

“DEVELOPMENT OF ICE-CREAM BY USING JACKFRUIT PULP”

By
Miss. Gaikwad Swapna Balu
Reg. No. K-15/149

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, DIST. AHMEDNAGAR,
(M.S.), INDIA**

*In partial fulfillment of the requirements for the degree
of*
MASTER OF SCIENCE (AGRICULTURE)

In
DAIRY SCIENCE

**DIVISION OF ANIMAL HUSBANDRY AND DAIRY
SCIENCE
COLLEGE OF AGRICULTURE, KOLHAPUR
MAHATMA PHULE KRISHI VIDYAPEETH,
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Approved by

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**DIVISION OF ANIMAL HUSBANDRY AND DAIRY SCIENCE
COLLEGE OF AGRICULTURE, KOLHAPUR
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI, DIST. AHMEDNAGAR,
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2017**

CANDIDATE'S DECLARATION

*I hereby declare that this thesis or part
there of has not been submitted by
me or other person to any other
University or Institute
for a Degree or
Diploma.*

Place: Kolhapur

(S. B. Gaikwad)

Date : / /2017

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Division of Animal Husbandry and Dairy Science,

College of Agriculture, Kolhapur

CERTIFICATE

This is to certify that the thesis entitled, “**DEVELOPMENT OF ICE-CREAM BY USING JACKFRUIT PULP** ” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra State in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **DAIRY SCIENCE**, embodies the result of the piece of bonafide research work carried out by **Miss. Gaikwad Swapna Balu**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree, diploma or publication in other form.

Place: Kolhapur.

Date: / / 2017

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Maharashtra State (India).

CERTIFICATE

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Place : Kolhapur.

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Date : / / 2017

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Place: Kolhapur

Date: / /2017

(Miss. Gaikwad Swapna Balu.)

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LIST OF ABBREVIATIONS

<i>et al.</i>	Any other
@	At the rate of
CD	Critical difference
CV	Coefficient variance
°C	Degree Celsius
etc.	Et cetera
Fig.	Figure
g.	Gram
IS	Indian standards
JP	Jackfruit pulp
ml.	Milli liter
min.	Minute
mm	Milli meter
viz.,	Namely
NS	Non-significant
%	Per cent
% LA	Per cent lactic acid
MSNF	Milk Solid not fat
SNF	Solid not fat
SE	Standard error
TS	Total sugar
i.e.	That is
w/w	Weight per weight
Wt.	Weight
>	More than
<	Less than

lit.	Litre
CRD	Completely Randomised Design
CMC	Carboxy Methyl Cellulose
kg/cm ²	kilo gram per centimeter square
K cal	Kilo calorie
TSS	Total soluble solid
SMP	Skim milk powder
WMP	Whole milk powder
WPC	Whey protein concentrate
ICM	Ice-cream mix

ABSTRACT

“DEVELOPMENT OF ICE-CREAM BY USING JACKFRUIT PULP”

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GAIKWAD SWAPNA BALU

A candidate for the degree

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Mahatma Phule Krishi Vidyapeeth,

Rahuri.

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Research Guide : Dr. D. K. Kamble

Division : Animal Husbandry and Dairy Science

Major Field : Dairy Science

Ice-cream is a frozen food, typically eaten as snack or dessert, usually made from milk, cream and often combined with fruits or other ingredients and flavours. The jackfruit (*Artocarpus heterophyllus* Lam.) belonging to family Moraceae is an integral part of common Indian diet and commonly known as “Kathal”. Jackfruit is eaten fresh and used in fruit salads. The present study was carried out to prepare jackfruit pulp ice-cream considering the demand of ice-cream and nutritive value as well as flavour of jackfruit. The optimized ice-cream was evaluated for sensory and physico-chemical qualities.

Ice-cream was prepared from buffalo milk standardized at 6 per cent fat. Initially the type of jackfruit was selected by preparing ice-cream using ‘*Barka*’ and ‘*Kappa*’ type and it was found that addition of the JP of *Barka* type had more scores for all the sensory attributes over the *Kappa* type. Subsequently the level of jackfruit pulp (JP), levels of sugar and level of stabilizer were optimized.

It was observed that maximum score for flavour, colour and appearance, body and texture, sweetness and overall acceptability were observed for the ice-cream containing 15% jackfruit pulp. Further increase in level of jackfruit pulp resulted in lower overall acceptability score. Simultaneously when sugar was added @ 13, 15 and 17 per cent of ice-cream mix the overall acceptability score for 15 per cent sugar level was maximum, (8.18). Subsequently, the ice-cream was prepared using three different stabilizers with 15 per cent JP ice-cream. The maximum sensory score was observed for ice-cream with 0.1 per cent carrageenan stabilizer. Overall acceptability score of 0.1 per cent carrageen was maximum (8.12) as compared to other stabilizer sodium alginate and CMC.

The optimized product had 8.00 ± 0.10 , 8.05 ± 0.06 , 8.28 ± 0.08 , 8.20 ± 0.09 and 8.12 ± 0.04 scores for flavour, colour and appearance, body and texture, sweetness and overall acceptability respectively. The ice-cream prepared by optimized formulation showed 11.33 ± 0.12 , 3.39 ± 0.05 , 7.80 ± 0.29 , 16.25 ± 0.26 , 24.05 ± 0.23 , 0.92 ± 0.01 , 39.65 ± 0.45 , 0.30 ± 0.01 , 6.14 ± 0.02 , 27.50 ± 0.55 and 76.20 ± 0.22 per cent, fat, protein, reducing sugar, non-reducing sugar, total sugar, ash, total solid, acidity, pH, melting rate and overrun, respectively. The cost of experimental jackfruit ice-cream was found to be Rs. 82.43/lit.

1. INTRODUCTION

The milk production during 2015-16 has been estimated at 155.5 million tons (nddb.org). Since ages, milk has been held as an excellent health tonic for our body. As per FSSAI definition (2011) milk is the normal mammary secretion derived from complete milking of healthy milch animal without either addition there to or extraction there from unless otherwise provided in these regulations and it shall be free from colostrum. Milk is the “Bank of Nutrients”. Milk has unique position in the diet of almost all the people in the world due to its nutritional importance, which is mainly presence of high quality fats, proteins, carbohydrates, minerals and vitamins. Hence it is called as ideal food. It also supplies bone forming minerals, health giving vitamins. Milk has immunoglobulin, lactoferrin, lysozymes, lactoperoxidase and vitamin B₁₂ binding protein, which has demonstrated anti-microbial effects. Several milk derivatives have been shown to be effective in preventing health disorders. Milk sugar (lactose) and its derivatives are excellent therapeutic agents.

At present, nearly 54 per cent milk is converted in to various milk products while 46 per cent is utilized as fluid milk. The milk products are classified into different categories like concentrated milk products such as khoa, basundi, rabari, pedha, burfi, etc., acid coagulated milk products such as paneer, channa, rasogola, sandesh etc., fermented milk products such as dahi, chakka, lassi, shrikhand etc., frozen milk products like ice-cream, kulfi etc., fat rich milk products such as ghee, butter, butter oil, cream, dried milk products like Skim Milk Powder (SMP), Whole Milk Powder (WMP)etc., enzyme coagulated milk products like cheese etc.

Ice-cream is leading growth in the global market for innovative dairy products as consumers increasingly associate the segment as being more of an everyday, year-round household grocery, according to Global

Industry Analysts. It is expected that the global ice cream market will witness a growing number of flavour introductions as part of a shift towards premium products. (Soukoulis et al 2009). Ice-cream is a frozen food, typically eaten as a snack or dessert, usually made from milk, cream and often combined with fruits or other ingredients and flavours. It is sweetened with sucrose, corn syrup, cane sugar, beet sugar and other sweeteners. Food grade flavours and colours are added in addition to stabilizers. Ice-cream represents a sector in dairy industry where the most value addition has taken place in past two decades. It is a rich source of energy providing 180-250 kcal/ 100g (Marshall *et al.*, 2003). Ice-cream is a delicious, delicate and nutritious food liked by all age groups and popular throughout the world. It is manufactured by freezing and aerating a pasteurized mixture of ingredients including milk products, sugars, emulsifiers, stabilizers, flavouring compounds and water. According to FSSAI (2011), ice-cream is frozen product obtained from cow or buffalo milk or a combination thereof or from cream, and or other milk products with or without the addition of cane sugar, eggs, fresh fruits, fruit juice, preserved fruits, nuts, chocolate, edible flavours and permitted food colours. The ice-cream should contain not less than 10 per cent fat, 36 per cent total solids and 3.5 per cent protein.

During manufacture of ice-cream, delicate flavours are more preferred than the stronger ones. The intensity of flavour should be just enough to be easily recognized and delicately pleasing to taste (Arbuckle, 1986b). Flavouring materials are available in natural, artificial and blended forms (mix of natural and artificial). Vanilla is the most popular ice-cream flavour that is extracted from *vanilla planifolia*. It also used as flavour enhancer with other flavours such as chocolate, cocoa, fruits and nuts. Some herbal ice-creams also have been developed using mint, green tea, ginger, asparagus etc as flavouring agents intended to provide the medicinal properties to consumers through this largely consumed snack

The ice-cream demand in the country has increased from about 12.5 million liters in the year 1990-91 to 185.5 million liters in 2008-09. Also, the value ice-cream marketed in India is estimated to have reached the level of Rs 15 bn per annum. Although, in recent years, the production of ice-cream has increased remarkably in India, the per capita consumption is still very low at 300 ml per year compared with that of the US, which is about 22 litres (indiastat.com).

The jackfruit (*Artocarpus heterophyllus* Lam.) belonging to family moraceae is a fruit in fruit basket of costal Indian. It is commonly known as “Kathal”. Jackfruit is a tropical tree native to Western Ghats of India, Malaysia and also found in Central and Eastern Africa, South-Eastern Asia and many pacific islands. India is the second biggest producer of the jackfruit in the world and is considered as the motherland of jackfruit. It is popularly known as poor man’s fruit in the eastern and southern parts of India. The tender fruits of the tree are used as vegetables and the ripe ones as table fruits. The pulp constitutes 25-40 per cent of the fruit's weight. Jackfruit pulp is eaten a fresh and used in fruit salads and possesses high nutritional value (Samaddar *et al.*, 1985). There are two main type of jackfruit; one is small fibrous, soft and mushy and the carpel’s are sweet called *Barka* and the other one is crisp and crunchy, but not very sweet called *Kappa* (Swami *et al.*, 2012). Jackfruit is available in local area during summer season.

The proximate nutritional composition per 100 g of ripen jackfruit has been shown to vary. The ripe fruit has a proximate energy value of 88–410 KJ and principally contains 1.2–1.9 g protein, 0.1–0.4 g fat, 16–25.4 g carbohydrates, 175–540 IU vitamin A, 7–10 mg vitamin C, 20–37 mg calcium, 38–41 mg phosphorus, and 191–407 mg potassium (Swami *et al.* 2012). Almost all parts of the jackfruit tree are used in the preparations of various ayurvedic and unani medicines and ripe fruits are consumed to

prevent excessive formation of bile, to develop flesh, phlegm, to strength the body, and increases virility. Depending on the variety, jackfruit was shown to be rich in compounds like carotenoids, volatile acids, sterols, tannins, and important compounds like morin, dihydromorin, cynomacurin, artocarpin etc. Jackfruit also has been reported to contain antioxidant prenylflavones. Recently, antioxidant capacity of jackfruit pulp has been reported by Jagtap and Panaskar (2010).

The jackfruit is also used for various products development like jackfruit candy, juice, jam, jelly, finger chips, fruit bars, fruit leather, halvah, pickles, papad, ready to-serve beverages, wine, toffee, cake and milk based shrikhand, rasogolla, basundi, ice-cream and kulfi. As per research reports jackfruit has shown various medicinal properties such as anti-ageing, improve oral health, antiulcer properties, cardiovascular diseases, improve digestion, antioxidant, skin disease, anticancer properties (Swami *et al.* 2012).

Considering the demand for the ice-cream and nutritional importance of jackfruit, attempt has been made to develop of ice-cream by using jackfruit pulp. This is available in local area during summer season. Since there is no evidence of systematic research work on jackfruit ice-cream and technological aspects of the product, the program has been undertaken with the following objectives.

- 1) To optimize the levels of addition of jackfruit pulp for developing ice-cream.
- 2) To study the sensory qualities of jackfruit ice-cream.
- 3) To study the physico-chemical qualities of jackfruit ice-cream.

2. REVIEW OF LITERATURE

Various aspects of Ice-cream on which research was to be carried out have been reviewed here under.

2.1 Nutritional importance of ice-cream:

Kansal (1992) has conducted a research on health effects associated with consumption of ice-cream. Lactose i.e. milk sugar constitutes approximately 20 per cent of carbohydrates in ice-cream while the other commonly used sugar is sucrose i.e. cane sugar. Their major function is to provide taste body, and energy. The digestibility of ice-cream proteins is 96 per cent compared to 74-84 per cent for plant proteins. So they are valuable in diet for people suffering from liver and gall bladder disease and patients with impaired kidney functions.

Kansal (1998) reported that ice-cream is a product which is rich in calcium, phosphorus and other minerals of vital importance in building good bones and teeth. Being also rich in lactose, ice-cream flavours greater assimilation of the calcium content of the diet.

Goff and Hartel (2013) has reported that total energy value of ice-cream depends on (1) the percentage of carbohydrates including lactose, added sweeteners, many bulking agents and sugars that may be present in fruit or flavoring (2) the percentage of protein including that from milk, whey protein-based fat replacers, nuts, eggs, or stabilizer and (3) the percentage of fat from any source including cream, emulsifier, egg, cocoa or nut fat. Ice-cream contains 34–36 per cent milk protein i.e. 2.5–4 per cent by weight. They are of excellent biological value because they contain all the essential amino acids and are important sources of tryptophan and especially rich in lysine. Milk fat content in ice-cream supplies energy, essential fatty acids, fat-soluble vitamins, saturated and unsaturated fatty acids and sterols including cholesterol. Carbohydrates serve as a source of heat and energy in the body. The commonly used sugar is sucrose.

2.2 Preparation of ice-cream: -

Bansode (1999) reported that the ice-cream made with 15 per cent taro tuber powder, as a replacer of milk solid not fat (MSNF) was found to have firm body and smooth, creamy texture.

Roland *et al.* (1999) studied the effects of fat content on the sensory properties, melting, color and hardness of ice-cream. Ice-creams were prepared that varied only in the percentage of milk fat (0.1, 3, 7, or 10%) and the corresponding total solids. All mixes were formulated to have similar freezing points. Quantitative descriptive analysis and a trained sensory panel was used to assess the appearance, flavor, texture, color, hardness and melting characteristics of the ice-creams. Melting time and hardness were not significantly different among the 0.1, 3, and 7 per cent fat samples of ice-cream but the 10 per cent fat samples took longer to melt and were softer than the 7 per cent fat samples.

Bolliger *et al.* (2000) conducted study on influence of emulsifiers on ice-cream produced by conventional freezing and low-temperature extrusion processing. The aim was to examine the influence of emulsifiers on the process, since both emulsifier addition and low-temperature extrusion may have similar effects on promotion of colloidal structure in ice-cream. Ice-cream samples from both processes were analyzed for stiffness at draw, fat destabilization indices, melting performance and microstructure.

Sofjan *et al.* (2003) carried out a study on effects of overrun on structural and physical characteristics of ice-cream. In their research ice-creams with different overruns were stored either in bulk containers (at -10°C with normal refrigeration cycling) or on microscope slides (at -6°C, -10°C or -20°C) for analysis. In bulk storage, mean air cell size initially increased during hardening, decreased during the early stages of storage and ultimately increased to larger sizes at longer (up to 3 months) storage times. Higher overrun led to slightly more stable air cells during storage.

Granger *et al.* (2004) studied the influence of formulation on the structural networks in ice-cream. They prepared six different formulations, corresponding to three types of fat (hydrogenated, refined coconut oils, refined palm oil) and two mixtures of mono and diglycerides, namely saturated and partially unsaturated were chosen to investigate the influence of the oil phase nature and the low molecular weight emulsifier type on the networks present in ice-cream. The influence of the fat type on ice-cream characteristics was mainly illustrated by different rheological parameters and, to a lesser extent, by melting time, whereas the amount of proteins in the aqueous phase did not allow discriminating among the formulations.

Muse and Hartel (2004) studied the structural elements in ice-cream that affect its melting rate and hardness. Ice-creams were frozen in a batch freezer with three types of sweetener, three levels of the emulsifier polysorbate 80, and two different draw temperatures to produce ice-creams with a range of microstructures. Ice-cream mixes were analyzed for viscosity and finished ice-creams were analyzed for air cell and ice crystal size, overrun, and fat destabilization. Fat destabilization, ice crystal size, and the consistency coefficient of the mix were found to affect the melting rate of ice-cream, whereas hardness was influenced by ice phase volume, ice crystal size, overrun, fat destabilization, and the rheological properties of the mix.

