrun

5.4.7.2.1 Addition of ginger in any form i.e. P (186 s) , J (199 s), S (215 s) and T (236 s) was found to increase the time required to reach 90 per cent overrun compared to control (180 s). In case of J, S and T, this increase was significant whereas the time required for P was as par with that of C.

5.4.7.3 Melting resistance

5.4.7.3.1 Sample T had the highest melting resistance followed by S, J, P and C. The melting rates of all the experimental samples were significantly lower than control. The melting rates in terms of per cent ice cream melted (g/100g ice cream) in 40 min. at 37.5 C for C, P, J, S and T were 31.04, 24.53, 21.63, 20.72 and 12.68 respectively.

5.4.7.4 Bacterial status

5.4.7.4.1 No significant influence of ginger in any form whatsoever on the microbiological count was observed during storage of ice cream for 30 d, there was an increase in bacterial count in all the samples.

5.4.7.5 Sensoric profile

5.4.7.5.1 The sensoric quality of freshly hardened, heat shocked and stored (30 d) products was adjudged by a panel of 6 judges using the score card recommended by Arbuckle, 1977.

5.4.7.5.2 Flavour profile: In case of freshly hardened ice creams, J was preferred the most which was followed by T, the

flavour score of J and T being statistically alike. The flavour score obtained by J, T, S, C and P was 41.58, 41.25, 40.58, 39.92 and 39.58 respectively. A similar trend was noted after heat shock treatment, but additionally, the flavour preference of S and T was similar statistically. In comparison to heat shocked products, the stored products differed for C vs. S which were now undistinguishable flavourwise. Heat shock as well as storage of ice cream did not influence the flavour score in any of the products statistically.

5.4.7.5.3 Body and texture profile: In case of freshly hardened ice creams, the order of preference was: J > C > S > T > P. Even though S, T and P had significantly lower body and texture scores than C, they scored 92.5, 91.7 and 90 per cent marks of the maximum body and texture score i.e. 30. However, after heat shock treatment, the body and texture preference changed to: J > S > T > C = P. Heat shock treatment significantly decreased the body and texture of control. The experimental samples maintained their body and texture characteristics even after the heat shock. In case of stored products, the average body and texture score of J was significantly higher and that of P, significantly lower than that of C, whereas samples S and T could not be distinguished from C statistically. Storage for 30 d did not affect the body and texture characteristics of the samples significantly.

5.4.7.5.4 Melting quality scores: The different forms of ginger used at selected levels were found to have significant

influence on the melting quality scores except for stored samples S and T which were statistically alike. Neither the heat shock treatment nor the storage of ice cream had any influence on any of the products statistically.

5.4.7.5.5 Colour scores: No significant differences in colour scores of C, J, S and T was observed in any of the treatments. Colour scores of P was significantly lower than those of C, J, S and T throughout the study. Heat shock treatment as well as storage of samples did not have any effect on the average colour scores. The order of preference in terms of colour score was $C > J > T > S > P$.

5.4.7.6 The total score of J was significantly higher than all the remaining samples either in case of freshly hardened, heat shocked or stored products. The order of preference obtained for total score in case of freshly hardened products was : $J > C > T > S > P$, that of heat shocked products was: $J > S > T > C > P$ and that of stored product was : $J > T > C > S > P$. Thus, the superiority of ice cream containing ginger juice (@ 4 per cent level) was established on the basis of the total score even under normal or adverse storage conditions. Samples C, S and T were equally preferred, all being at par statistically.

5.4.8 From this part of the study the flavour preference of all forms of ginger except powder is confirmed statistically over the control; though control and P were also indistinguishable flavourwise ($P > 0.05$). However,

incorporation of ginger especially in the form of untreated or treated shreds tended to decrease the body and texture score leading to dry and gummy body as observed in case of home made ice cream also (Section 5.4.6.4). Similar to home made ice cream, the melting quality of ice cream was adversely affected by incorporation of ginger in any form used in this study. This adverse effects tended to decrease the total score of fresh experimental products, i.e. T and S compared to the control, though both being at par with control ($P > 0.05$). These defects may be overcome by using ice cream mix with lower stabilizer concentration than usual concentration in ginger ice cream. Further, it can also be concluded from this study that the ice cream containing ginger in all the forms except powder can withstand adverse storage conditions like thermal shock.

5.5 In conclusion it is seeming evident from this study that use of ginger, an novel herb as juice @ 4 per cent (J) or as treated shreds @ 6 per cent (T) or as untreated shreds at 4 per cent (S) would give a highly acceptable completely naturally flavoured product. Further, treatment of ginger shreds in boiling sugar syrup would also improve the product by reducing pungency and chewiness. The ginger employed in these three forms (J, S and T) could protect the ice cream against adverse storage conditions i.e. thermal shock. Use of ginger powder is not advocated because of their adverse effect on almost all sensoric attributes. Furthermore, improvement in overall quality of ginger ice cream prepared from mix

containing lower stabilizer concentration than usual may be considered. However, systematic study is needed to confirm this aspect. The need of considering dilution effect of ginger in ice cream in computing ice cream mix ingredients to comply with legal standards is also indicated by this study.

