

Variants of ice creams and their health effects

Abstract

Ice cream is a sweetened frozen dairy product preferred as snacks or dessert made of milk and milk products, that is often added with fruits (raw and/or dried form), along with other essential ingredients like flavours, colours etc. In the last decade, the perceptions of consumers have changed from ice creams as a mere enjoyment snacks/dessert to functional food with health benefits. Several communities across the world and research institutes have shown keen interest and demand for fortified ice creams with additional nutrients or bioactive substances. Attempts have been made to make ice cream as functional food by incorporation of probiotics, having several additional advantages, such as improving consumer's health and nutritional value of product along with improvement in ice cream properties. Prebiotics like insulin and Fructooligo-saccharides (FOS) are widely exploited as sugar substitutes that also have shown positive effect on gut health. Spirulina powder, as an additive to ice cream, helps in replacing stabilizers and giving natural light green colour to ice cream. The increasing concerns about the effects of diet on health have elevated demand for reduced fat ice cream. For this reason dietary fibres, whey protein and modified starch addition in ice cream preparations have been exploited. Ice creams prepared with vegetable oils extracted from soy and several other sources exhibit health benefits like lowering the risk of cancer and cardiovascular diseases. Incorporation of tiger nut based milk in ice cream is expected to replace cow milk and could be alternative for designing ice cream addressing lactose-intolerance consequences. Incorporation of kinnow peels as a source of photochemical, improves colour as well as flavour of the ice cream. In this review different varieties of ice creams and their positive impacts on consumer's health is explored.

Keywords: ice cream, fortification, bioactive compounds, prebiotics & probiotics, health benefits

Introduction

Ice cream is a sweetened frozen food mostly eaten as a snack or dessert. It is usually made up of dairy products, such as milk and milk cream and also often combined with fruits or other ingredients for flavour and as well as colour. It is typically sweetened with sugar or sugar alternatives. Flavourings and colourings are added in combination to stabilizers and emulsifiers. For ice cream preparation, the prepared ice cream mixture is agitated to incorporate void or air spaces and cooled down rapidly below the freezing point of water to prepare ice cream of desired characteristics.¹ As a result, produced ice cream would have smooth, semi-solid foam which is solid at low temperature. It becomes softer again as the temperature increases. Nutritional and physico-chemical attributes are important deciding factor when consumers purchase any dairy products. Earlier ice cream was considered a food for enjoyment, rather than a basic food. Driven by increasing incomes and health consciousness among the consumers, value addition to dairy products has witnessed a significant increase over the past few years. Fortification of ice cream with nutrients or other bioactive substances is of high demand and widely supported in current market.²

Discussion

This section contains the detailed discussion about different types of alternate ice creams produced by incorporation of probiotics, spirulina, vegetable milk, nuts etc for making ice cream more nutritious and healthy for the consumers. A part of this section is dedicated for reduced fat ice cream, flavoured soy milk ice cream and fruit peel ice cream.

Incorporation of probiotics into ice cream

Ice cream and frozen desserts are most suitable carriers of probiotics.³ The effect on the viability of probiotic organism by freezing during manufacturing and prolong storage are still matter of consideration. Probiotic cultures add value to the ice cream and prove better illustration of being functional food. For guaranteeing functional properties, every process stage must be optimized. Milk acts as fermentative substrate. For avoiding undesirable changes during fermentation and storage of food product, optimal temperature and pH levels are maintained. Probiotic strains are very sensitive to lower pH values (4.0-4.5), which pose negative impact on sensory acceptability of the product. To overcome these problems of varying pH of fermentative substrate as a result of production of lactic acid, the fermentation process is seized at pH between 5.0 to 5.5.⁴

Frozen yoghurt technology is widely adopted for the inclusion of probiotic cultures into ice creams and desserts. Several combinations of *Bifidobacterium* and *Lactobacilli* have been used.⁵ It can be directly (blending of probiotic cultures and ice cream mix prior freezing process) added or milk is involved in fermentation for probiotic cell proliferation into the ice cream mix. The protection of cells from cryogenic damage or shock is important in both cases.