Guner *et al.* (2007) carried out study on production of yogurt ice-cream at different acidity. The effect of using yogurt on the viscosity, overrun, melting characteristics, pH, acidity, microbiological aspects and sensory characteristics of ice-cream was investigated. The ice-cream mix in all groups was 10% fat, 18% sucrose, 12% MSNF (milk solids not-fat), 0.8% stabilizer and 0.4% emulsifier. The use of yogurt instead of milk decreased the viscosity of ice-cream mix and over-run capacity of ice-cream. There was no negative effect of yogurt on the melting characteristics of ice-cream. The sensory scores of ice-cream produced using the yogurt at

0.7% lactic acid were statistically similar to the control group. It was concluded that the conversion of milk to yogurt for ice-cream production can be made at acidity 0.7% lactic acid with no loss of ice-cream quality. Higher levels than 0.7% lactic acid contribute to progressive loss of sensory quality.

Khillari *et al.* (2007) carried out a study on low fat ice-cream made with incorporation of whey protein concentrate (WPC). They reported no significant change in the sensory quality of ice-cream due to addition of WPC replace up to 40 per cent fat. However above 20 % for replacement, the overrun and melting quality changed significantly. Viscosity of mix was found to decrease progressively with increase in fat replacement.

Upadhyay *et al.* (2007) utilized the left-over pomace of carrot after juice extraction in powder form (i.e. CPP-Carrot pomace powder) in soft served ice-cream. Skim milk powder (SMP) (10.39–13.21%) and CPP (0.09–2.91%) were kept variable, the experimental trials were designed using Response Surface Methodology for two variables. The samples were tested for chemical, sensory and kinesthetic attributes as response. A linear effect of CPP incorporation was seen. Except hardness other kinesthetic attributes were agreeable to the control. As a final outcome 0.5% CPP was found good for overall acceptability.

Bisla *et al.* (2012) conducted research on development of ice-creams from soybean milk and watermelon seed's milk and evaluation of their acceptability. Total six different types of ice-creams were prepared from soymilk, watermelon seed's milk as whole and their blends with or without addition of guava pulp. The nutritional analysis of most acceptable ice-creams indicated that protein and fat value was found to be excellent and iron as well as vitamin C content were also found in good amount in comparison to standard ice-cream.

Manoharan and Ramasamy (2012) carried out a research on physico-chemical and microbial properties of herbal (*Aloe Vera*) ice-cream

with natural colour beet root for strawberry flavor. The sensory evaluation revealed that acceptability was highest for the ice-cream prepared from ICM with 20 per cent *Aloe Vera* pulp.

Santos and Silva (2012) studied on Mangaba (*Hancornia speciosa* Gomez) ice-cream prepared with fat replacers and sugar substitutes. Ice-cream formulations were tested with the fat replacers: Selecta Light, Litesse, and Dairy Lo and the sugar substitutes: Lactitol and Splenda. Were used all formulations were subjected to physical, chemical and microbiological analyses and evaluated by acceptability tests. In the sensory analysis, larger acceptance was observed for the formulations containing Selecta Light (SL) and the combination of Litesse, Lactiol, and Splenda (LLS). All formulations showed good levels of global acceptability and appearance. The low-fat mangaba ice-cream elaborated with Selecta Light was the best formulation in terms of viscosity and air incorporation when compared with the control.

Wangcharoen (2012) studied on development of ginger-flavored soya milk ice-cream with 6 and 7% (w/w) sugar and ginger extract at the concentration of 4 and 5% (w/w). One hundred consumers were requested to taste four samples of ginger-flavoured soya milk ice-cream and rate the intensity of ginger flavour, sweetness, richness and smoothness, together with their indication for ideal intensity of these attributes as well as their preference of each sample by using the 10 cm-line scale. Ideal ratio scores, principal component analysis and analysis of variance with mean comparison were used for data analysis. It was shown that the recipe with 7% sucrose and 4% ginger extract was close to the ideal product ($p>0.05$) and it had the highest preference mean score ($p<0.05$).

Ahanian *et al.* (2014) investigated the production of sesame ice-cream by substituting skim milk with soya milk (the ratios of 0:100, 25:75, 50:50, 75:25 and 100:0). The evaluation of chemical, physical and sensory properties revealed that increase in the proportion of soya milk increased the

total solids, protein, pH, fat, overrun and viscosity of mixture but the acidity and solids non-fat decreased significantly in all samples ($p < 0.001$). The results of sensory evaluation showed that adding sesame extract in amount of 0.1 % and sesame oil in the formulation could completely remove the beany flavour. Also, soy milk replacement up to 50% does not have significant effect on flavour, texture, colour and overall acceptability. According to the results of chemical, physical and sensory tests, best ratio was 50:50 soy milk : skim milk.

Abdel-Haleem and Awad (2015) investigated some quality attributes of low fat ice-cream (LFIC) substituted with hull less barley flour (HBF) and barley β -glucan (BBG). The methodology included adding HBF (1, 2, 3 and 4 %) as a partial substitution of skim milk powder (SMP) and BBG (0.40 %) as a complete substitution of carboxy methyl cellulose (CMC). All mixes and resultant ice-cream samples were evaluated for their physicochemical properties as well as the sensory quality attributes. The results indicated that substitution of SMP with HBF significantly increased total solids (TS), fat and crude fiber, while crude protein and ash significantly decreased in ice-cream mixes. BBG exhibited the same manner of control. Specific gravity was gradually increased with adding HBF and BBG in the mixes and therefore the overrun percent was significantly changed in the resultant ice-cream. Adding HBF in ice-cream formula led to significant decrease in acidity with higher freezing point and the product showed higher ability to meltdown. BBG treatment showed the same trend of control. Values of flow time and viscosity significantly increased with increasing HBF in the ice-cream mixes, but these values significantly decreased in BBG mix. Freezing time decreased with increase in HBF but increased in BBG treatment. The substitution of SMP with 1 and 2 % HBF significantly ($P \leq 0.05$) enhanced sensory attributes of ice-cream samples. While the BBG treatment achieved mild score and acceptability.

Agrawal *et al.* (2015) used ginger, a natural herb as a flavouring agent in ice-cream. Ginger juice was incorporated at levels of 0, 1, 2, 3, 4 and 5 per cent w/w of ice-cream mix. After experimentation, it was found that the gradual increase of ginger juice caused increase in freezing time with decrease in freezing point depression. The ice-cream made with 4 per cent ginger juice comprising of 11.53 per cent fat and 3.89 per cent protein and having 43 per cent overrun was found to be most acceptable among all the treatments used under study.

Dhivya *et al.* (2015) conducted the research to ascertain the suitability of utilizing the natural carbohydrate based fat replacers (CBFRs), potato and tapioca in low fat ice-cream (LFI) formulation were prepared using toned milk by substituting potato at 10, 15, 20 and 25% and tapioca at 5, 10, 15 and 20% levels. The changes in proximate composition, Vitamin – C content, overrun and sensory parameters were studied. Results obtained revealed that LFI formulation containing 20% potato and 15% tapioca received higher consumer acceptance.

McGhee *et al.* (2015) worked on evaluation of textural and sensory characteristics of three types of low-fat soft serve goat milk ice-cream manufactured using goat milk (3.64% fat, 2% fat and 0.71% fat). A commercial powdered vanilla flavor pre-mix containing 0.25% fat (Alpha Freeze, D466-A9047, Tampa, FL, USA) was formulated into the three types of goat milk base for the manufacture of the ice-creams and textural and sensory properties of the products were determined at 0, 2, 4, 8 weeks of frozen-storage at -18°C . Additional textural traits at 0, 1 and 56 days of storage were compared among the three types of low-fat caprine ice-creams using a texture analyzer. The results showed approximately three-fold increases in firmness and consistency of all three types of soft-serve low-fat goat ice-creams after 1 day frozen-storage. The similar trend of elevation was observed in cohesiveness and index of viscosity for all tested products, probably due to the hardening of the texture of the frozen products after 1

day storage. Regardless of fat level treatments of the low-fat goat ice-creams, all textural properties after 56 days frozen-storage revealed substantial elevations especially in firmness and consistency traits compared to those of the original soft-serve ice-creams with extreme high variations. In sensory quality, storage period significantly affected the flavors of cooked ($P < 0.01$), sweetness ($P < 0.05$), freshness ($P < 0.05$), rancidity ($P < 0.05$), whey ($P < 0.05$) and oxidized ($P < 0.05$), but not in acid flavor. There was a general trend of a slight decline in overall acceptability of the three types of low-fat goat ice-creams as storage period advanced. It was concluded that the textural and sensory qualities of the low-fat goat milk ice-creams were still acceptable by the sensory panel after 8 weeks frozen-storage.

Pourahmad and Ahanian (2015) conducted the study to investigate production of cocoa ice-cream by using soy milk. In this study, the effect of substituting soymilk instead of skim milk (the ratios of 0:100, 25:75, 50:50, 75:25 and 100:0 soymilk to skim milk) was evaluated on chemical, physical and sensory properties of ice-cream. The results showed that by increasing the substitution of soymilk the total solids, protein, pH, fat, overrun and viscosity of mixture increased but acidity and solids not-fat decreased significantly in all samples ($p < 0.01$), while have no significant effect on amount of sucrose samples. All samples showed pseudo plastic behavior and viscosity of ice-cream samples decreased with increasing shear rate. Finally, it was found that the viscosity of ice-cream was kind of Herschel Bulkley. The results of sensory evaluation showed that adding cocoa powder (1%) in the formulation could completely mask the beany flavour. Also, soymilk replacement up to 50% had no significant effect on flavour, texture, colour and overall acceptability. According to the results in terms of chemical, physical and organoleptic properties is 50:50 ratio of soy milk to skim milk was declared the best.

2.3 Non-dairy ingredients in ice-cream:

Olenev and Prokofeva (1980) studied the use of sodium alginate stabilizer in ice-cream manufacture. Sodium alginate when used at the rate of 0.20 per cent yielded superior quality ice-cream than the one containing gelling potato starch. Ice-creams made with the alginate exhibited a higher degree of dispersion of air bubbles, contained smaller ice crystals which led to better structure and soft, elastic consistency.

Goff and Jordan (1989) studied the action of emulsifiers in promoting fat destabilization during ice-cream manufacture. It was found that fat destabilization results from the combination of ice crystallization and shear forces during ice-cream manufacture. The results suggested that, based on their ability to lower the interfacial tension, emulsifiers control the adsorption of protein to the fat globule surface. The fat globules thus become more susceptible to coalescence induced by the shear forces of agitation and ice crystallization during manufacturing process.

Bolliger *et al.* (2000) conducted research on influence of emulsifiers on ice-cream produced by conventional freezing and low-temperature extrusion processing. The aim was to examine the influence of emulsifiers on the process, since both emulsifier addition and low-temperature extrusion may have similar effects on promotion of colloidal structure in ice-cream.

Marshall *et al.* (2003) studied the flavouring and colouring materials in ice-cream. They stated that the primary purpose of using stabilizers in ice-cream is to produce uniformity in the product, smooth body and texture, retards ice and lactose crystal growth during storage, especially during periods of temperature fluctuation and provide some degree of shape retention during melting. They also contribute to mix viscosity, stabilize the protein in the mix to avoid wheying off, help in suspension of flavouring particles, create a stable foam with easy cut-off and stiffness at the barrel freezer for packaging, slow down moisture migration from the product to

the package or the air and assist in preventing shrinkage of the product volume during storage.

Sharma and Hissaria (2009) studied the hydrocolloids - competent ice-cream stabilizers. According to them, carrageenan prevents serum separation due to incompatibility of the other polysaccharides with milk proteins and also aids in suspension of liquid flavors. Carrageenan is not used by itself, but rather as a secondary colloid to prevent the wheying-off of mix, which is usually promoted by one or the other stabilizers like guar gum.

Bahramparvar and Tehrani (2011) studied the application and functions of stabilizers in ice-cream. Carrageenan is used in many stabilizer blends at levels of 0.01–0.02% to prevent phase separation (wheying off) through its interaction with milk protein. This chemically modified natural gum is a linear, long-chain, water-soluble and anionic polysaccharide. Purified sodium carboxymethyl cellulose is a white-to-cream-colored, tasteless, odorless, free-flowing powder. It is a strong stabilizer and only 0.1–0.2% is needed in a mix. It imparts body and chewiness to ice-cream.

Seval and Boran (2012) studied the effects of carboxyl methyl cellulose and edible cow gelatin on physico-chemical, textural and sensory properties of yoghurt. CMC addition at the rate of 0.25 per cent contributed to higher viscosity (7175 cP) in comparison with the control being (4526 cP).

2.4 Preparation of ice-cream added with various fruit pulps:-

Borhade (1997) reported that ice-cream prepared with 4 per cent mango pulp had the best quality in respect of flavor, texture and colour. The level of milk fat and SNF had influence on overall acceptability. In general, 10-12 per cent fat and 15 per cent milk solid-not-fat yielded good result.

Gaikwad (2000) reported that the titratable acidity in ice-cream increased with an increase in the level of karonda pulp and it was the highest with 30 per cent karonda pulp.

Bajwa *et al.* (2003) studied strawberry ice-cream with 10, 15, 20 and 25% strawberry pulp was prepared. Ice-cream was analyzed for physico-chemical and sensory characteristics at 0, 10, 20, 30 and 40 days of storage. Overrun stand-up time, meltdown, moisture, ash, total solids, MSNF, sucrose ascorbic acid, pH and acidity were significantly affected by ice-cream treatments as well as storage. While protein, fat and lactose have shown significant difference in case of treatments and non-significant difference for storage. In organoleptic evaluation, the highest score was awarded to the ice-cream with 15% strawberry pulp followed by ice-cream with 20% strawberry pulp. It was found that ice-cream could be prepared with exotic flavour and taste by using strawberry fruit colour and aroma.

Marshall *et al.* (2003) reported that as the amount of strawberry fruit was increased, the colour and appearance as well as flavour to improved while the texture became coarser. It was recommended to use 7.7 per cent strawberry puree plus 15.0 per cent solid pack strawberries. Another supplier recommended the use of 16.5 per cent sliced strawberries plus strawberry flavouring at 3.33 ml/l.

Salem *et al.* (2003) used Jerusalem artichoke (JA) in preparation of low fat and low sugar ice-creams. Replacement of 25, 50, 75 and 100 percent of milk fat in ice-cream mix with JA increased protein content, viscosity and melting resistance of the resulting product, but overrun was decreased. Use of JA had no effect on ice-cream flavour, but the product was softer and smoother than the control. Low sugar ice-cream was made by complete replacement of sugar in the mix with sativoside and addition of JA and/or oat fiber (2-5 percent) as prebiotic and bulking agent. The final product, which had 31.3 percent less calories than the control, had improved viscosity, overrun and melting resistance. The low sugar ice-cream had a similar flavour to the control, but improved body and texture.

Athukorala *et al.* (2008) studied eight types of ice-cream prepared by incorporating different levels of jack fruit and tamarinds pulp. The levels

of jack fruit pulp incorporated were 5 per cent, 10 per cent, 15 per cent and 20 per cent by weight of ice-cream. Tamarinds fruit pulp was incorporated at 5.0 per cent, 7.5 per cent, 10.0 per cent, and 12.5 per cent by weight of ice-cream. Vanilla flavoured whey ice-cream was selected as the control. Ice-cream samples were evaluated organoleptically using consumer panelists consisting of 30 members. It was concluded that 15 per cent of jack fruit (waraka) incorporated whey ice-cream and 7.5 per cent tamarinds incorporated ice-cream were the most acceptable products.

El-Samahy *et al.* (2009) produced the ice-cream with concentrated cactus pear pulp. Red cactus pear (*Opuntia ficus-indica*) pulp was tested for some technological and chemical characteristics. The pulp was concentrated up to 30 °Brix then added at four levels (0, 5, 10 and 15%) to basic ice-cream mix. The basic mix contained 0.5 % gelatin, 8 % fat and 10.5 % milk solids non-fat (MSNF) and 16 % sucrose. Some of rheological parameters of both mixes and resultant ice-cream samples, in addition to some technological characteristics of resultant ice-cream samples were measured. The rheological properties of all ice-cream mixes before and after aging showed that the flow behaviour of mixes is non-Newtonian (pseudo plastic). While specific gravity and weight per gallon of resultant ice-cream samples increased by increasing of added pulp, overrun decreased. Sensory evaluation of resultant ice-cream samples showed that sample with 5% cactus was very desirable and very close to control sample. This work shows the possibility of producing a new product of ice-cream using cactus pear pulp as a good fruit substitute.