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APPENDICES

APPENDIX I: ICE CREAM SCORE CARD

Perfect score	Criticisms	Sample No.				
		1	2	3	4	5

FLAVOUR 45

Normal range 31 - 40	<ul style="list-style-type: none"> -Cooked -Lacks fine flavour -Too high flavour -Lacks flavouring -Lacks freshness -Lacks sweetness -Too sweet -Metallic -Old ingredient -Oxidized -Rancid -Salty -Storage -Syrup flavour
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BODY AND TEXTURE 30

Normal range 25 - 30	<ul style="list-style-type: none"> -Coarse or icy -Crumbly -Fluffy -Soggy -Sandy -Weak
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MELTING QUALITY 5

Normal range 4 - 5	<ul style="list-style-type: none"> -Curdy -Does not melt
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COLOUR 5

Normal range 4 - 5	<ul style="list-style-type: none"> -Colour uneven -Colour unmatched
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BACTERIA 15

TOTAL 100 Total score of each sample

Date: _____

Name: _____
Signature: _____

APPENDIX II : ICE CREAM SCORING GUIDE

Defect	Slight	Definite	Pronounced
FLAVOUR			
Cooked	39	37.5	35
Egg	39	38	36.5
High acid	36	34	33
Lacks fine flavour	39.5	38.5	38
Lacks flavouring	39.5	38.5	37.5
Lacks freshness	39	38	37
Lacks sweetness	39	38.5	36
Metallic	36.5	34.5	32.5
Neutralizer	36.5	33.5	32
Old ingredient	37	35.5	33
Oxidized	37	34.5	32
Rancid	35	33	31
Salty	38	35.5	32.5
Storage	38	36	33
Too high flavour	39	38	37
Too sweet	39	38	37
Unclean	35	33.5	31
Unnatural flavouring	37	36	34
Unnatural sweetner	38	37	34
BODY AND TEXTURE			
Coarse	29	28	27
Crumbly	28.5	27.5	26
Fluffy	28	27	26
Icy	27.5	26.5	25
Sandy	27	26	25
Soggy	28	27	26
Weak	28	27	26
MELTING QUALITY			
Curdy	4.5	4.5	
Does not melt	4.5	4.5	
COLOUR & PACKAGE			
Colour uneven	4.5	4.5	
Colour unnatural	4.5	4.5	

APPENDIX III Average composition of dairy products employed in preparation of ice cream mixes

	Cow milk	Cream	Skim milk powder
Fat (%)	4.25 ± 0.129	68.2 ± 2.167	0.84 ± 0.114
SNF (%)	8.5 ± 0.158	2.98 ± 0.216	94.967 ± 0.152
Total milk solids (%)	12.75 ± 0.148	71.18 ± 2.97	95.807 ± 0.18
Acidity (% lactic acid)	0.17 ± 0.02	0.062 ± 0.002	0.984 ± 0.378
Solubility index (ml)	-	-	0.475± 0.05

APPENDIX IV Average composition of the dried ginger powder employed in preparation of ice cream mixes

Moisture (%)	10.85
Crude fibre (%)	5.94
Starch (by acid hydrolysis, %)	52.8
Non-volatile oil (%)	1.51
Crude protein (N X 6.25, %)	11.8

APPENDIX V Average composition of ginger extract and fresh peeled ginger employed in preparation of ice cream mixes

	Ginger extract	Fresh, peeled ginger
Moisture (%)	84.63 ± 0.586	75.33 ± 1.527
Starch (by acid hydrolysis, %)	8.67 ± 0.49	11.1 ± 0.265
Protein (N X 6.25, %)	1.5 ± 0.15	2.3 ± 0.2
pH	6.22 ± 0.057	-

APPENDIX VI: Influence of various forms of ginger at selected levels on the average compositional characteristics, pH and acidity of factory made ice cream

Level of addition of ginger in ice cream in various forms (% w/w)	Percentage of ice cream constituents			Titrate-ble acidity (% lactic acid)	pH	
	Fat	Protein	Non-reducing sugars			
0 (C)	11.89	4.08	14.82	38.20	0.914	6.34
4 (J)	11.51	4.02	14.74	37.39	0.203	6.33
1 (P)	11.77	4.14	14.78	38.97	0.205	6.33
4 (S)	11.70	3.99	14.79	37.51	0.198	6.35
6 (T)	11.34	3.91	14.68	37.52	0.205	6.35
Statistical analyses						
SEM	0.022	0.033	0.017	0.022	0.001	0.01
CD (0.05)	0.17	0.1	0.05	0.08	NS	NS
C.V.%	0.38	1.66	0.30	0.14	1.31	0.33

APPENDIX VII Influence of various forms of ginger at selected levels on the average viscosity and whipping ability of ice cream mix

Level of addition of ginger in ice cream in various forms (% , w/w)	Viscosity (in centi-poise at 7 C)	Whipping ability (cubic cm/ g) after a whipping time of		
		0 min.	3 min.	5 min.
0 (C)	178.0	0.915	1.231	1.174
4 (J)	220.9	0.924	1.167	1.121
1 (P)	185.8	0.925	1.226	1.154
4 (S)	267.3	0.923	1.166	1.140
6 (T)	319.8	0.926	1.111	1.094
Statistical analyses				
SEM	3.311	0.002	0.009	0.012
CD (0.05)	9.98	-	0.027	0.037
C.V.%	2.90	0.18	1.50	2.14