Encapsulation, freeze-drying and co-encapsulation of various microbial strains belonging to *Lactobacillus acidophilus*, *B.infantis*, *B.longum* and *B.animalis* have been studied.¹ Experimental results inferred that freshly encapsulated cells without freeze-drying showed higher probiotic culture survival rates. *Lactobacillus johnsonii* showed higher viability in increased sugar levels in ice cream but

had shown sub-lethal damages upon freezing. Studies concluded that probiotic counts of 107CFU/ml were maintained for 10 weeks and other researchers claimed storage life of vegetative probiotic culture for 8 months.⁶ Some strains failed to resist the freezing and churning

that occur during ice cream manufacturing, but other organisms like *B.longum* and *B.Infantis* have capacity to survive various processes and could be stored up to 11 weeks or some even up to 52 weeks.⁷

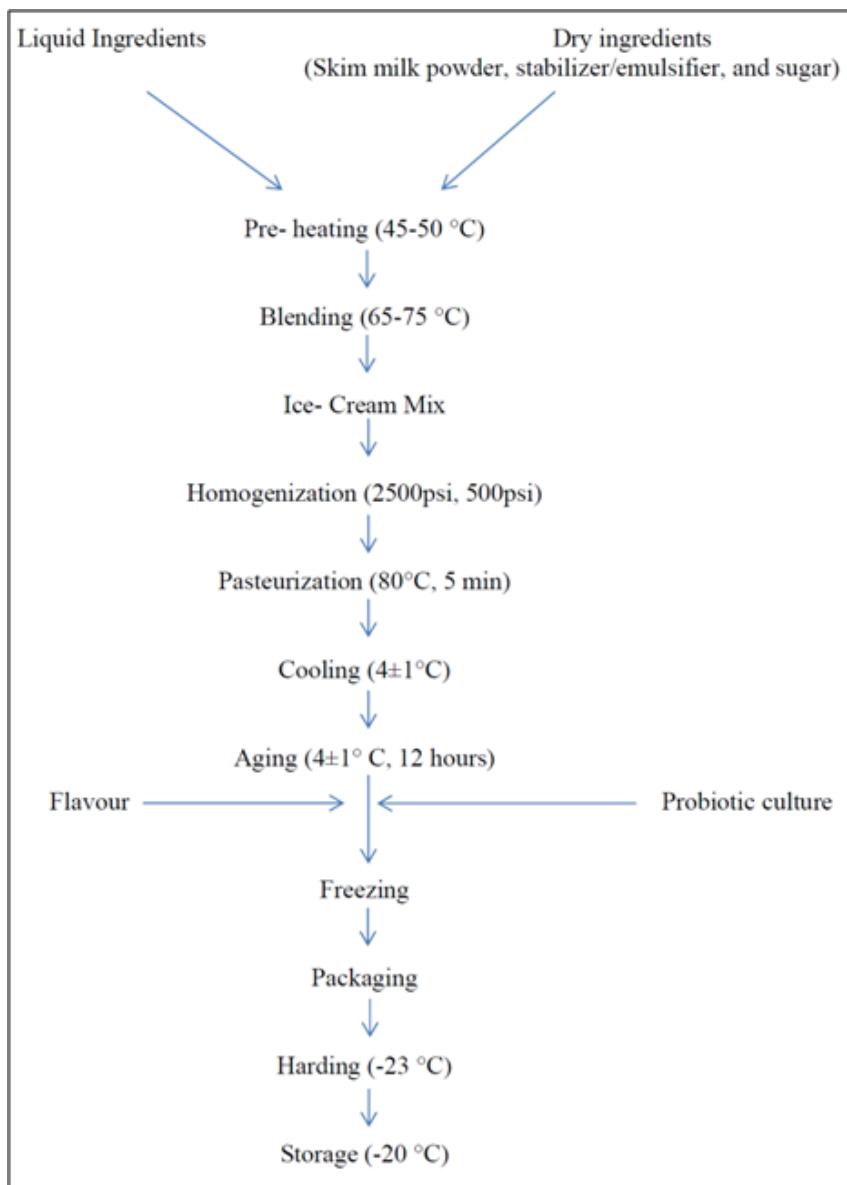


Figure 1 Flow diagram for the preparation of probiotic ice cream.²

Viability of the cultures had shown no influence on the fat content of the product.⁷ A study conducted by using 13 strains of *L.acidophilus* and 11 strains of *Bifidobacterium* illustrated that the effects were strain-dependent as ice cream is an example of non-fermented food products and impact of the probiotic microorganisms over the flavour should be considered as another important parameter. Some microorganisms like *L.reuteri* or *Bifidobacterium* are among examples having capability to produce slightly acid flavour as a reason of fermentation. Manufacturing conditions that limit fermentation can be implemented to minimise such off-flavours.⁷

The increased interest of stakeholders in therapeutic products have led to the incorporation of probiotic cultures into ice cream to make dietetic or functional ice cream. Fermented ice cream production is considered as a healthy challenge to the ice cream industry which stress on the ways of preventing too strong yoghurt like flavour into the ice creams. The use of cultured milk and their products acts as a platform for manufacturing healthy ice cream products. Probiotic strains are considered to be safe and useful in its prominent uses as a functional food or functional food ingredient.