Hwang *et al.* (2009) evaluated the effect of adding grape wine lees (GWL) (50, 100 and 150 g kg⁻¹, wet weight basis) on the rheological and antioxidant properties of ice-cream to determine the potential of using GWL as a value-added ingredient in ice-cream. Black queen grape was selected because it was the only species for red winemaking in Taiwan. The addition of GWL decreased the specific gravity, pH, melting rate, firmness, lightness

and the amount of freezable water in ice-cream, but increased the viscosity, yellowness and fat destabilization in a dose dependent circumstance. However, the ice-cream with high GWL contents (100 and 150 g kg⁻¹) also showed unpleasant effects, such as the decrease of overrun and the increase of particle size of fat globule. The level of 50 g kg⁻¹ was applicable because it improved the functionality without the disadvantages in the overrun and particle size. Furthermore, GWL significantly increased the DPPH radical scavenging activity and reducing power of ice-cream and also its inhibitory effect toward the oxidation of human erythrocyte membrane. It appeared that the antioxidants in GWL were quite stable to the process of ice-cream making.

Pawar *et al.* (2010) studied the sensory evaluation of low fat custard apple ice-cream. They prepared low fat ice-cream from 15 per cent custard apple pulp, 15 per cent sugar and 10 per cent fat with 0(T₀), 0.2 (T₁), 0.3(T₂), and 0.4 (T₃) per cent of ascorbic acid and studied for its sensory evolution. The sensory score for overall acceptability of low fat ice-cream of treatments T₀, T₁, T₂ and T₃ were 7.57, 8.18, 8.67 and 7.50, respectively. It was observed that 0.3 per cent (T₂) level of ascorbic acid was most acceptable and rated between liked very much to like extremely for all sensory attributes. Highly perishable custard apple pulp can be well utilized in the preparation of ice-cream.

Iguttia *et al.* (2011) studied the substitution of ingredients by green coconut (*Cocos nucifera* L) pulp in ice-cream formulation. The growth in consumption of green coconut water in Brazil comes with a proportional growth of its waste, constituted of coconut husk and pulp. The objective of this study was to apply green coconut pulp in ice-cream formulation to replace milk, fat, gums and emulsifier, common ingredients in this kind of food. The formulations included coconut pulp, cocoa powder, sucrose, water, carrageenan gum, guar gum and hydrogenated vegetable fat. The formulation with all the ingredients, except milk, did not present

satisfactory creaminess. The product in which green coconut pulp replaced only fat and milk was not good either. The most satisfactory product contained 41% coconut pulp, 11% cocoa, 17% sucrose and 31% water. The overrun was 19.9% and 10 g presented melting time of 12 min. The results indicated that coconut pulp can be used to manufacture free milk, no lactose, low fat and no cholesterol food

Goff and Hartel (2013) reported that blueberries make wonderful flavours but can be difficult to work with, owing to the fact they do not absorb much sugar so remain frozen hard in ice-cream. Various forms of cooked blueberries, however, do become viable alternatives. Blueberry purees and concentrates can be used to flavour mix while blueberry ripples can be introduced as variegates. Recent ice-cream flavour introductions have included blueberry pie, blueberry ginger, blueberry muffin, blueberry cheese cake, and blueberries with mint or lavender.

Kumar *et al.* (2013) carried out a research study on the functional, rheological and sensory attributes of tulsi extract based herbal ice-cream. The product was formulated with different levels of herbal extract at 2.0 per cent, 3 per cent and 4.0 per cent. There was a proportionate decrease in the fat, protein, reducing sugars, non-reducing sugars and total solids (TS) in the experimental samples with increasing levels of tulsi extract compared to control.

Malik *et al.* (2013) studied the quality characteristics of ice-cream enriched with *spirulina* powder. *Spirulina* is a rich source of nutrients namely essential amino acids, essential fatty acids, carotenoids, minerals and vitamins and thus can potentially represent an important staple in the human diet. The work focuses on enrichment of ice-cream with *Spirulina* with its addition in concentrations of 0.075%, 0.15%, 0.23% and 0.3% to replace 25%, 50 %, 75 % and 100 % of stabilizer, respectively for ice-cream preparation. With increase in level of *Spirulina* there was improvement in nutritional profile, increase in over run and penetration value and decrease

in whipping rate was observed. It also gave natural light green color to ice-cream enriched with it. Ice-cream prepared by replacing 50 per cent stabilizer with *Spirulina* had comparable scores for sensory parameters with that of control.

Mann *et al.* (2013) carried out a study to develop ice-cream using frozen Kinnow peel. In the research, kinnow peel was used in both unblanched and blanched form, at the levels of 1, 3 and 5 per cent, each. The ice-cream samples were analyzed for sensory and chemical parameters which showed improvement in the appearance, flavour and overall acceptability of the ice-cream samples. The total solids (TS), ascorbic acid and flavonoids (naringin) content of the ice-cream samples were found to increase with increased level of addition of peel. Ice-cream with 3 per cent unblanched-frozen kinnow peel was found to be the best.

Mufas and Perera (2013) the research conducted to develop an ice-cream incorporated with pitaya pulp and evaluated its shelf life. Ice-cream samples were prepared with three different proportions of pitaya pulp viz., 12 per cent, 15 per cent and 18 per cent (w/w). Sensory evaluation was done by 20 semi-trained panelists using seven-point Hedonic scale score card. The ice-cream with 12 per cent (w/w) pulp yielded the highest consumer preference.

Sharifi *et al.* (2013) prepared the alginate nano particles loaded with Fe/n and used them in ice-cream structure. First all of the consequents of mixture included milk, sugar, cream, dried milk, and flavoring agent (Vanilla) calculated by Pearson square method and weighed. Then, milk and cream were mixed well for 5min with electrical mixer. This mixture was poured in steel bottle and heated till 40 °C slowly. The other materials were added to ice-cream after this stage. The mixture was then set at 80°C for 25 seconds and stored at refrigerator for 4 hours. After this, Fe/n-loaded nano particles were added to ice-cream and was checked for absorption of the salts and sensory and rheological evaluations were taken for samples. The

results showed that alginate nanoparticles could decrease the loss of Fe/n in comparison to control and have no side effects on sensory and rheological properties

Sun-waterhouse *et al.* (2013) carried out a research study on producing ice-cream using juice from kiwi fruit with green, gold or red flesh. The aqueous fractions from purees of kiwi fruit with green, gold or red flesh were added at 49% v/v to a basic low fat ice-cream. The resultant ice-creams were subjected to comparative product evaluation.

Barot *et al.* (2014) carried out a research study on development of technology for manufacture of bottle gourd ice-cream. Among three varieties of bottle gourd viz. Pusa Naveen, Anand bottle gourd-1 and Pusa Summer, Pusa Naveen variety was found most suitable with a combination of processed sugar treated cubes and puree in ice-cream mix formulation for manufacture of bottle gourd ice-cream. Processed bottle gourd puree was incorporated in ice-cream mix and subsequently frozen, while the processed bottle gourd cubes were incorporated into the partly frozen ice-cream, when drawn from the ice-cream freezer. The prepared product was evaluated for sensory scores.

Rizk *et al.* (2014) studied the characterization of the carotenoids (lyco-red) extracted from tomato peels and its uses as natural colorants and antioxidants of ice-cream. Sensory evaluation higher scores for ice-cream containing 3 per cent and 2 per cent carotenoids (lyco-red) compared to 1 per cent, 4 per cent and 5 per cent.

Fuangpaiboon and Kijroongrojana (2015) studied the qualities and sensory characteristics of coconut milk ice-cream containing different low glycemic index (GI) sweetener blends. Three mixtures of sweeteners (6.2 per cent xylitol + 7 per cent inulin, 4 per cent erythritol + 7 per cent inulin + 2.15 per cent fructose, 8.5 per cent inulin + 5 per cent fructose) were reformulated to obtain the similar characteristics as using 12 per cent sucrose, including sweetness, freezing point depression and total solid. The

sensory and chemical evaluation showed that the mixture of erythritol, inulin and fructose might be successfully used to replace sucrose as sugar sources in low GI coconut milk ice-cream production

Patel *et al.* (2015) studied the development technology for manufacture of ragi ice-cream. Caramel flavoured medium fat ice-cream (6 per cent fat) was prepared by addition of gelatinized malted ragi flour roasted in butter (MRB)@8 per cent, 9 per cent and 10 per cent by weight of mix and compared with control (C) i.e. vanilla ice-cream containing 10 per cent fat. In the next part of the study, ragi ice-cream was prepared using 4 different flavours viz. vanilla, mango, chocolate and caramel. Chocolate flavoured ragi ice-cream was adjudged as best, followed by mango, caramel and vanilla ice-cream.

2.5 Physico-chemical properties of ice-cream and factors affecting it: -

Lee and White (1991) used ultra-filtration retentate (concentrated to three times) and whey protein concentrate to replace different levels of solids not fat in vanilla ice-cream (12% fat) at 25, 50, 75 or 100 percent, respectively. pH of the ice-cream mixes was evaluated and it was found that pH increased as percentage of ultra-filtration retentate substitution increased but decreased as percentage of substitution of whey protein concentrate increased.

Marshall and Arbuckle (1994) worked on the physico-chemical properties of ice-cream depend on the quality and quantity of ingredients and processing conditions used for its preparation. Some of the important properties include acidity and pH, specific gravity, viscosity, overrun, meltdown time and firmness. Acidity of ice-cream is related to the composition of ice-cream mix. The natural or normal acidity of mix is due to the milk proteins, minerals and dissolved gases. Also reported that viscosity is an important property of the ice-cream mix and a definite amount of it is essential for proper whipping and retention of air. It is the internal friction that tends to resist the sliding of one part of the fluid over

another. Among the various ingredients, milk fat and stabilizer influence the viscosity more. On the other hand, sugar decreases the viscosity of the ice-cream mix. Ice-cream mix has both apparent and true viscosities. The true viscosity of the ice-cream mix may range from 50 to 300 cp. The higher the viscosity of a mix greater is the power required to freeze the mix.

Tirumalesha and Jayaprakasha (1998) studied the effect of an admixture (50:50) of spray dried WPC and buttermilk powder on physico-chemical and sensory characteristics of ice-cream and observed that the hardness of ice-cream decreased with increasing level of the admixture in to the ice-cream.

Bolliger *et al.* (2000) reported that the stabilizers in ice-cream attenuate the effects of recrystallization during storage, but have no significant effect in the freezer itself.

Hartel *et al.* (2001) studied development of air cells in a batch ice-cream freezer. The effects of operating conditions (freezing, not freezing, and freezing part way) and formulation (fat, emulsifier and stabilizer content) on development of air cells were studied. Air cell size decreased progressively with time during batch freezing. Whipping alone (no freezing) did not result in decrease in air cell size, indicating that freezing was necessary for stabilization of small air cells. Fat level and emulsifier content had no effect on air cell size, whereas stabilizer addition led to smaller initial air cells. The reduction in air cell size was correlated to change in apparent viscosity of the slurry being formed within the freezer.

Marshall *et al.* (2003) studied the course of crystallization as determined by many factors that interact with and depend upon one another. Ice-cream formulation can affect ice crystallization by influencing the freezing point and the crystallization mechanism. The sugars and milk salts in ice-cream mix affect the freezing point of the mix, which affects the degree of super cooling for a given coolant temperature.

Sofjan and Hartel (2003) reported that the proteins, having a high molecular weight, diffuse more slowly than other solutes, which could cause them to interfere with the lattice incorporation step of ice crystallization. The air cells may act as an insulator, mitigating temperature fluctuations and thereby leading ice crystal growth.

Singh (2007) found that increase in milk fat content in of low fat, fiber enriched fruit ice-cream, decreased its viscosity. This finding was attributed to the insignificant crystallization / clumping of fat globules during ageing of mix, which resulted into non-significant increase in viscosity.

Cook and Hartel (2010) studied the mechanism of ice crystallization in ice-cream production. They reported that ice-cream formulation can affect ice crystallization by influencing the freezing point and the crystallization mechanism. The sugars and milk salts in ice-cream mix affect the freezing point of the mix, which affects the degree of super cooling for a given coolant temperature. Fat can reduce ice crystal size by taking the place of water. In this case, for a given number of nuclei formed in ice-cream that is hardened to a given temperature, there will be less water to freeze when fat replaces some of the water. Partial coalescence of fat globules may also have a role in keeping ice crystals small.

2.6 Nutritional importance of jackfruit:

Jackfruit (*Artocarpus heterophyllus* L.) is one of the ancient tropical fruits of India. It is known as ‘*phanas*’ in Maharashtra. Jackfruit is commonly found in two major types viz., firm flesh, known as ‘*kapa*’ and soft flesh as ‘*barka*’ in Marathi. Unripe jackfruit is used as vegetable or made into pickle, while ripen jackfruits are eaten a fresh, preserved in syrup or used in various products. Jackfruit pulp possesses high nutritive value. The nutritional quality and method of extraction of pulp reported by various research workers have been cited under.

Bhatia *et al.* (1955) gave the composition of ripe jackfruit as 72.51 per cent moisture, 1.6 per cent protein, 0.22 per cent fat, 3.24 per cent fibers,

3.57 per cent minerals and 7.78 mg/100 g pulp ascorbic acid. They also reported 1.24 and 1.27 total titratable acidity on per cent anhydrous citric acid in bulbs of ripe and tender jackfruit, respectively on moisture free basis.

Watt and Merill (1963) reported that ripe jackfruit contained 72.00 per cent moisture, 1.39 g / 100 g pulp protein, 0.3 per cent fat, 1.00 per cent ash, 25.40 per cent carbohydrates and 8 mg / 100 g pulp ascorbic acid.

Bhore *et al.* (1980) stated the chemical composition of jackfruit pulp as:

Table 2.1. Chemical composition of jackfruit pulp

Constituents	Local Jackfruit Type (%)	Promising Jackfruit Type (%)
Moisture	79.00	71.30
Carbohydrates	16.25	23.07
Fat	0.20	0.50
Protein	1.95	2.43
Fibre	1.20	1.50
Ash	0.90	1.20
Total Solids	21.00	28.70

Gopalan *et al.* (1982) while studying the nutritive value of Indian foods, reported that pulp of ripe jackfruit is rich in vitamin 'A', carbohydrates and mineral matter containing 76.2 per cent protein, 0.1 per cent fat, 19.8 per cent carbohydrates, 1.1 per cent fiber, 175 µg/100 g vitamin 'A' and 7 mg/100 g vitamin 'C'.

Nadkarni (1985) studied some important jackfruit selections of 'kapa' type jackfruit and reported the average chemical composition of bulbs as moisture- 68.99 per cent, protein- 2.39 per cent, fat- 0.492 per cent,

fiber- 1.664 per cent, ash- 1.29 per cent, carbohydrates-22.92 per cent, acidity-0.1934 per cent and total sugars- 14.22 per cent.

Samaddar (1985) reported that the pulp of ripe jackfruit is eaten fresh and used in fruit salads. It possesses high nutritional value. As per report, ripe jackfruit pulp (per 100gm) contains 18.9 g carbohydrate, 1.9 g protein, 0.1 g fat, 77 per cent moisture, 1.1 g fiber, 0.8 g total mineral matter, 20 mg calcium, 30 mg phosphorus, 500 mg iron, 540 I.U. vitamin A, 30 mg thiamin, energy 84 calories, phytonutrients like carotene – β 61 μ g, Cryptoxanthine- β -55 μ g, Lutein-zeaxanthin - 157 μ g.

Morton (1987) Stated that 100 gm edible jackfruit fruits bulbs of warm climates provide 95 calories. The fruit is made of soft, easily digestible flesh (bulbs) made up of simple sugars like fructose and sucrose that when eaten replenishes energy and revitalizes the body instantly.

Antarkar (1991) carried out investigations on physico-chemical composition of jackfruit, storage and processing of it and reported the chemical composition of ripe soft flesh jackfruit as follow:

Table 2.2. Physico-chemical composition of jackfruit pulp.

Constituents	Composition
Moisture (%)	74.63
T.S.S. (%)	25 °Brix
Reducing Sugars (%)	7.60
Total Sugar (%)	16.20
Titrateable Acidity (%)	0.23
p ^H	5.20
Ascorbic Acid (%)	2.90mg/100g
Protein (%)	1.54
Fat (%)	0.24

Krinsky *et al.* (2003) reported that the jackfruit- contains carotenoids, which can be important for the prevention of several chronic degenerative diseases, such as cancer, inflammation, cardiovascular disease, cataract, age-related macular degeneration.

Mukprasirt and Sajjaanantakul (2004) reported that jackfruit contains vitamin-A, vitamin-C, thiamin, riboflavin, calcium, potassium, iron, sodium, zin and niacin among many other nutrients. It has low calorie content: 100 g of jackfruit only contains 94 calories. Jackfruit is a rich source of potassium with 303 mg found in 100 g of jackfruit which helps to lower blood pressure.

Chandrika *et al.* (2005) reported that the jackfruit is a good source of provitamin A carotenoids, though not as good as papaya. Thus, increased consumption of ripe jackfruit could be advocated as part of a strategy to prevent and control vitamin A deficiency.