Over the last two decades, the ice cream science and technology

have undergone a remarkable progress in understanding structure, texture and various attributes of storage and stability interactions. Findings from these studies have enabled food/dairy technologists to realize the importance of incorporation of novel and functional ingredients in ice cream systems in order to provide customized desired aspects in techno-physiological parameters like enhancement in viscosity, cryo-protection, emulsification, water-binding along with improvement in health and nutritional value of the product designed.

Challenges in incorporating probiotics to ice creams

Several hurdles in form of challenges exist for development of probiotic ice cream, i.e., type of probiotic, its amount to be added to have a beneficial effect, toxicity, viability or sustainability of probiotic cultures, type and pre-treatment of substrate, heating, freezing, concentration of the strains or cell populations to be inoculated. Stability of the probiotics during storage depends on type of strain chosen, microbial species interactions and H_2O_2 generation by bacterial metabolisms and pH/ acidity.⁸⁻¹⁰

Prebiotic ingredients in ice cream substituted for sugar

Two prebiotic ingredients i.e. insulin and FOS (Fructooligosaccharides) have an effect on physical and sensory qualities of ice cream when substituted for sugar in ice cream. As reported by Wood (2011), ice cream colour may be affected if more than 30% of sugar is substituted but no changes in quality aspects were observed when insulin or FOS is added till 20% of sugar in ice cream. The researcher however concluded that more research studies are needed to confirm these findings.^{11,12}

Ice cream enriched with spirulina powder

In ice creams, additives like colours, stabilizers and emulsifiers are used in the manufacturing. On several occasions the bio-safety of food is threatened due to addition of synthetic additives in food as they may inhibit the absorption of some nutrients and cause allergy. Dairy products enriched with minerals, proteins and essential fatty acids can be manufactured using cyan bacteria.¹³ It also gives natural colour to ice cream enriched with it.¹⁴ Studied and inferred that besides enrichment, addition of spirulina also helps in replacement of stabilizers in ice cream preparation as its composition is 60% proteins only.

Spirulina powder can be used in concentration of 0.15% to replace 50 percent stabilizer in ice cream preparation without affecting the sensory attributes of the product. Spirulina powder addition also gave natural light green (pista) colour to ice cream. So it can be concluded that spirulina powder offers great potential use in dairy industry to enrich dairy products and to substitute synthetic additives viz., colours, stabilizers and emulsifiers etc., employed in various dairy products.¹⁴

Reduced fat ice cream

Ice cream is a complex colloidal system having a unique structure which depends on size of air bubbles and other structural entities.¹⁵ At present there is an increasing concern about the effect of diet on health and quality of life. Stake holders are interested in low fat products

that are less associated with the risk of chronic diseases like obesity and coronary heart diseases.¹⁶ The Food and Drug Administration has approved the use of labelling name of reduced-fat, low-fat and non-fat ice creams for such products containing less than 10% milk fat.¹⁷

Fat content is a vital parameter for texture and quality of ice cream and reduced fat ice cream has a body and texture associated with customer dissatisfaction. For improving the sensory qualities of ice cream, the dairy manufacturers use some fat replacers for the improving quality of reduced fat ice creams.^{16,18} Variety of dietary fibres have been tried to use as fat replacers in reduced fat ice creams.¹⁹ The fat can be partially replaced with low energy generating nutrients such as proteins (whey proteins) or carbohydrates (modified starch).²⁰

Dietary fibre includes heterogeneous food entities like cellulose, hemicelluloses, lignin, pectin, sea weed etc. Dietary fibres are widely found in various food sources like oats, wheat, fruits and vegetables. Different studies have tried to incorporate dietary fibre in numerous food products to enhance their health related benefits.²¹ The use of dietary fibre shows excellent improvement in physical properties like melting potential of ice cream having a minimal effect on viscosity, over run and texture.¹⁹ In another study involving both oat and wheat fibre has shown improvement in viscosity development due to water-binding capacity.²² Whey and whey products have been used successfully in ice cream manufacturing and other frozen dairy desserts for many years. Whey proteins are excellent source of essential amino acids and biologically active peptides. The incorporation of whey protein in ice cream has showed an improvement in overrun, creaminess, smoothness and flavour.²³