Soobrattee *et al.* (2005) reported that jackfruit contains phytonutrients: lignans, isoflavones and saponins that have health benefits. These phytonutrients have anticancer, antihypertensive, antiulcer and antiaging properties. The phytonutrients found in jackfruit, can prevent forming of cancer cells in the body, can lower blood pressure, fight against stomach ulcers and slow down the degeneration of cells that make the skin look young. Jackfruit also contains niacin that is known as vitamin B₃ and necessary for energy metabolism, nerve function, and the synthesis of certain hormones. A portion of 100 g of jackfruit pulp provides 4 mg niacin.

Further, she explained the procedure of extraction of pulp from bulbs of soft-flesh jackfruit as follows. Bulbs were removed from the ripe jackfruit. These bulbs were deseeded and then boiled for 20 minutes and passed through grinder to obtain pulp.

Umesh *et al.* (2010) stated that jackfruit health benefits of vitamin C are that it is an antioxidant that protects the body against free radicals strengthens the immune system and keeps our gums healthy.

2.7 Utilization of jackfruit pulp in dairy products

Shipurkar (1999) conducted the research on preparation of shrikhand fortified with jackfruit pulp and reported that incorporation of jackfruit pulps up to 10% level is recommendable in manufacture of shrikhand. He reported that addition of jackfruit pulp in shrikhand results in enhancing its nutritional value without adversely affecting sensory quality and also results in reduction in the cost of production.

Rahman *et al.* (2001) carried out study on utilization of jackfruit juice in manufacture of yogurt. Yogurt sample were prepared by adding 0, 5, 10, 15 per cent jackfruit juice with milk. The quantity of prepared yogurt was measured by some organoleptic, chemical and microbiological tastes. Smell and taste, body and consistency, colour and texture scores of yogurt improved due to addition of jackfruit juice. Addition of jackfruit juice increased the total solid content but decreased the fat, protein and ash contents. Yeast cell were higher in jackfruit yogurt than plain yogurt. It was suggested that yogurt could be prepared successfully by adding different proportions of jackfruit juice with milk and among of them 5% jackfruit juice level in yogurt showed better performance.

Holmukhe (2002) studied on utilization of jackfruit pulp in the manufacture of milk pudding. He reported that incorporation of jackfruit pulp @10% is most acceptable in milk pudding.

Dey *et al.* (2014) conducted research to produce fruit juice yogurt by the addition of jackfruit juice, which is nutritious as well as delicious, in milk @ (5%, 10% and 15%). The chemical, microbiological and sensory characteristics were analyzed. The statistical analysis showed that sensory acceptability decreased with the increase of fruit juice level. However, all sensory characteristics of 10% jackfruit fruit juice yogurt sample were not significantly ($P>0.05$), different from 5% jackfruit juice yogurt sample and 5% fruit juice yogurt sample was not significantly different ($p>0.05$) from plain (0% jackfruit juice) yogurt. The 15% jackfruit juice yogurt sample was

significantly different from plain yogurt. The total solid contents and acidity were increased with jackfruit juice incorporation as jackfruit juice contain higher total solid (23.38%) and acidity (0.59%). While protein and fat contents of prepared yogurt samples decreased with the addition of jackfruit juice as juice contains low protein (1.75%) and fat (0.76%). The microbiological quality was also acceptable. Experiment showed that various types microbial (TVC, TFC) counts were reduced due to high acidity of jackfruit juice. The findings of the research may give a suggestion to prepare yogurt successfully by adding different proportion of jackfruit juice with milk and among them 15% jackfruit juice yogurt showed slightly better taste owing to high acid content.

Naik *et al.* (2015) on studying the addition of jackfruit pulp @ 5, 10, 15 and 20 % in plain *basundi* concluded that jackfruit pulp could be successfully utilized for the preparation of *basundi*. Addition of jackfruit pulp in *basundi* improved sensory quality and acceptability of the product. The most acceptable quality *basundi* could be prepared by using sugar @ 5 per cent of the milk and jackfruit pulp at the rate 15 per cent of the plain *basundi*.

3. MATERIAL AND METHODS

The present study entitled “Development of ice-cream by using jackfruit pulp” was carried out at the Division of Animal Husbandry and Dairy science, College of Agriculture, Kolhapur, during the year 2015-2017. The material used and methodology adopted during the study are described as under.

3.1 Material

3.1.1 Ingredients

3.1.1.1 Milk:

The fresh buffalo milk was procured from Dairy farm, College of Agriculture, Kolhapur and it was standardized to 6.0 per cent fat.

3.1.1.2 Cream:

Cream of Amul brand (India) was procured from the local market of Kolhapur.

3.1.1.3 Skim milk powder:

Skim milk powder (spray dried) was procured from Kolhapur District Milk Union Ltd. (Gokul, Kolhapur, India)

3.1.1.4 Sugar:

Good quality cane sugar (crystalline) was procured in a single lot from local market of Kolhapur city.

3.1.1.5 Jackfruit:

Firm flesh jackfruit of *Barka* and *Kappa* type were procured from local market of Kolhapur city and the pulp was obtained.

3.1.1.6 Stabilizer:

3.1.1.6.1 Carboxy-methyl cellulose

Carboxy-methyl cellulose (E466) made by Bijur Scooper Foods Pvt. Ltd. was used at 0.1 per cent concentration as stabilizing agent.

3.1.1.6.2 Sodium alginate

Sodium alginate made by Bijur Scooper Foods Pvt. Ltd. was used at 0.1 per cent concentration as stabilizing agent.

3.1.1.6.3 Carrageenan

Carrageenan made by HI media laboratories Pvt. Ltd. was used at 0.1 per cent concentration as stabilizing agent.

3.1.1.7 Emulsifier:

Glycerol monostearate made by Bijur Scooper Foods Pvt. Ltd. was used as emulsifying agent.

3.1.2. Equipments:

3.1.2.1 Grinder:

Jyoti Make food grinder was used for homogenizing jackfruit pulp.

3.1.2.2 Vessels:

Convenient sized stainless steel vessels were used for preparation of mix.

3.1.2.3 Stirrer:

Long handled stirrer with flattened end made up of stainless steel was used for stirring the milk during preparation of mix.

3.1.2.4 Weighing balance:

Anamed electronic balance model M-3000, capacity 3000 g was used during the course of investigation.

3.1.2.5 Homogenizer:

Make Sandeep Engineering Ltd. Kolhapur (M.S) was used to homogenize the mix.

3.1.2.6 '4 Quart ice-cream freezer'

Make Hamilton Beach brands Inc. USA was used for freezing the ice-cream mix.

3.1.2.7 Deep freezer:

Make Sandeep Engineering Lt. Kolhapur (M.S) was used for hardening and storage of ice-cream at low temperature.

3.1.2.8 pH meter:

Oroion 3 star pH benchtop pH meter made by Thermo Scientific, Singapore, was used to determine the pH of prepared ice-cream sample.

3.1.2.9 Incubator:

Metalab Ltd. make incubator was used to determine melting rate.

3.1.3 Glassware:

All glassware of Borosil make was used for analytical work. It was thoroughly cleaned and properly sterilized before use.

3.1.4 Chemicals

All the chemicals used for the analytical work were of Analytical Reagent (AR) or Guaranteed Reagent (GR) grade manufactured by Merk, India Ltd/Glaxo India Ltd.

3.2 Methodology

3.2.1 Process optimization

3.2.1.1 Preparation of jackfruit pulp (JP):-

Fresh well ripe jackfruit was procured from local Kolhapur market. Fruit were washed in running tap water to remove dirt and dust, cut with sharp knife to get bulbs after removal of seed. The bulbs or carpel was grind in grinder for 3 min at medium speed and passed through 1 mm stain less steel sieve in order to get uniform pulp. The pulp thus obtained was stored at refrigeration temperature and used as and when required.

3.2.1.2 Formulation and preparation of ice-cream mix:-

The quantity of milk, cream, skim milk powder, sugar and glycerol monostearate (GMS) required for a batch (i.e. 1 lit of ice-cream mix) was calculated by serum point method (Marshall and Arbuckle, 1994). The composition of basic mix was kept constant with 12% fat, 10.5% MSNF, 15% sugar and 0.1% glycerol monostearate (Table 3.1). The ice-cream was prepared as shown in fig.1 as per procedure described by De (2015) with certain modification. The mix was formulated and then added with jackfruit pulp (JP) @ different level as per treatments. After addition of pulp mix was allowed for homogenization and pasteurization followed by ageing for 4 hr to 6 hr. The process was continued by freezing the mix at -4 to -5⁰C in 4 Quart ice-cream freezer and ice-cream was packed in 100 ml polystyrene cups followed by hardening at -23 to -29⁰C.

3.2.1.3 Preparation of ice-cream using JP: -

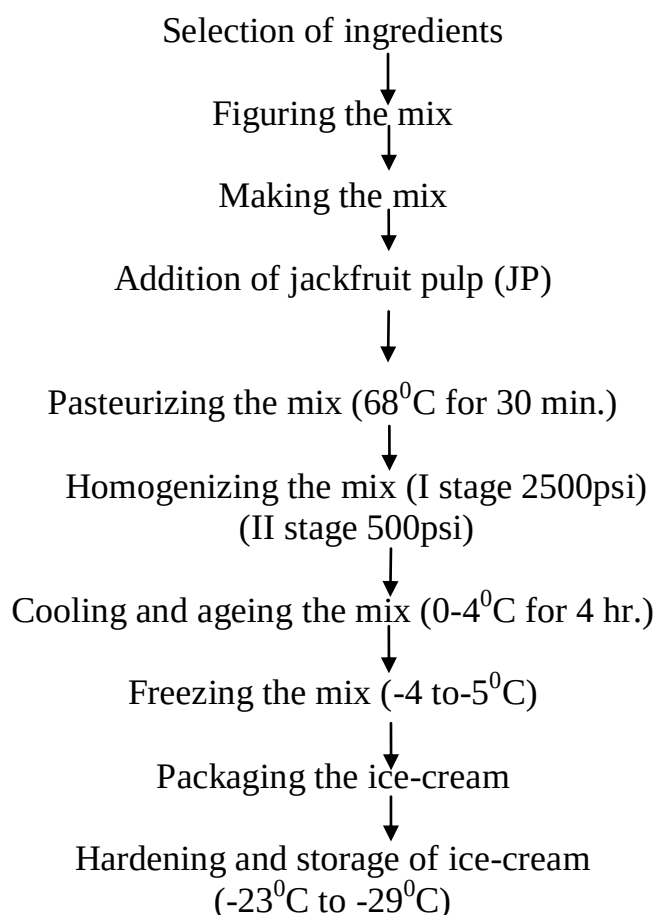


Fig.1 Flow diagram of manufacture of JP Ice-cream.

3.2.1.4 Formulation of jackfruit ice-cream

Table 3.1 Formulation of jackfruit ice-cream

Constituents	Level of addition (per cent)
Milk Fat	12
MSNF	10.5
Sweetener (Sugar)	15
Stabilizer (as per the treatments)	0.1
Emulsifier (Glycerol mono stearate)	0.10
Total solids	37.7
Jackfruit pulp (JP)	As per the treatments

3.2.1.5 Selection of jackfruit type

In the preliminary study, two types of jackfruit viz. *Barka* and *Kappa* available in the local market of Kolhapur city were evaluated for their suitability in preparation of JP ice-cream and these were added @ 10 per cent of ice-cream mix. The prepared ice-cream was evaluated for sensory qualities. The treatment were as follows

X₁- Ice-cream prepared by using *Barka* type jackfruit

X₂- Ice-cream prepared by using *Kappa* type jackfruit

From the above one type of jackfruit was selected on the basis of sensory attribute of ice-cream.

3.2.2 Optimization of level of JP in ice-cream:-

Depending upon the beaker trial, the selected type of JP was added at 10, 15 and 20 per cent level of ice-cream mix and is compared with ice-cream without addition of JP. The treatments were as below.

T₀ = Ice-cream mix without addition of JP and with 0.1 per cent sodium alginate (control).

T₁ = Ice-cream containing JP at 10 per cent of ice-cream mix.

T₂ = Ice-cream containing JP at 15 per cent of ice-cream mix.

T_3 = Ice-cream containing JP at 20 per cent of ice-cream mix.

The ice-cream prepared with these formulations were, evaluated for sensory and physico-chemical qualities and level of addition was optimized on the basis of sensory qualities of ice-cream.

3.2.3 Optimizing the level of sugar in JP ice-cream.

The optimized formulation of JP was added with sugar at following levels to know its effects on sensory properties of ice-cream. The treatments were as follows:

R_1 = JP ice-cream added with sugar @ 13% of ice-cream mix

R_2 = JP ice-cream added with sugar @ 15% of ice-cream mix

R_3 = JP ice-cream added with sugar @ 17% of ice-cream mix

3.2.4 Study of effect of stabilizer on JP ice-cream:

To improve the stabilizing and yield property of ice-cream by adding following stabilizer @ 0.1% of ice-cream mix. The treatments were as follows:

S_0 = JP ice-cream without addition of stabilizer (control).

S_1 = JP ice-cream containing sodium alginate @ 0.1 % of ice-cream mix.

S_2 = JP ice-cream containing carboxy methyl cellulose @ 0.1 % of ice-cream mix.

S_3 = JP ice-cream containing carrageenan @ 0.1 % of ice-cream mix.

The above sample was also evaluated for sensory and physical qualities and best level was found out.

3.3 Analysis:-

Analysis of ice-cream ingredients and finished product was analyzed for their physico-chemical and sensory properties.

3.3.1 Analysis of ice-cream ingredients.

3.3.1.1 Milk

3.3.1.1.1 Titratable acidity

The Titratable acidity of milk was determined by procedure described under A.O.A.C. (1995).

3.3.1.1.2 Milk fat

The fat content of milk was estimated by Gerber method (IS: 1224-Part I, 1977).

3.3.1.1.3 Protein

The protein content of milk was determined by Pynes method given by Shrivastav (2010).

3.3.1.1.4 Lactose

The lactose content of milk was determined by the Lane-Eynon's method described in the Indian Standards (IS: 1479-Part II, 1961).

3.3.1.1.5 Ash

The ash content of milk was measured as per method given in IS: 1479 (Part-II) 1961.

3.3.1.1.6 Total solids

The total solid content of milk was determined by gravimetric method as per IS: 1479 (Part-II), 1961.

3.3.1.1.7 pH

The pH of milk was measured by using Oroion 3 star pH benchtop pH meter.

3.3.1.2 Cream

3.3.1.2.1 Fat

The fat content of cream was estimated by the Gerber method as given in IS: 1224-Part I, 1977.

3.3.1.2.2 Total solids

The total solid content of cream was determined by method as given in IS: 12333(1997).

3.1.1.3 Analysis of JP

3.3.1.3.1 Total soluble solids:

Total soluble solid were determined with the help of hand refractometer and values were corrected at 20°C using temperature correction chart. (A.O.A.C. 1995)

3.3.1.3.2 Titratable acidity (%):

The titratable acidity was determined by titration of 5 ml juice diluted with 25 ml distilled water. Titrate with 0.1 N NaOH using a few drops of 1% phenolphthalein solution as indicator until the colour changes to faint pink. The titration completed within 10-15 sec. The final burette reading was recorded and using following formula the acidity was determined. The TA was calculated as percentage of acidity by the equation.

$$\text{Percent total acid} = \frac{\text{Titre} \times \text{N. of alkali} \times \text{Vol. make up} \times \text{Equi. wt. of acid}}{\text{Vol. of sample taken for estimation} \times \text{vol. of sample taken}} \times 100$$

3.3.1.3.3 pH:

The pH of sample was measured by using Oroion 3 star pH bench top pH meter. Firstly, the pH meter was standardized at 25°C by using standard buffer solution. The pH of the sample was observed on the dial and recorded.

3.3.1.4 Physico-chemical analysis of jackfruit ice-cream:-

3.3.1.4.1 Over-run (per cent):

The overrun was determined as per procedure described in IS: 2802 (1964). A known volume of ice-cream mix was weighed accurately and then the same volume of ice-cream was weighed and the overrun was determined as.

$$\text{Percent overrun} = \frac{W_1 - W_2}{W_2} \times 100$$

Where,

W_1 = Weight of ice-cream mix (kg)

W_2 = Weight of same volume of ice-cream (kg)

3.3.1.4.2 Melting rate:

It was determined by the procedure with certain modification described by Agrawal *et al.* (2015). About 100 g ice-cream was cut in duplicate. The slices were separately placed over a 250 wire mesh and then placed over a long stem glass funnel of 15 cm diameter. The funnel with 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. The volume and weight of melted ice-cream was noted down. In this way the melting characteristic was determined as percentage weight of total ice-cream melted in 40 min at 37.5°C.

3.3.1.4.3 Fat:

Fat in the ice-cream sample was determined by Gerber method as described in IS: 1224, Part-I (1977) with some modifications. Clean and dry ice-cream butyrometer was kept in butyrometer stand with mouth upward. 5

g of melted sample was weighed accurately into butyrometer followed by addition of 6 ml of hot water (for dilution). 10 ml of sulphuric acid (70 %) with the help of automatic tilt measure was poured into the butyrometer and about 1ml of amyl alcohol was added by using 1ml automatic tilt measure. The butyrometer were stopped by the rubber stopper using guiding pin. The content of the butyrometer was mixed thoroughly till mahogany colour was obtained. When mixing was completed the butyrometer was placed into the Gerber centrifugal machine for 5 min, in upright position with stopper end downward. After 5 min reading on the column of butyrometer (appeared clear yellowish liquid at the stem portion) was recorded.

3.3.1.4.4 Protein:

Total protein in milk samples was determined by using Pynes method given in Handbook on Analysis of Milk by Shrivastav (2010). Burette was filled with 0.1N NaOH solution. Simultaneously 10 ml sample was transferred to the 100 ml conical flask. Phenolphthalein indicator 1 ml was added to the flask. Then saturated potassium oxalate 0.4 ml was added to the flask and was set aside for 2 min. Titrating against the 0.1 N sodium hydroxide solution till the faint pink colour appeared. After 2 min neutralized formaldehyde solution was added and the content was again titrated with 0.1N NaOH until the colour changes to faint pink colour. The titration is completed within 10- 15 sec. The final burette reading was recorded and using following formula the Protein was determined.

$$\text{Protein (\%)} = V \times 1.7$$

Where,

V = Volume in ml of standard NaOH solution required for second titration.

1.7= Pyne's constant or formal factor.

3.3.1.4.5 Reducing sugar:

Reducing sugar was determined as per Lane-Eynon's method given in IS: 1479 (Part-II) 1961. For that 25ml of ice-cream sample was transferred in a 250 ml conical flask and diluted with 200 ml of distilled water. Then 10 per cent acetic acid was added drop by drop until the clear precipitate appeared and the final volume was made to 250 ml with distilled water. It was filtered through dry Whatman No. 42 filter paper, discarded first few milliliters filtrate and rest was collected in dry conical flask. Then burette was filled with that filtrate. 5 ml of each Fehling's solution A and B were taken into 250 ml conical flask and were kept on boiling water bath and 3-4 drops of methylene blue indicator was added in it. During boiling, Fehling solution was titrated against the filtrate till the blue colour change to brick red. This titration value was recorded and calculated the lactose percentage by following formula.

$$\text{Reducing sugar (\%)} = \frac{67.8}{\text{burette reading}}$$

3.3.1.4.6 Total sugar:

Total sugar of ice-cream samples was determined as per Lane-Eynon's method given in IS: 1479 (Part-II) 1961. About 40 ml of filtrate prepared under (3.3.1.4.5) was taken in 250 ml conical flask and diluted with 25 ml distilled water. 10 ml of 6.34 N HCL solutions was added in it and heated to 49°C for half an hour. After cooling it was neutralized with 1N sodium hydroxide solution using methyl red indicator and final volume was made up to 250 ml. The sugar was measured as mentioned in the procedure above (3.3.1.4.5).

$$\text{Total sugar (\%)} = \frac{\text{Factor}}{W} \times \frac{V_1}{V_2} \times \frac{V_3}{MBR} \times 100$$

Where,

W= Weight of sample

V₁= Volume made of sample

V₂= Volume taken for inversion.

V₃= Volume made after inversion.

MBR= mean burette reading.

3.3.1.4.7 Non-reducing sugar:

Non-reducing sugars were determined by subtracting reducing sugars from total sugars.

3.3.1.4.8 Ash:

Ash content of all the samples was determined by the procedure described in IS: 1547 (1989). Two to three grams of homogenous sample were weighed in a silica crucible. The sample in crucible was heated on naked-flame till it was completely reduced to ash. The sample was then transferred to muffle furnace and held for 3.5 hrs at $550 \pm 2^\circ\text{C}$. After cooling in the desiccator, the crucible was weighed. The process was repeated till a constant weight was obtained. The total ash content in per cent was calculated as follows:

$$\text{Total ash (per cent by weight)} = \frac{100 (W_2 - W)}{(W_1 - W)}$$

Where, W = Weight in g of the empty crucible

W₁ = Weight in g of the crucible with sample

W₂ = Weight in g of the crucible with as

3.3.1.4.9 Total solids:

The total solids content of ice-cream was determined by subtracting moisture content of sample from weight of sample, which was determined as per method given in IS: 2802 (1964). The sample was prepared by softening at room temperature. The sand was heated in the oven and cooled in desiccators for 40 min. About 3 gm of ice-cream sample was taken in dish and slightly saturated sand was mixed. Then the dish was kept on boiling water bath for 30 min and then transferred to oven at $102 \pm 1^\circ\text{C}$. After four hours, the dish was removed and transferred to an efficient desiccator, allowed to cool as before, and weighed. The dish was again replaced in the oven for a further period of one hour at $102 \pm 1^\circ\text{C}$; removed

to the desiccator and cooled and weighed again. The process of heating, cooling and weighing was repeated for one hour till consecutive reading agree to within 0.5 mg.

$$\text{Total solids (percent by weight)} = \frac{100 W_1}{W_2}$$

Where, W_1 = Weight in g of the residue after drying

W_2 = Weight in g of the prepared sample taken for the test.

3.3.1.4.10 Acidity (% Lactic acid):

IS: 2802-(1964) method was adopted for determining acidity in terms of per cent lactic acid. The procedure followed was same as given in section (3.3.1.1.1), but using 20 g of sample being diluted with about 50 ml of recently boiled water. Using following formula the acidity was determined.

$$\text{Acidity (\% LA)} = \frac{9 V N}{W} \times 100$$

Where,

V = Volume in ml of standard NaOH solution required for titration

N = Normality of standard NaOH solution used

W = Weight in g of the test sample

3.3.1.4.11 pH:

The pH of sample was measured by using Oroion 3 star pH benchtop pH meter. Firstly, the pH meter was standardized at 25 °C by using standard buffer solution. The pH of the sample was observed on the dial and recorded.

3.3.2 Sensory evaluation:

The acceptability of ice-cream prepared by using jackfruit pulp was assessed by the panel of 5 semi trained judges from Division of Animal Husbandry and Dairy Science and Division of Horticulture, College of Agriculture, Kolhapur.

Table 3.2 Numerical values of ‘9’ Point Hedonic Scales

Remark	Score
Like extremely	09
Like very much	08
Like moderately	07
Like slightly	06
Neither like nor dislike	05
Dislike slightly	04
Dislike moderately	03
Dislike very much	02
Dislike extremely	01

The colour and appearance, flavour, body and texture, mouthfeel and overall acceptability was assessed by using 9 point' hedonic scale as per procedure described in Amerine *et al.* (1965).

3.4 Cost of production of 1 lit ice-cream mix:

The cost of production of JP ice-cream was calculated by using standard procedure suggested by Lal et al. (1980) with some modifications.

3.5 Statistical analysis:

The data generated during experiment was analyzed using Completely Randomized Design (CRD) of statistics to draw valid inferences. The mean values generated from the analysis of duplicate samples of ice-cream in four replications as per Steel and Torrie (1980). The equation for the same is illustrated as given below:

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

Where,

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

μ = General mean

T_i = Effect of I^{th} treatment

E_{ij} = Error due to j^{th} observation in the i^{th} treatment

3.6 Facilities required:

All the facilities available at the Division of Animal Husbandry and Dairy Science, College of Agriculture, Kolhapur were utilized for experiments.

4. RESULTS AND DISCUSSION

Ice-cream is an important frozen dairy product, usually made from milk, cream and often combined with fruits or other ingredients and flavours. It is a food, typically eaten as a snack or dessert so, it is rarely consumed plain. Ice-cream is one of the oldest fat rich delicious dairy products relished by all age groups of people throughout the world. Vanilla, strawberry and chocolate, together constitute approximately 70 per cent of the market (Murlidharan, 2009). This sector continues to rely on new flavour and a rich assortment while an increasing number of products with added nutritional value are being introduced. By considering these aspect here attempt was made to prepare ice-cream by blending with jackfruit pulp (JP). The results obtained during this investigation are presented in following headings.

- 4.1 Analysis of ice-cream ingredients, utilized in manufacture of JP ice-cream.
- 4.2 Selection of type of jackfruit.
- 4.3 Optimization of level of JP in ice-cream.
- 4.4 Effect of different levels of sugar on the sensory and physico-chemical properties of JP ice-cream.
- 4.5 Effect of different stabilizer on the sensory and physical properties of JP ice-cream.
- 4.6 Physico-chemical analysis of JP ice-cream.
- 4.7 Cost of production of JP ice-cream.

4.1 Analysis of ice-cream ingredients utilized in manufacture of JP ice-cream.

4.1.1 Chemical composition of milk

The buffalo milk was obtained from Dairy farm, College of Agriculture, Kolhapur. The procured buffalo milk was standardized using Pearson's square method (De, 2015) to 6 per cent milk fat. The milk was

analyzed for total solids, fat, protein, lactose and acidity. The data are furnished in Table 4.1.

Table 4.1: Chemical composition of milk used for experiments

Sr. No.	Constituents	Mean values*
1.	Fat (%)	6.00 ± 0.19
2.	Protein (%)	3.57 ± 0.07
3.	Lactose (%)	5.15 ± 0.04
4.	Ash (%)	0.8 ± 0.04
5.	Total solids (%)	15.6 ± 0.39
6.	Acidity (%)	0.15 ± 0.01
7.	pH	6.6 ± 0.07

* mean $\pm$ SE of four replications.

The results presented in Table 4.1 indicate that the milk used in the present investigation was of good quality. The fat, protein, lactose, ash, total solids, acidity and pH were 6.00 ± 0.19 , 3.57 ± 0.07 , 5.15 ± 0.04 , 0.8 ± 0.04 , 15.6 ± 0.39 , 0.15 ± 0.01 and 6.6 ± 0.07 per cent, respectively.

De (2015) also reported an average chemical composition of buffalo milk as moisture 84.2 per cent, fat 6.6 per cent, protein 3.9 per cent, lactose 5.2 per cent and ash 0.8 per cent.

4.1.2 Chemical composition of Cream

The cream sample were subjected to chemical analysis for fat and total solids, contents. Results of the same are tabulated as Table 4.2.

Table: 4.2: Chemical composition of cream

Constituents	Mean values*
Fat (%)	25.1 ± 0.05
Total solids (%)	32.9 ± 0.12

* mean $\pm$ SE of four replications

Table 4.2 shows that the cream used for preparation of experimental ice-cream contained 25.1 per cent fat and 32.9 per cent total solids.

4.1.3 Chemical composition of JP.

The average chemical composition of JP used in the present study is presented in Table 4.3.

Table 4.3: Chemical composition of jackfruit pulp

Physico-Chemical parameters	Mean values*
TSS (%)	23.00± 0.17
Acidity (%)	00.25 ± 0.17
pH	06.5 ± 0.12

* mean ± SE of four replications

The results presented in Table 4.3 indicate that the JP used in the present investigation contained total acidity and pH and the values were 0.25 and 6.5, respectively, whereas TSS of JP was 23.00.

Antarkar (1991) also reported that the chemical composition of soft flesh JP contained TSS of 23 to 24 per cent, acidity of 0.23 per cent which is in close in agreement with present observations. Shipurkar (1999) also reported the chemical composition of soft flesh JP as acidity of 0.24 per cent and pH values of 6.4.

4.2 Selection of suitable type of jackfruit pulp

The commonly available type of jackfruit i.e. *barka* and *kappa* were used in preparation of ice-cream. In the preliminary study treatments were; ice-cream mix with *barka* type JP (X_1) and ice-cream mix with *kappa* type JP (X_2).

The products prepared using both the types of JP were subjected to sensory evaluation. The results obtained are presented in Table 4.4 and fig. 4.1

4.2.1 Flavour

It is clear that the flavour score of JP ice-cream was significantly ($p < 0.05$) affected by addition of type of jackfruit. The flavour score was recorded maximum (7.25 ± 0.10) for JP ice-cream prepared by using the pulp of *Barka* type, whereas, the minimum score (6.75) prepared with JP of *Kappa* type. Swami *et al.* (2012) reported that the carpel of *barka* type of jackfruit was sweeter than *kappa* type.

Table 4.4: Effect of jackfruit type on sensory attributes (score)* of ice-cream.

Jackfruit type	Scores for sensory attributes				
	Flavour	Colour and appearance	Body and Texture	Sweetness	Overall acceptability
X ₁	$7.25^b \pm 0.10$	$7.10^b \pm 0.04$	7.05 ± 0.12	$7.85^b \pm 0.06$	$7.65^b \pm 0.05$
X ₂	$6.75^a \pm 0.11$	$6.80^a \pm 0.11$	6.78 ± 0.13	$7.35^a \pm 0.12$	$7.08^a \pm 0.18$
SEm	0.10	0.08	0.12	0.09	0.13
CD (P<0.05)	0.35	0.28	NS	0.33	0.45
CV	2.86	2.34	3.53	0.252	3.56

* mean $\pm$ SE of four replications within column followed by same letter are non-significantly different at $p < 0.05$. NS = non-significant.

4.2.2 Colour and appearance

It is clear from the data presented in Table 4.4 and fig.4.1 that the effect of types of JP was significant ($P < 0.05$) on colour and appearance score of JP ice-cream. The JP ice-cream prepared from *Barka* type JP had recorded higher colour and appearance score (7.10 ± 0.04) significantly greater than the *Kappa* type JP ice-cream. Swami *et al.* (2012) reported that the carpels of *barka* type of jackfruit were darker yellow in colour than *kappa* type, which might give more golden and shiny appearance to the product.

4.2.3 Body and Texture

The body and texture score of JP ice-cream as affected by the type of jackfruit is also presented in Table 4.4 and it indicated that the score for both the types of ice-cream were at par with each other. The body and texture score ranged from 6.78 to 7.05 (Fig 4.1). The maximum score was recorded for treatment X_1 (score-7.05) and minimum score for X_2 (score-6.78). The maximum score for *barka* type JP ice-cream might be because of carpel of *barka* type was fibrous, soft and mushy as reported by Swami *et al.* (2012), which supports the finding of the present study.

4.2.4 Sweetness

The effect of type of jackfruit pulp was also significant ($p < 0.05$) on sweetness score of JP ice-cream due to presence of sugar at equal levels in the JP ice-cream. Higher score (7.85) was recorded for *Barka* type than that (7.35) for *Kappa* type pulp JP ice-cream. The higher score for *Barka* type ice-cream may be because of sweeter carpel of *barka* type as also reported by Swami *et al.* (2012) which support the present study.

4.2.5 Overall acceptability

The effect of different types of JP on overall acceptability score was depicted in Table 4.4 and Fig 4.1. The data revealed that the overall acceptability score was significantly ($P < 0.05$) affected by the type of jackfruit. The overall acceptability score for X_1 and X_2 were 7.65 ± 0.05 and 7.08 ± 0.18 , respectively.

It was observed that the ice-cream prepared using *Barka* were dark yellow in colour, had optimum firmness and pleasing sweet and sour jackfruit flavour. On the other hand, ice-cream prepared using *Kappa* were light yellow in colour, had dry surface, lightly hard body and lacked in flavour. On the basis of these results, *Barka* type of jackfruit was selected and used for further study.

4.3 Optimization of level of JP in ice-cream.

4.3.1 Effect of JP levels on sensory attributes of ice-cream

Acceptability of ice-cream by the consumers is mainly influenced by the product's flavor, body and texture and melting quality; colour too influences their choice. The quality of ice-cream is mainly influenced by the flavor of the ingredients. Flavor is a chemosensory characteristic sensed by the receptors housed in the tongue and nose, while texture is outright perceived in the mouth during mastication process (Taylor and Linfoth, 1996; Kilcast and Clegg, 2002). Flavoring components are used to impart flavour to food products, to enhance inherent flavour and to ensure uniformity of flavour between batches of food product prepared. The effect of form of addition of JP in the preparation of JP ice-cream on sensory quality is presented in Table 4.5 and fig. 4.2

Table 4.5: Effect of JP levels on sensory attributes (score)* of ice-cream

Level of JP	Scores for sensory attributes				
	Flavour	Colour and appearance	Body and Texture	Sweetness	Overall acceptability
T ₀	7.00 ^a ±0.11	7.03 ^a ±0.19	7.40 ^a ±0.11	7.80 ^a ±0.04	7.52 ^a ±0.15
T ₁	7.33 ^a ±0.17	7.15 ^a ±0.06	7.08 ^a ±0.05	7.93 ^a ±0.08	7.77 ^b ±0.13
T ₂	8.03 ^b ±0.17	8.00 ^b ±0.15	8.08 ^c ±0.17	8.25 ^b ±0.12	8.25 ^c ±0.10
T ₃	7.60 ^b ±0.09	8.03 ^b ±0.13	7.55 ^b ±0.15	8.00 ^{ab} ±0.11	7.90 ^b ±0.17
SEm	0.14	0.14	0.12	0.10	0.14
CD (P<0.05)	0.43	0.42	0.38	0.29	0.20
CV	3.69	3.67	3.31	2.33	3.53

* mean ± SE of four replications within column followed by same letter are non- significantly different at p< 0.05.