Recent studies have shown whey protein as an improving factor capable of improving sensory characteristics besides only improving the protein content of reduced fat ice cream.^{11,24} Starch is a commonly known and widely used plant polysaccharide, consisting of a long chain of glucose units. For enhancement of functional properties of starch; several studies have been conducted using different chemicals or enzymes to modify starches. The resulted modified starch showed enhanced properties like increased water binding capacity and improved thickening that has enable modified starch to be used as a food additives and as fat replacers.²⁵ Modified starch was used previously for production of low fat butter spread, margarine and low fat milk type products.²⁶ Also attempts were made to manufacture low fat ice cream.¹⁸

Ice cream with vegetable milk

The increased demand for alternatives to cow's milk in ice cream making is growing due to problems associated with its fat content, cholesterol, lactose intolerance (allergy) and increasing desire for vegetable milk based ice cream. Soy milk is considered to be a best suitable choice²⁷ because of its high nutritional quality especially in regards with protein content and balance essential amino acids contents.²⁸ Regular consumption of soy and soy products contributes health benefits like lowering the risk of cancers, diseases associated with heart and vascular systems, hypercholesterolemia, diabetes, bone and kidney related diseases.²⁹

Coconut (*Cocos nucifera*) milk is vegetable milk which might be used to replace cow milk. This milk is easy to digest and it is abundant source of minerals (specifically calcium, phosphorus and potassium) and vitamins (B, C and E vitamins). It is a rich source of antioxidants.

The high oleic and lauric acids containing in coconut milk help in preventing arteriosclerosis and other heart related illness. Coconut milk is widely used by confectioners, bakeries, biscuits and ice cream manufacturing industries to increase flavour and taste of various related products.³⁰

Wide usage of these two vegetable milks in food preparation can be related with vegetable proteins having favourable effects on enhancing physical properties of foods. For an illustration, viscosity, melting time and hardness of ice cream samples enhanced by substituting of skim milk powder with soy protein isolates.³¹ The fortification of yogurt ice cream with soy protein improved the texture, firmness and viscosity of the product.

It was reported that soy lecithin acts as emulsifier and also helps in enhancing the viscosity, stability, texture and in extending the melting time of the ice cream.^{27,32,33} It is also believed to improve the quality of ice cream by exploring various proportions of skim milk in soy milk blends and was found that large quantity of skim milk with soy milk helped in reducing the beany flavour of soy beans and also resulted in increased quality of ice cream.

Few research studies have been carried out with coconut milk to replace cow milk in ice cream. In achieving this attempts were made to improve the physical properties of low fat coconut milk ice cream by replacing skim milk powder with whey protein concentrate and it also resulted in the increased ice cream mix viscosity and reduced melting rates of ice cream. The main challenge in using coconut or soy milk in ice cream is to achieve a stable colloidal system. For example lecithin in the soy milk is responsible for the formation of hard ice cream which resulted in the delay of about 15minutes of standing at room temperature to soften before serving.³⁴

Studied and infers that on addition of soy milk in ice creams containing cow and coconut milk improves their physical properties (viscosity, melting rate and freeze point).³⁵ The overall acceptability and hard texture of ice cream were improved by the addition of cow milk. The vegetable milks can also be exploited for use in the production of functional ice creams with significant and prominent nutritional and therapeutic properties and also contributing for high physical qualities and overall acceptability.

Ice cream from blends of cow milk and tiger nut

Over the years, attempts have been made to find cheaper substitutes for cow milk, due to the rising cost of cow milk and its products irrespective of its high nutritional quality in terms of proteins. The development of tiger nut (*Cyperus esculentus*) based milk is a cheap substitute for traditional cow milk. In Nigeria, cow milk is predominantly used to produce commercial ice cream, while hardly any attention have been given to the use of nuts, milk extract or in combination with milk to produce palatable ice cream.³⁶ Tiger nut is included as one of the underutilized crop and is popular my name “earth almond”, “chufa” and “zula” nuts. Tiger nut can be consumed raw, roasted, dried, baked or be made into refreshing beverage called “Horchata De Chufas” or tiger nut milk. Tiger nut is considered to be rich in dietary fibre, essential minerals like potassium, phosphorus and Vitamins E and vitamin C.