It was revealed from the data (Table 4.5) that the sensory parameters like flavour, colour and appearance, body and texture, and overall acceptability were significantly ($p < 0.05$) affected by the level of JP.

4.3.1.1 Flavour

Flavour is the single most important characteristic, which can decide the acceptability of any food product. High quality ice-cream should be pleasantly sweet, suggest a creamy background sensation, exhibit a delicate flavour and leave most pleasant, but brief, rich aftertaste (Bodyfelt *et al.*, 1988).

The data presented in the above Table 4.5, clearly shows that the flavour score of JP ice-cream was significantly ($P < 0.05$) affected by the addition of JP at various levels. It was observed that the flavour score obtained to the ice-cream prepared by addition of JP at the rate of 10, 15, and 20 per cent were 7.33, 8.03 and 7.60, respectively (fig 4.2). The maximum score (8.03) was recorded to the sample containing 15 per cent JP and minimum score (7.00 per cent) was to the product prepared by 0 per cent JP (control). Naik *et al.* (2015) while discussing effect of addition of jack fruit pulp in preparation of basundi reported similar type of trend. Inclusion of flavour particulate has been reported to enhance the flavor impact in peanut ice-cream (Martin and Swenson, 1969). With increasing the level of amala in ice-cream increasing pleasing flavour and aroma of the ice-cream was reported by Kaur and Bajwa (2015).

4.3.1.2. Colour and appearance

Colour and appearance of the product is the visual perception, which in turn, defines product quality. The colour of ice-cream, its intensity, visibility of JP level, patches of colour or colour migration and unevenness, if any, were considered while rating the colour and appearance of the ice-creams.

The sensory score for colour and appearance collated in Table 4.5 revealed that the 'eye appeal' of product, the colour and appearance score of

ice-creams was significantly ($P < 0.05$) affected by the level of JP. The maximum score (8.03) was obtained to the ice-cream containing 20 per cent JP (Fig 4.2.). The ice-cream prepared by using 0 per cent JP (control) scored the lowest colour and appearance score. It was found that as the level of JP increased the score of colour and appearance increased. Dias (2012) reported that increase in level of carrot puree and shred in ice-cream the colour and appearance score of ice-cream was also increased. Similar finding has also been reported by Moumita (2014) in her study for the preparation of mango tid bits flavoured ice-cream that increase in level of mango cubes and shred colour and appearance score of ice-cream was increased.

4.3.1.3 Body and Texture

The ice-cream should be judged for relative smoothness, coarseness, presence or absence of sandiness and relative size of ice crystals (Alvarez, 2009). Body is the standing up properties of food. Texture is that property of food which is associated with the sense of feel or touch experienced by fingers or the mouth. The body and texture score of JP ice-cream was also affected by the level of addition of JP. The body and texture scores of JP ice-cream depicted in Table 4.5 indicated the score were ranged from 7.08 to 8.08. The maximum score (8.08) was obtained to the ice-cream containing 15 per cent JP. While 10 per cent JP scored lowest for body and texture. It was also noted that ice-cream containing 0 and 10 per cent JP level had slightly hard body and that was difficult to scoop. On the other hand, ice-cream made with 20 per cent JP level had slightly weak body.

Since, JP ice-cream made using 15 per cent JP had significantly superior scores for body and texture it obviously had the maximum sensory score that was significantly ($P < 0.05$) greater than the scores allotted to other three ice-creams made using 0, 10 and 20 per cent JP. Jana *et al.*, (1994) reported that increase in total sugar concentration of ice-cream depresses the freezing point. Chang and Hartel (2002) reported that as the

sugar level is raised, the consistency of ice-cream mix improved due to increased viscosity but the ice-cream had reduced hardness at -21°C .

4.3.1.4. Sweetness

From the Table 4.5 it is also noted that the sweetness of product also influenced by the level of JP. The score ranged from 7.80 to 8.25. The minimum score was obtained for formulation containing 0 per cent JP whereas maximum score was obtained for JP ice-cream contains 15 per cent JP. The sweetness of JP ice-cream was affected significantly at linear level. Figure 4.2 showed that pulp percentage increased the sweetness score was rapidly increased up to middle pulp level (15 per cent) followed it start declined. Swami *et al.* (2012) reported that the bulb of jackfruit was sweeter in taste. Moumita (2014) reported that increase level of mango tid bits in ice-cream increases sweetness of ice-cream.

4.3.1.5 Overall acceptability

The JP ice-cream was made using 15 per cent JP had significantly superior scores for flavour, colour and appearance, body and texture and sweetness. It obviously had the maximum overall acceptability score. The overall acceptability scores allotted to T_0 , T_1 , T_2 and T_3 were 7.52, 7.77, 8.25 and 7.90, respectively.

Least overall acceptability score was associated with ice-cream containing 0 per cent JP. The overall acceptability scores of T_1 were at par ($P > 0.05$) with T_3 It can be seen in the Table 4.5 and fig. 4.3. The overall acceptability scores of T_0 was significantly ($P < 0.05$) lower than rest of the ice-cream samples.

Hence, from the above discussion it was imperative to select 15 per cent JP in ice-cream.

4.3.2 Effect of JP levels on physical attributes of ice-cream

4.3.2.1 Overrun

Overrun, which is directly related to the amount of air in ice-cream, is very important as it influences product quality and profits. Overrun

also affects the body, texture and palatability of the final product. The incorporation of too much air produces a fluffy ice-cream and too little produces a soggy, heavy product. The major physical characteristics of ice-cream that concerns regulatory agencies is weight per unit volume of ice-cream, and this is affected by the overrun obtained in the product.

The influence of adding JP to ice-cream mix on the overrun of ice-cream is presented in Table 4.6, which shows that T₃ had the highest overrun of 75.40 per cent.

Table 4.6: Effect of JP levels on physical attributes of ice-cream

Levels of JP	physical attributes	
	Overrun (%)*	Melting rate (%ice-cream melted in 40 min.)*
T ₀	59.50 ^a ±1.55	32.98 ^c ±0.17
T ₁	64.75 ^b ±0.48	34.48 ^d ±0.44
T ₂	70.18 ^c ±0.72	31.58 ^b ±0.55
T ₃	75.40 ^d ±0.20	30.20 ^a ±0.28
SEm	0.91	0.39
CD (P<0.05)	2.76	1.20
CV	2.65	2.40

* mean ± SE of four replications within column followed by same letter are non- significantly different at p< 0.05.

The statistical analysis (Table 4.6) indicates that incorporation of JP up to 20.00 per cent level (T₃); increases the overrun significantly. The overrun of ice-cream ranges from 59.50 to 75.40 per cent. Dhivya *et al.*, (2015) reported that increases level of potato and tapioca in ice-cream, overrun was increased due increased in that total solid. Patel *et al.*, (2015) reported that incorporation of ragi in ice-cream increase in overrun slightly.

4.3.2.2 Melting quality

A desirable melting quality in an ice-cream means the melted product should have the appearance and consistency similar to the original

mix. Any defect in meltdown characteristic is an indicative of body and texture defect. Ice-cream should melt down to a liquid of smooth consistency, suggestive of a rich ice-cream. 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 extreme can make the ice-cream defective. As seen from Table 4.6, the melting resistance of ice-cream samples was different at different level of JP in ice-cream. The meltdown rate of T₁ was the highest (i.e. 34.48 per cent). The meltdown values (in terms of ml of ice-cream melted in 40 min at 37 °C per 100 ml ice-cream) varied from 30.20 per cent to 34.48 per cent. The maximum melting rate of T₁ ice-cream (34.48 per cent) and minimum melting rate of T₃ ice-cream (30.20 per cent) has been shown in fig. 4.3.

The melt-down rate of ice-cream is affected by many factors, including the amount of air incorporated, the nature of the ice crystals and the network of fat globules formed during freezing. The increase in melting resistance with change in level of JP addition to ice-cream mix is quite evident from this study. The results for melting characteristics suggest that JP may act as a stabilizer due to its high capacity for binding water.

Santos and Silva (2012) found that increased ice-cream overrun values resulted from the considerable of fat globules in the homogenization process, resulting in lower meltdown speed. Sakurai (1996) found that ice-creams with low overruns melted quickly, whereas ice-creams with high overruns began to melt slowly and had a good melting resistance. This slower melting rate in the ice-creams with high overruns was attributed to a reduced rate of heat transfer due to a larger volume of air but may also be due to the more tortuous path through which the melting fluid must flow (Hartel 2001). Rosalina *et al.*, (2004) reported that ice-creams with lower overruns were harder than those made with high overrun but melted more rapidly. In present study, it was found that ice-cream with the lowest overruns i.e. T₁ melted fast as compared to ice-creams with higher overruns

T₃. (Table 4.6) However, Guinard *et al.*, (1997) reported that no relationship exists between the instrumental and sensory melting rates, perhaps due to different melting environment in the measurements.

4.3.3 Effect of JP levels on chemical attributes of ice-cream

The ice-cream prepared by using different levels of JP was analyzed for various chemical parameters viz. fat, protein, reducing sugar, non-reducing sugar, total sugar, ash, total solids, acidity and pH. The results are furnished in Table 4.7.

4.3.3.1 Fat

The values of fat content in JP ice-cream ranged from 11.05 to 12.20 per cent. JP ice-cream prepared by using 20 per cent JP had lowest fat content (Table 4.7 and fig. 4.4) and JP ice-cream prepared by using 0 per cent had highest fat content.

The dilution effect of JP was found to have significant influence ($P < 0.05$) on the fat content of ice-cream. There was a progressive decreased in fat content of experimental samples with increased level of addition of JP. However, the average values of fat in all the experimental ice-creams were well above the minimum values specified for ice-cream (FSSAI, 2011 and ISI, 1970). Barot *et al.*, (2014) reported that increase in the level of bottle gourd resulted in decreased fat content of ice-cream. Similarly Dias (2012) stated that increased level of carrot puree and shred decreased fat content. The present result may be due to the negligible per cent of fat in JP. Shipurkar (1999) reported that fat contain in JP is 0.21-0.22 per cent. The results are in concordance with Bajwa *et al.*, (2003), Murtaza (2004), Pinto *et al.*, (2004) and Temiz and Yesilsu (2010), Kaur and Bajwa (2015) who observed that fat content in ice-cream decreased on addition of strawberry pulp, fig paste, ginger shreds and grape and mulberry pekmez and amala, respectively.

4.3.3.2 Protein

The protein content in JP ice-cream (Table 4.7) ranged from 3.93 to 3.32 per cent. The minimum per cent of protein content in JP ice-cream was obtained for formulation, which had JP @ 20 per cent of ice-cream mix. While the maximum per cent of protein content was in ice-cream without JP. The protein per cent of JP ice-cream decreased with increase in JP level. (Fig. 4.5) The similar findings were stated by Kaur and Bajwa (2015) in ice-cream prepared by addition of amla. Temiz and Yesilsu (2010) also found the reduction in protein content of the ice-cream with increased levels of mulberry and grape pekmez. Earlier, Pinto *et al.*, (2004) also found that equal result in ginger shreds and juice ice-cream. Moumita (2014) reported that addition of mango tid bits in ice-cream increased the level of protein in ice-cream. Pandya (2014) also reported increase in rate of addition of petha in ice-cream decreased the protein content in ice-cream.

4.3.3.3 Reducing sugar

The Reducing sugar content of JP ice-cream (Table 4.7) ranged from 5.13 to 8.18 per cent. The minimum per cent of reducing sugar was obtained for formulation, which had JP 0 per cent of ice-cream mix (control). While the maximum per cent of reducing sugar was found in ice-cream which had 20 per cent JP. The reducing sugar per cent of JP ice-cream increased with increase in JP level because Morton (1987) reported that JP naturally about contains reducing sugar is 7 per cent.(Fig. 4.6) The treatment T₂ and T₃ are significantly at par with each other reducing sugar increased.

4.3.3.4 Non-reducing sugar

The non-reducing sugar content of JP ice-cream (Table 4.7) ranged from 15.23 to 16.70 per cent. The minimum per cent of non-reducing sugar content in JP ice-cream was obtained for formulation, which had JP @ 0 per cent of ice-cream mix (control), while the maximum per cent of reducing sugar content was obtained in ice-cream which had 20 per cent JP.

The non-reducing sugar per cent of JP ice-cream increased with increased in JP level. (Fig. 4.7) The treatment T₁ and T₂ are significantly at par with each other non-reducing sugar increased.

4.3.3.5 Total sugar

Total sugar content in ice-cream ranged from 20.35 to 24.52 (Table 4.7). The maximum total sugar was present in 20 per cent level of pulp and minimum total sugar in the control i.e. without JP. It was found that as the pulp level was increased, the total sugar of ice-cream also increased. The dilution effect of JP in ice-cream was found to exercise significant influence ($P < 0.05$) on the total sugar content. Total sugar content increased because of raised levels of reducing and non-reducing sugar in JP ice-cream. The treatment T₂ and T₃ were significantly at par with each other. Findings were on the line of the findings reported by Moumita (2014). Pandya (2014) also reported that concentration of petha in ice-cream increased total solid per cent.

4.3.3.6 Ash

The ash content of all the ice-creams made using different JP levels were significantly different from each other (Table 4.7). Nevertheless, minimum (0.77 per cent) ash contained ice-cream prepared without JP and maximum in (1.05 per cent) ash was associated with JP ice-cream made using 20.0 per cent JP (T₃). As the level of pulp increased the ash content in ice-cream also increased. Morton (1987) who reported that jackfruit pulp contained ash 0.8-1.0 per cent. It is because of the mineral contents in JP. Bhajwa *et al.*, (2003) reported that increased strawberry pulp in ice-cream ash content was also increased. Dhivya *et al.*, (2015) reported that raised level of potato and tapioca in ice-cream, ash content was also increased.

4.3.3.7 Total Solid

Total solids play an important role in controlling the ice-cream quality. As is evident from Table 4.7, there was increased in the total solids

Table 4.7: Effect of JP levels on chemical attributes of ice-cream

Level of JP	Chemical attributes (values)*								
	Fat (%)	Protein (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Ash (%)	Total solids (%)	Acidity (% LA)	pH
T ₀	12.20 ^c ±0.12	3.93 ^b ±0.19	5.13 ^a ±0.20	15.23 ^a ±0.27	20.35 ^a ±0.09	0.77 ^a ±0.02	37.30 ^a ±0.11	0.20 ^a ±0.004	6.44 ^c ±0.03
T ₁	11.65 ^b ±0.13	3.50 ^{ab} ±0.08	6.88 ^b ±0.15	15.85 ^a ±0.34	22.73 ^b ±0.13	0.85 ^b ±0.02	38.70 ^b ±0.12	0.26 ^b ±0.004	6.25 ^b ±0.06
T ₂	11.33 ^a ±0.12	3.39 ^a ±0.05	7.80 ^c ±0.29	16.25 ^{ab} ±0.26	24.05 ^c ±0.23	0.92 ^b ±0.03	39.65 ^c ±0.45	0.30 ^c ±0.009	6.14 ^b ±0.02
T ₃	11.05 ^a ±0.17	3.32 ^a ±0.04	8.18 ^c ±0.14	16.70 ^b ±0.34	24.52 ^c ±0.21	1.05 ^c ±0.02	39.90 ^c ±0.10	0.35 ^d ±0.01	5.98 ^a ±0.13
SEm	0.14	0.11	0.20	0.30	0.18	0.02	0.25	0.01	0.08
CD (P<0.05)	0.42	0.34	0.63	0.94	0.54	0.08	0.76	0.02	0.24
CV	2.38	6.22	5.84	3.81	1.54	5.44	1.27	5.28	2.47

* mean ± SE of four replications within column followed by same letter are non- significantly different at p< 0.05.

content of the ice-cream with increase in level of JP. The average total solids content of experimental samples were higher than the control. The total solids content of the experimental T₂ samples were at par ($P>0.05$) with T₃ samples.

The values of total solid content ranged from 37.30 to 39.90 per cent of JP ice-cream. JP ice-cream prepared by using 20 per cent JP recorded highest per cent of total solid content (Table 4.7 and fig. 4.10). These results are in accordance with report of Dhivya *et al.*, (2014) that, increase in total solid occurs with increased concentration of potato and tapioca in ice-cream. Whereas Moumita (2014) reported that increase in addition of mango tid bits in ice-cream increased level of total solid in ice-cream. Similarly Trivedi *et al.*, (2014) also reported increased level of basil powder in ice-cream increased the total solid contents.

4.3.3.8 Acidity and pH

Acidity content is the compositional attribute of JP ice-cream. The values of acidity content ranged from 0.20 to 0.35 per cent lactic acid of JP ice-cream (Table 4.7 and fig. 4.11). Ice-cream prepared by using 20 per cent JP had highest per cent acidity. Ice-cream prepared by addition of JP at 0, 10, 15 and 20 per cent had 0.20, 0.26, 0.30 and 0.35 per cent lactic acid, respectively,

The values of pH ranged from 5.98 to 6.44 of JP ice-cream. JP ice-cream prepared by using 20 per cent pulp addition had lower pH. JP ice-cream prepared by using 0 per cent and 10 per cent addition had higher values of pH (Table 4.7 and fig. 4.12). Bhajwa *et al.* (2003) reported that due to increase in level of strawberry pulp in ice-cream there was significant decrease in pH and significant increase in acidity. These result were due to presence of ascorbic acid in strawberries. Kaur and Bajwa (2015) during their study on addition of amala in ice-cream observed increase in the acidity and decrease in the level of pH.

4.4 Optimizing the level of sugar in JP ice-cream.

Sugar plays an essential role in contributing to the sensory properties of ice-cream, over and above contributing to the total solids of the mix too. Sugars perform several functions in ice-cream viz., provide nutritive value, sweetness, may enhance flavor and depresses the freezing point of ice-cream mix (Jana *et al.*, 1994). In this phase, basic ice-cream mix was prepared having composition as indicated in Section 3.2, with sugar addition carried out at three different levels i.e., 13, 15 and 17 per cent by weight of mix. The experiment involved preparing three batches of ice-cream. Each treatment was replicated four times and totally twelve batches of ice-cream were prepared.

4.4.1 Effect of different levels of sugar on sensory attributes of JP ice-cream

Table 4.8: Effect of different levels of sugar on sensory attributes (score)* of JP ice-cream

Sugar level	Scores for sensory attributes				
	Flavour	Colour and appearance	Body and Texture	Sweetness	Overall acceptability
R ₁	7.43 ^a ±0.05	7.58 ±0.11	7.58 ^a ±0.11	7.53 ^a ±0.10	7.53 ^a ±0.04
R ₂	8.03 ^c ±0.08	7.93 ±0.18	8.13 ^b ±0.5	8.20 ^b ±0.09	8.18 ^b ±0.12
R ₃	7.75 ^b ±0.06	7.95 ±0.06	8.03 ^b ±0.05	8.05 ^b ±0.06	8.06 ^b ±0.20
SEm	0.07	0.13	0.10	0.09	0.12
CD (P<0.05)	0.22	NS	0.31	0.28	0.38
CV	1.75	3.26	2.46	2.22	2.96

* mean ± SE of four replications within column followed by same letter are non- significantly different at p< 0.05. NS = non- significant.

4.4.1.1 Flavour

The rate of sugar addition had a significant ($P < 0.05$) influence on the flavour score of JP ice-cream (Table 4.8 and Figure 4.13). The flavour score of ice-cream made with 15 per cent sugar was maximum, which differed significantly from the flavour score of other two level ice-creams (i.e. using 13 and 17 per cent sugar). The ice-cream with 14.0 per cent sugar was felt reduced flavour intensity compared to those with higher sugar content. The ice-cream made using 15.0 per cent sugar was observed to have the desired flavour. Plain ice-cream usually contains about 14.0-16.0 per cent sugar (Arbuckle, 1986).

Guinard *et al.* (1996) demonstrated that too high or too low sugar was detrimental to the ice-cream quality. This finding is in consonance with the findings of Pandya (2014) who reported that *petha* ice-cream having 13.0 per cent sugar had greater acceptability than ice-creams having 12.0 or even with 14.0 per cent sugar. Moumita (2014) reported that addition of mango tid bits in ice-cream having 15 per cent sugar had greater acceptability than ice-cream containing 14.0 or even with 16.0 per cent sugar.

4.4.1.2 Colour and appearance

The colour and appearance scores of all the ice-creams made using different sugar levels were more or less similar to each other as seen in Table 4.8 and fig. 4.13. Nevertheless, maximum score was associated with JP ice-cream made using 15.0 per cent sugar. Pandya (2014) reported that *petha* ice-cream having 13.0 per cent sugar had greater acceptability than ice-creams having 12.0 or even with 14.0 per cent sugar.

4.4.1.3 Body and Texture

The body and texture score of ice-cream having 15.0 per cent sugar was significantly greater ($P < 0.05$) than ice-cream made using 13.0 per cent sugar; ice-creams made using 17.0 per cent sugar were rated at par in this regard (Table 4.8 and Figure 4.13). As per the panelists, ice-cream

having 13.0 per cent sugar had too firm body that was difficult to scoop. On the other hand, ice-cream made with 17.0 per cent sugar had slightly weak body. An increase in the sugar concentration is reported to depress the freezing point (Jana *et al.*, 1994). Hence, ice-cream having higher sugar level would have greater amount of unfrozen water at the time of its consumption, seemingly having weak body. These results are contradictory to the findings of Chang and Hartel (2002) who reported that as the sugar level was raised, the consistency of ice-cream mix improved due to increased viscosity but the ice-cream had reduced hardness at -21°C. Patel *et al.* (2015) reported that changes level of ragi in the ice-cream body of ice-cream was weak and texture is gummy.

4.4.1.4 Sweetness

From the table 4.8 sweetness score of ice-cream having 15.0 per cent sugar was significantly greater ($P < 0.05$) than ice-cream made using 13.0 per cent sugar and at par with ice-creams made using 17.0 per cent sugar. The increase in sugar score of ice-cream might be because of the presence of 16.20 per cent sugar in jackfruit pulp as reported by Antarkar (1991).

4.4.1.5 Overall acceptability

Since JP ice-cream made using 15.0 per cent sugar had significantly superior scores for flavour, body and texture and sweetness, it obviously had the maximum total sensory score that was significantly ($P < 0.05$) greater than the scores allotted to other two ice-creams made using 13.0 or 17.0 per cent sugar (Table 4.8 and Figure 4.13).

Hence, from the above discussion it was imperative to select 15.0 per cent sugar in JP ice-cream.

4.5. Effect of stabilizer on the sensory and physical properties of JP ice-cream

On an average JP contain 23 per cent total solids which is lower than ice-cream mix. These may affect on the firmness of product. Therefore,

in the present study it was believed that addition of stabilizer would improve the body and texture and thereby overall acceptability of JP ice-cream. The stabilizer added in the present study were sodium alginate @ 0.1 per cent (S_1), carboxy methyl cellulose @ 0.1 per cent (S_2), and carrageenan @ 0.1 per cent (S_3) per cent of ice-cream mix and compared with the product without stabilizer (S_0). The entire sample had addition of JP at 15 per cent and sugar at 15 per cent. The results generated are reported in Table 4.9 and Table 4.10.

4.5.1 Effect of stabilizer on sensory attributes of ice-cream

4.5.1.1 Flavour

It is clear from the data (Table 4.9) that the effect of level of stabilizer was non-significant on flavour score of ice-cream. The ice-cream prepared using 0.1 per cent CMC stabilizer had highest flavour score (8.13). The minimum score for flavour of 7.98 was recorded to the product containing sodium alginate stabilizer

Table 4.9: Effect of different stabilizer on sensory attributes (score)* of ice-cream

Stabilizer Types	Scores for sensory attributes			
	Flavour	Colour and appearance	Body and Texture	Overall acceptability
S_0	7.98±0.13	8.00±0.15	7.95 ^a ±0.10	7.90 ^a ±0.08
S_1	7.95±0.14	7.93±0.08	7.73 ^a ±0.13	7.95 ^a ±0.06
S_2	8.13±0.15	8.18±0.11	8.00 ^{ab} ±0.11	8.03 ^{ab} ±0.03
S_3	8.00±0.10	8.05±0.06	8.28 ^b ±0.08	8.12 ^b ±0.04
SEm	0.13	0.11	0.11	0.06
CD (P<0.05)	NS	NS	0.33	0.17
CV	3.23	2.65	2.72	1.41

* mean ± SE of four replications within column followed by same letter are non- significantly different at $p < 0.05$. NS = non- significant.

4.5.1.2 Colour and appearance

It is clear from the data (Table 4.9) that the effect of level of stabilizer was non-significant on colour and appearance score of ice-cream. The ice-cream prepared using 0.1 per cent carrageenan stabilizer had highest colour and appearance score (8.18). The minimum score for colour and appearance of 7.93 was recorded to the product containing sodium alginate stabilizer.

4.5.1.3 Body and texture

The effect of different stabilizers was significant ($p < 0.05$) on body and texture scores of ice-cream. The ice-cream prepared using 0.1 per cent carrageenan stabilizer had highest score (8.28) and which was significantly superior over the other ice-cream under study. The minimum score for body and texture of 7.73 was recorded to the product containing sodium alginate @ 0.1 per cent. The appearance of product become more thick and flocculated as observed by the judges to the S_3 product. The score between level S_2 and S_3 were at par with each other (Table 4.9 and fig. 4.14)

4.5.1.4 Overall acceptability

The data (Table 4.9) revealed that the overall acceptability score was significantly ($p < 0.05$) affected by the level of stabilizer. Though the level of sugar and JP was constant in all the treatments but the stabilizer is different. The overall acceptability score for S_3 , S_2 , S_1 and S_0 were 8.12, 8.03, 7.95 and 7.90 respectively. The maximum score (8.22) was received for overall acceptability of ice-cream containing 0.1 per cent carrageenan stabilizer. From the results it was concluded that addition of carrageenan stabilizer at 0.1 per cent in ice-cream was imparted good overall qualities to ice-cream as compared to other stabilizers. Carrageenan is a secondary stabilizer, which is used to prevent phase separation of a mix and also generally improves protein stability in the presence of negative influences such as shear, low pH and change in salt balance (Bahramparvar and Tehrani, 2011).

4.5.2 Effect of stabilizers on physical attributes of JP ice-cream

4.5.2.1 Overrun

The effect of type of stabilizer had significant effect ($p < 0.05$) on overrun of ice-cream. The overrun of ice-cream ranges from 76.20, 74.33, 72.13, and 69.13 for S_3 , S_2 , S_1 and S_0 . The highest overrun was obtained with S_3 i.e. carrageenan stabilizer.

4.5.2.2 Melting rate

The melting rate was mainly affected by stabilizer because it has ability to hold the water in product. The melting rate of S_0 (32.75%) was significantly ($p < 0.05$) more than S_1 , S_2 and S_3 . The melting rate was minimum for level S_3 (27.50%), which had 0.1 per cent carrageenan stabilizer. Santos and Silva (2012) found that increased ice-cream overrun values resulted from the considerable amount of fat globules in the homogenization process, resulting in lower meltdown speed.

Table 4.10: Effect of different stabilizers on physical attributes of JP ice-cream

Stabilizer treatments	Physical attributes	
	Overrun (%)*	Melting rate (% ice-cream melted in 40 min.)*
S_0	69.13 ^a ±1.01	32.75 ^a ±0.52
S_1	72.13 ^b ±0.43	30.38 ^b ±0.43
S_2	74.33 ^c ±0.35	28.68 ^c ±0.32
S_3	76.20 ^d ±0.45	27.50 ^d ±0.65
SEm	0.62	0.49
CD ($P < 0.05$)	1.90	1.52
CV	1.70	3.30

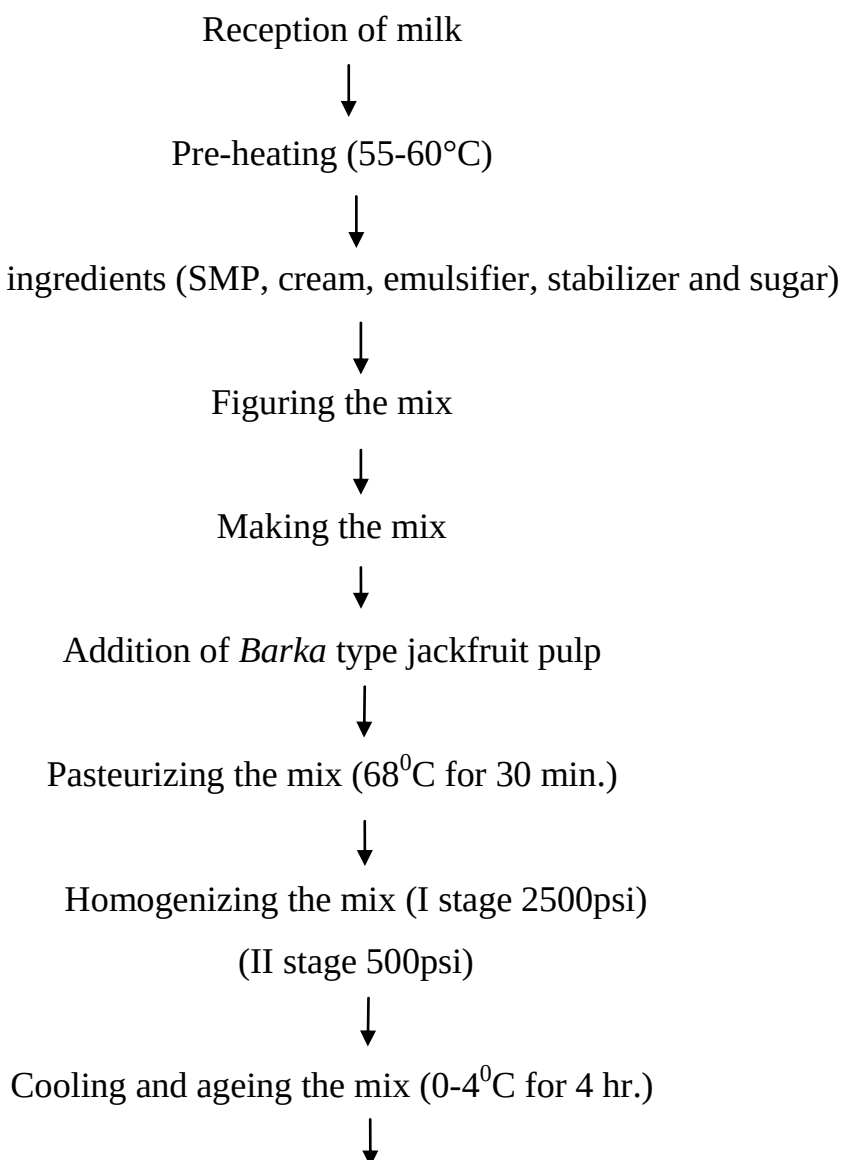
* mean ± SE of four replications within column followed by same letter are non- significantly different at $p < 0.05$. NS = non- significant.

Sakurai (1996) found that ice-creams with low overruns melted quickly, whereas ice-creams with high overruns began to melt slowly and

had a good melting resistance. This slower melting rate in the ice-creams with high overruns was attributed to a reduced rate of heat transfer due to a larger volume of air but may also be due to the more tortuous path through which the melting fluid must flow (Hartel 2003).

4.6 Physico-chemical properties and flow diagram of optimized level of JP ice-cream.

The obtained JP ice-cream prepared by using 15 per cent pulp, 15 per cent sugar and 0.1 per cent carrageenan stabilizer and following the method given in fig 4.16. The average physico chemical composition in terms of fat, protein, reducing sugar, non-reducing sugar, total sugar, ash, total solids, acidity, pH, melting rate and overrun have been indicated in Table4.11.



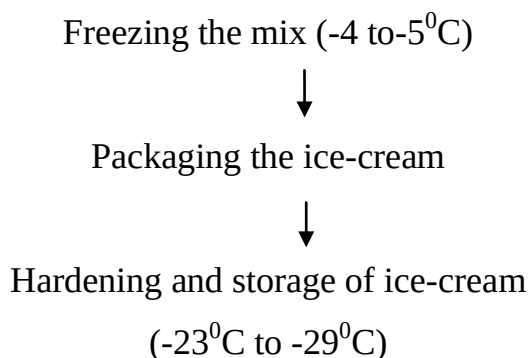


Fig. 4.16 Flow diagram of manufacture of JP Ice-cream.

From the table 4.11, it was observed that the experimental ice-cream prepared by incorporation of JP of *Barka* type @ 15 per cent, sugar @ 15 per cent and stabilizer 0.1 per cent had 11.33 ± 0.12 per cent fat, 3.39 ± 0.05 per cent protein, 7.80 ± 0.29 per cent reducing sugar, 16.25 ± 0.26 total non-reducing sugar, 24.05 ± 0.23 per cent total sugar, 0.92 ± 0.01 per cent ash, 39.65 ± 0.45 per cent total solids, 0.30 ± 0.01 (% LA) acidity, 27.50 ± 0.55 per cent melting rate and 76.20 ± 0.22 per cent overrun.

Table.4.11: Physico-chemical analysis of JP ice-cream.