Umelo et al.³⁷ conducted experiments and inferred that an ice cream with acceptable sensory attributes like taste, flavour and

consistency (mouth feel) could be resultant of blend of cow milk and tiger nut milk at 50% level of substitution of cow milk with tiger nut milk but preferably at 40% cow milk substitution with tiger nut milk.³⁷ In addition the high protein and calorie content of ice cream produced from mixer of cow milk and tiger nut milk are believed to solve the problem of protein-calorie malnutrition (PCM) in Africa as there is high price of imported milk and milk products including poor milk production in Nigeria.³⁸ In addition considering the nutritive and health benefits of tiger nut which is believed to be one of the underutilized tubers, and its incorporation in ice cream production can enhance its utilization and health benefits associated with it.³⁷

Cocoa flavoured soymilk ice cream

Intake of soy ice cream replacing of regular ice cream may decrease in saturated fat intake.^{39,40} Experimental results have shown that soy ice cream is lactose free and has higher degree digestibility. It can be appropriate alternative for cow’s milk mainly for people who are allergic to cow’s milk and have symptoms of lactose intolerance. It is also believed and recommended for diabetic people.³⁴

Addition of sesame oil can be desirable in producing soy ice cream. Sesame oil has a compound called Sesamol that causes resistance against oxidation, also contains lignin having antioxidant property and has amounts of vitamin E.⁴¹ Further, sesame oil consists of unsaturated fatty acids like Oleic acid and Linoleic acid having dietary and health importance. The addition of cocoa powder in soymilk based ice cream production can be suitable as it removes beany flavour of soymilk and improves its organoleptic quality.⁴²

Studies infer that soy milk with different ratios has shown significant effects on composition of total solids, solids non-fat, protein, fat, acidity, pH, overrun and viscosity of ice cream produced. The sample containing 50% soy milk and 50% skim milk proved to be the most desirable sample. The sensory evaluation results showed that, various ratios of substitution for soymilk had significant effects on parameters like taste, flavour, texture, colour and total product acceptability of samples.⁴²

Phytochemical rich ice cream incorporating kinnow peel

Now a days the consumer’s elevated interest towards foods with more natural antioxidants, dietary fibre, natural colorants, minerals, vitamins, low calories, low cholesterol and low fat and free of synthetic additives, etc. has been noticed.⁴³ Citrus possess many health promoting beneficial components that are present in the parts that most consumers would prefer to throw away. The residual amounts obtained from citrus fruits, account for 50% of the original total amount of whole fruit. Citrus fruits are mainly exploited or used for juice, oil and pectin production and also as sources for dietary fibre and antioxidants.⁴⁴ The fruit juice industries produce significant quantity of by products which pose problems in their disposal.

In citrus fruits, about three-fourth of the total vitamin C is present in the peel, pulp and seed, that goes waste.⁴⁵ It is an antioxidant and vitamin C has potential to protect LDL cholesterol from oxidation. It can also help in reducing the occurrence of heart related diseases and can also inhibit the formation of carcinogenic nitrosamines in the body.⁴⁶ Citrus peels are also source of phenolic compounds which consisting of phenolic acids and flavonoids. These citrus flavonoids which include Hesperidins and Naringin, shown to have antioxidant

and other health benefiting characteristics like anticancer, antiviral and anti-inflammatory activities.⁴⁷

The study carried Mann et al.⁴⁸ that the addition of frozen Kinnow peel (un-blanch and blanch both) to ice cream enhances the appearance and flavour characteristics of ice cream, presenting it in a good natural orange colour and flavour.⁴⁸ Both forms of frozen Kinnow peel were added to ice cream at different levels of 1, 3 and 5%, respectively. The Total Solids, ascorbic acid (Vitamin-C) and flavonoids (naringin) contents of both the ice cream types enhanced with raised level of peel addition. According to sensory evaluation carried, the most suited concentrations of frozen Kinnow peel in ice cream were un-blanch-3% and blanch-5% respectively. When compared with ice cream containing and 3% un-blanch-frozen Kinnow peel was found to have better sensory scores than that of ice cream having 5% blanch peel. Hence, ice cream can be prepared by the combining frozen Kinnow peel with improved colour, flavour and enriched with photochemical having functional properties.

Ice cream business & its market in India

Ice cream noticeably being a seasonal product, with increased demand during the summer months from April to June has leaning demand in the winter months from November to January.⁴⁹ Though in last few years, an increased trend in consumption of ice creams and other frozen desserts in winter have discarded its seasonal impact due to various factors like changing consumer perception, regional variations, diverse consumer acceptations, favourable retail locations, wide product range and innovation, festivities and sale, marketing promotions. Various factors boosting ice cream business in India are:

- i. Rapid growth and urbanization
- ii. Increase in purchasing capacity
- iii. Increased awareness of the consumers
- iv. Modernized cold supply chain and storage facility
- v. Evolution of retail outlet facilities

Huge competition due to entry of new players and entrepreneurs are making the ice cream industry competitive and local processors are looking forward for expanding their territory of sales.⁴⁹ Ice cream industry growth is not only restricted to India but in whole world. Reasons for this growth have been predicted to be caused by increase in global population, economic stability and growth in terms of income, innovations adding to higher sensory acceptability and nutritional values both in terms of macro and micro nutrients etc. It was further reported that Asia as the largest ice cream market followed by North America, Europe and others.

Major reason for this competitive market is because On consideration of lower consumption of ice creams in India at 200-500ml per individual per annum in comparison to the world wide average of 2,300ml, companies are trying hard to keep the category important in the food sector segment through innovative programs on flavours, formats, availability etc. to provide some market cushion against seasonality. Since, for ice cream business requires a separate supply chain, completely different cold storage and dealer networks, communication or marketing and price points with other companies. Criteria like supply of electricity during summers affects the ice cream stocking and behaviour of the retailers as when it melts becomes non-saleable. As of present scenario, ice cream business is underinvested

in India and expected that it continues for the next couple of years because of poor profit margins sometimes even less than 10%. Due to health conscious consumers, Indian ice cream makers are introducing market with pro-biotic and low fat versions through processes that reduce air content in ice creams. The ice- cream consumers follow a variety seeking behaviour as ice cream is a low involvement item and such behaviour can be better tackled by various perceptual components. Probiotic ice creams that enhance metabolism are functional foods in nature whose consumption mainly depends on healthy eating intentions in turn enables the company and marketer to find the right market strategy.⁵⁰

Out of the major Indian ice cream producers like Amul, HUL's Quality Walls, Mother Dairy, Vanilla, Cream Bell, Baskin Robbins, Amul's proposition is ice creams made of natural milk at reasonable prices while Quality Walls' ice creams are for pleasure and bonding and Baskin Robbins promotes its offerings as high quality premium ice creams with innumerable exotic flavours. Apart from premium class, Amul, Vanilla, Cream Bell and Mother Dairy have their portfolios available at wide-ranging price points.⁵⁰ The Indian ice cream market having over 40% belongs to the organized sector growing at about 15% on yearly basis. Amul leads the pack with about 36-38% market share (5% of its total revenues) followed by Quality Walls & Vanilla with about 12-14% share each. A large portion of ice cream sales in India, nearly half of the market is driven by Impulse purchase and rest by family consumption (about 35%) at home and about 15% in parlour sales.

Studies conducted Dutta⁵⁰ infer that the brand awareness plays a vital role influencing the consumer's purchase decision.⁵⁰ Best marketing & brand awareness activity in current scenario is "Advertisement". Satisfied customer also plays an important role in brand awareness as they recommend others to purchase and such referral brings new customers and promotes positive brand image whereas dissatisfied customers may lead negative brand image which hinders successful brand awareness activity. Purchase has a positive correlation with ice cream brand, flavour/colour and format/pack size of the product but a negative correlation with price.⁵⁰

In Indian ice cream industry, where switching cost is negligible a product can't be placed in the market on the basis of brand alone, but it should match the spending power of customers and cordial relationship. It is not only the ice cream itself, but the yummy flavour, effective distribution channel as well as hard working sales team that differentiate one company from another and drives a company on front drive.

Conclusion

Ice creams now days paving new opportunities in research and development of new ice cream varieties having beneficial functional attributes and interest of health conscious public segment is expected to grow in days to come in developing countries. The varieties discussed above in this review are expected to set new trends in markets worldwide in days to come. Ice cream varieties like soy based, spirulina based, phytochemical, probiotic impregnated, and lean fat ice creams, .etc. are expected to show more demand and are expected to be advertised for their health promoting properties. Challenges do occur for the ice cream industries , it is factual that there is set back for ice cream sales and revenue generation from many years as reason being non perennial demand and market for ice creams in tropical countries like India. It also faces back foot in storage, transportation,

technical and technological hurdles, under marketing in developing countries. Along with these challenges, ice cream demand is expected to take speedy phase for reason being peak globalization, change in perception of public towards ice creams and dairy products, increase in economics and vibrant tradition across globe.

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Conflict of interest

The author declares no conflict of interest.

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