Chemical parameters	Mean values*
Fat (%)	11.33 ± 0.12
Protein (%)	3.39 ± 0.05
Reducing sugar (%)	7.80 ± 0.29
Non-reducing sugar (%)	16.25 ± 0.26
Total sugar (%)	24.05 ± 0.23
Ash (%)	0.92 ± 0.01
Total solids (%)	39.65 ± 0.45
Acidity (%)	0.30 ± 0.01
pH	6.14 ± 0.02
Melting rate (%)	27.50 ± 0.55
Overrun (%)	76.20 ± 0.22

* mean $\pm$ SE of four replications within column

4.7 Cost of production

The cost of production of JP ice-cream was worked out by using standard procedure suggested by Lal (1980) and presented in Table 4.12. The prevailing price/rate of each ingredient and services were taken into consideration. The labour

Table 4.12: Cost model for production of 100 lit JP ice-creams mix.

Sr. No	Cost component	Unit price (Rs.)	Quantity (for 100 lit mix)	Amount (Rs.)
A. Raw Material				
1	Milk	38 / lit	40.00 lit	1520.00
2	Cream	190 /lit	38.38 lit	7292.00
3	Skim milk powder	320 /kg	6.39 kg	2044.80
4	Stabilizer	768 /100g	100 g	768.00
5	Emulsifier	9 /100g	20 g	1.80
6	Sugar	42 / kg	15.00 kg	630.00
7	JP	80 /kg	15	120.00
B. Processing				
1	Electricity	--	--	250.00
2	Water	--	--	25.00
3	Gas	50 /kg	15 kg	750.00
4	Labour	200 / day	1 day	200
5	Store & Maintenance	--	--	50.00
6	Packaging	--	--	750.00
7	Supervision	--	--	25.00
Total production cost 100 lit mix		--	--	14425.8
Total production cost 1 lit mix				144.25

charges were considered on the basis of actual hours of work of the preparation of 100 lit JP ice-creams mix.

The total cost for manufacturing of 1lit of ice-cream mix was calculated as Rs. 144.25. The average overrun of optimized JP ice-cream was found to be about 75 per cent which will give about 1.75 lit of final ice-cream i.e. the cost of 1.75 lit of ice-cream was about 144.25. Therefore, the cost of 1 lit of ice-cream will be Rs. 82.43 approximately.

5. SUMMARY AND CONCLUSIONS

5.1 Summary

Amongst frozen milk products, ice-cream assumes special importance for its distinct flavour, taste, richness, delicacy and sweetish caramel aroma. Jackfruitice-cream was prepared with addition of jackfruit pulp (JP) @ 10, 15 and 20 per cent and sugar @ 13, 15 and 17 per cent (w/w basis) of ice-creammix. Ice-cream was judged for its sensory qualities viz. flavour, colour and appearance, body and texture, sweetness and overall acceptability by semi trained panel of judges and the chemical properties viz., fat, protein, reducing sugar, non-reducing sugar, total sugar, ash, total solids, acidity and pH were determined using standard prescribed procedures. The statistical analysis was carried out by using Completely Randomized Design. The results of the present study are summarized in the following paragraphs.

5.1.1 Analysis of ice-cream ingredients

5.1.1.1 Chemical qualities of milk

The milk used for preparation of JPice-cream in present study contained on an average 15.6 ± 0.39 , 6.00 ± 0.19 , 3.57 ± 0.07 , 5.15 ± 0.04 , 0.15 ± 0.01 and 0.8 per cent, total solids, fat, protein, lactose, acidity and ash respectively.

5.1.1.2 Chemical quality of Cream

The cream used for preparation of experimental ice-cream contained 25.2 per cent fat and 32.9 per cent total solids.

5.1.1.2 Chemical quality of JP

The JP used in the present investigation was of good quality. The total solids, fat, protein, acidity, Total sugar and pH were 23.69, 0.22, 1.75, 0.25, 17.25 and 6.5, respectively.

5.1.2 Process Optimization

5.1.2.1 Selection of type jackfruit for preparation of ice-cream.

Barka and *Kappa* type of jackfruit pulp were used in preparation of ice-cream. The JP ice-cream prepared by the addition of the JP of *Barka* type had more score for all the sensory parameters over *Kappa* type JP ice-cream. The sensory score of JP ice-cream prepared from *Barka* type of jackfruit recorded 7.25 ± 0.10 , 7.10 ± 0.04 , 7.05 ± 0.12 , 7.85 ± 0.06 and 7.65 ± 0.05 score for flavor, colour and appearance, sweetness and overall acceptability, respectively. Hence, JP ice-cream of *Barka* type was selected for optimization experiment.

5.1.2.2 Optimization of Level of JP in ice-cream.

Total three formulations were prepared using three different levels of JP and were compared with control ice-cream and analyzed for sensory and physico-chemical qualities.

5.1.2.2.1 Effect of level of JP on sensory qualities of ice-cream

In case of flavour the JP ice-cream prepared with 15 per cent JP was recorded highest (8.03) score. The jackfruit ice-cream prepared by addition of 0 per cent jackfruit (control) which recorded significantly lowest (score 7.00). The maximum score for colour and appearance (score 8.03) of JP ice-cream was recorded for the ice-cream with 20 per cent JP. The highest score (8.08), for body and texture was obtained by jackfruit ice-cream prepared by addition of JP @15 per cent of ice-cream mix whereas the lowest (7.08) score was observed for JP ice-cream prepared with 10 per cent pulp of total mix. As far as sweetness is concerned the maximum score (8.25) was recorded for ice-cream prepared with the addition of 15 per cent JP combination and the lowest score (7.80) was recorded for 0 per cent pulp (control) of mix.

Most acceptable product in the present study was observed to be ice-cream prepared by using 15 per cent pulp level with overall acceptability score of 8.25.

5.1.2.2.2 Effect of JP levels on physical attributes of JP ice-cream

The result recorded that incorporation of JP in ice-cream mix resulted in increase in the overrun. The overrun of ice-cream ranges from 59.50 to 75.40 and the maximum overrun was recorded for JP ice-cream mix incorporated with 20 per cent JP.

The meltdown values varied from 30.20 per cent to 34.48 per cent. The maximum melting rate was recorded in ice-cream prepared with JP @ 10 per cent and minimum melting rate was recorded in ice-cream prepared with JP @ 20 per cent

5.1.2.2.3 Effect of JP level on chemical qualities of JP ice-cream

The values of fat content in JP ice-cream ranged from 11.05 to 12.20 per cent. JP ice-cream prepared by using 20 per cent JP addition had lowest fat content and ice-cream prepared without addition of JP had highest fat content (12.20 per cent). The protein content in JP ice-cream ranged from 3.93 to 3.32 per cent. The protein per cent of JP ice-cream decreased with increase in JP level. The Reducing sugar content in JP ice-cream ranged from 5.13 to 8.18 per cent. The minimum per cent of reducing sugar content was recorded in control ice-cream. While the maximum per cent of reducing sugar content was recorded in ice-cream with 20 per cent JP. The non-reducing sugar content in JP ice-cream ranged from 15.23 to 16.70 per cent. The minimum per cent of non-reducing sugar content in JP ice-cream was obtained from JP 0 per cent of ice-cream mix (control). Total sugar content in ice-cream ranged from 20.35 to 24.52. Whereas the minimum (0.77) ash content was observed in T₀ ice-cream and maximum (1.05) ash was associated with JP ice-cream made using 20.0 per cent JP. Reducing and non-reducing sugars, Ash and Total solid was found to increase in the ice-cream with increased level of JP whereas the fat and protein contents decreased.

The maximum per cent of Titratable acidity 0.35 per cent of JP ice-cream was recorded and it was prepared with 20 per cent JP. The lowest

titratable acidity was recorded in control ice-cream. The pH of in ice-cream was 5.98 to 6.44 and it was observed that as the level of JP increased, the pH of ice-cream decreased.

5.1.2.3 Effect of different level of sugar on sensory attributes of JP ice-cream.

The sugar was added @ 13, 15 and 17 per cent in JP ice-cream mix. The flavour score of JP ice-cream ranged from 7.43 to 8.03. The maximum score was obtained for JP ice-cream prepared with 15 per cent sugar addition. The colour and appearance score of JP ice-cream ranged from 7.58 to 7.95 and the maximum score was obtained for formulation (mix), having 17 per cent sugar. The body and texture score ranged from 7.58 to 8.13. The maximum score was obtained for JP ice-cream contained 15 per cent sugar. Maximum overall acceptability score was also recorded for the same product. The minimum overall acceptability score was recorded for product containing 15 and 13 per cent pulp and sugar respectively.

5.1.2.4 Effect of different stabilizer on the sensory and physical properties of JP ice-cream

The effect of different stabilizer was not significant affect ($p < 0.05$) on flavour and colour and appearance. The score of body and texture and overall acceptability for ice-cream prepared by carragenan stabilizer were maximum. The type of stabilizer was significantly affected ($p < 0.05$) over run and melting rate of ice-cream. The over run of ice-cream ranges from 69.13 to 76.20 per cent. The melting rate of type S_0 was maximum (32.75%). The melting rate was minimum for ice-cream prepared by addition of carragenan stabilizer (28.68%).

5.2 Conclusion

From the result it can concluded that,

1. The best quality ice-cream could be prepared by addition of 15 per cent JP of *Barka* type, 15 per cent sugar and 0.1 per cent carragenan stabilizer of total volume of mix and the optimized product had 8.00 ± 0.10 , 8.05 ± 0.06 ,

8.28 $\pm$ 0.08 and 8.22 $\pm$ 0.04 score for flavour, colour and appearance, body and texture, and overall acceptability.

2. The ice-cream prepared by optimized formulation had 11.33 $\pm$ 0.12, 3.39 $\pm$ 0.05, 7.80 $\pm$ 0.29, 16.25 $\pm$ 0.26, 24.05 $\pm$ 0.23, 0.92 $\pm$ 0.01, 39.65 $\pm$ 0.45, 0.30 $\pm$ 0.01, 6.14 $\pm$ 0.02, 27.50 $\pm$ 0.55 and 76.20 $\pm$ 0.22. per cent, fat, protein, reducing sugars, non-reducing sugars, total sugars, ash, total solid, acidity, pH, melting rate and overrun, respectively.
3. The cost of production of experimental jackfruit ice-cream was found to be Rs.82.43/lit.

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<http://www.nddb.org/information/stats/milkprodindia>

www.indiastat.com

Appendix-I

Evaluation of JP ice-cream on 9 point Hedonic scale

(Evaluation card)

- 1) Trial no:
- 2) Name of the evaluator:
- 3) Date of evaluation:

Sample no.	Sensory Characteristics				
	Colour and appearance	Flavour	Body and texture	Melting rate	Overall acceptability
1					
2					
3					

Maximum score 9.0 for each characteristics

Remark	Score
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like or dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Note: Score of 5.5 and above indicates acceptability within the score of 1 to 9.

Remarks:

- 1.
- 2.

Signature of the judge

8. VITA

Miss. Gaikwad Swapna Balu

A candidate for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

In

DAIRY SCIENCE

Thesis title	:	Development of ice-cream by using jackfruit pulp.
Major field	:	Dairy Science
Biographical Information	:	Born at Kohokadi, Taluka-Parner, District-Ahmednagar (M.S) on 15 th June, 1993. Daughter of Shri. Balu Rambhau Gaikwad and Sau. Ranjana Gaikwad.
Educational	:	Passed SSC from Shri. Dharmnath Vidyalay, Jawla, Taluka-Parner, District-Ahmednagar (M.S) in 2009. Passed HSC from Shri. Mulikadevi Jr. College, Nighoj Taluka-Parner, District-Ahmednagar (M.S) in 2011. Received B.Sc. (Agri.) degree from College of Agriculture, Sonai, Tal-Newasa, Dist-Ahmednagar (M.S) in 2015 with first class.
Address	:	At-Kohokadi post-Ralegan therpal, Taluka-Parner, District-Ahmednagar.(M.S)
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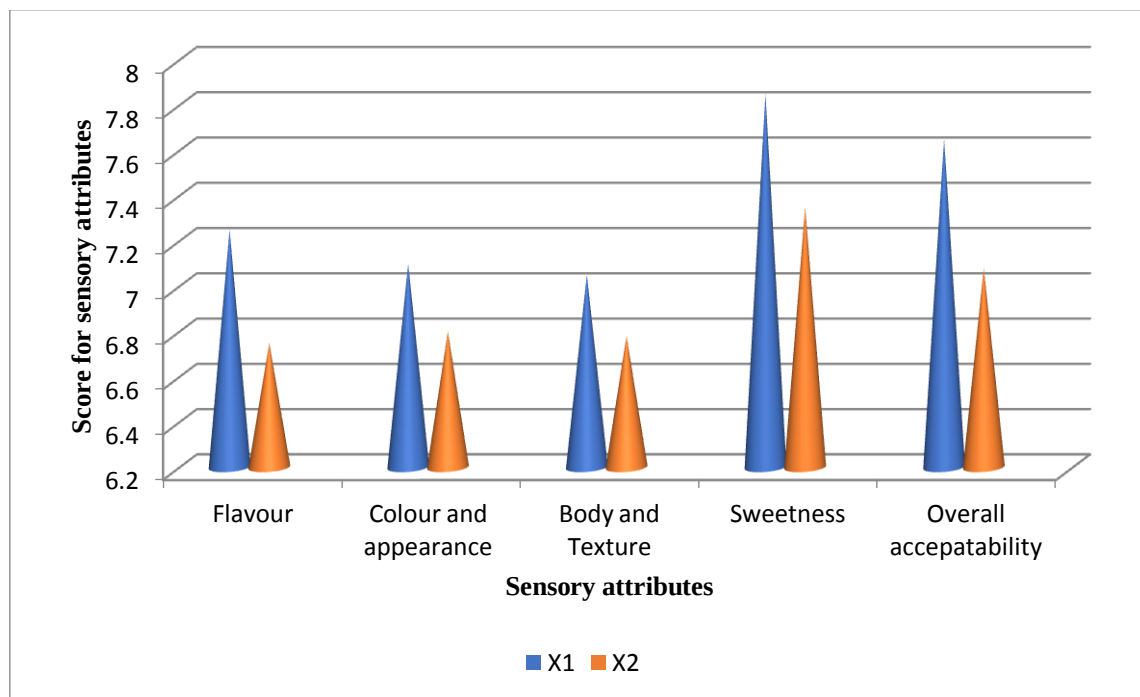


Fig. 4.1: Effect of the jackfruit type on sensory attributes of ice-cream.

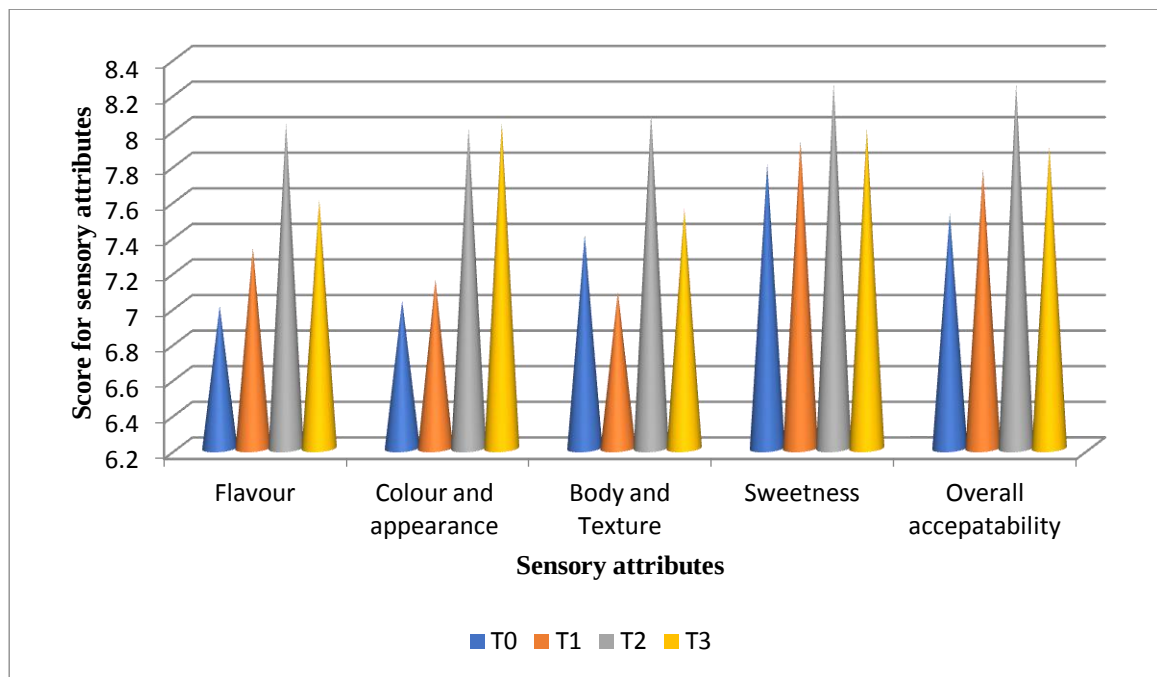


Fig. 4.2: Effect of JP level on sensory attributes of ice-cream.

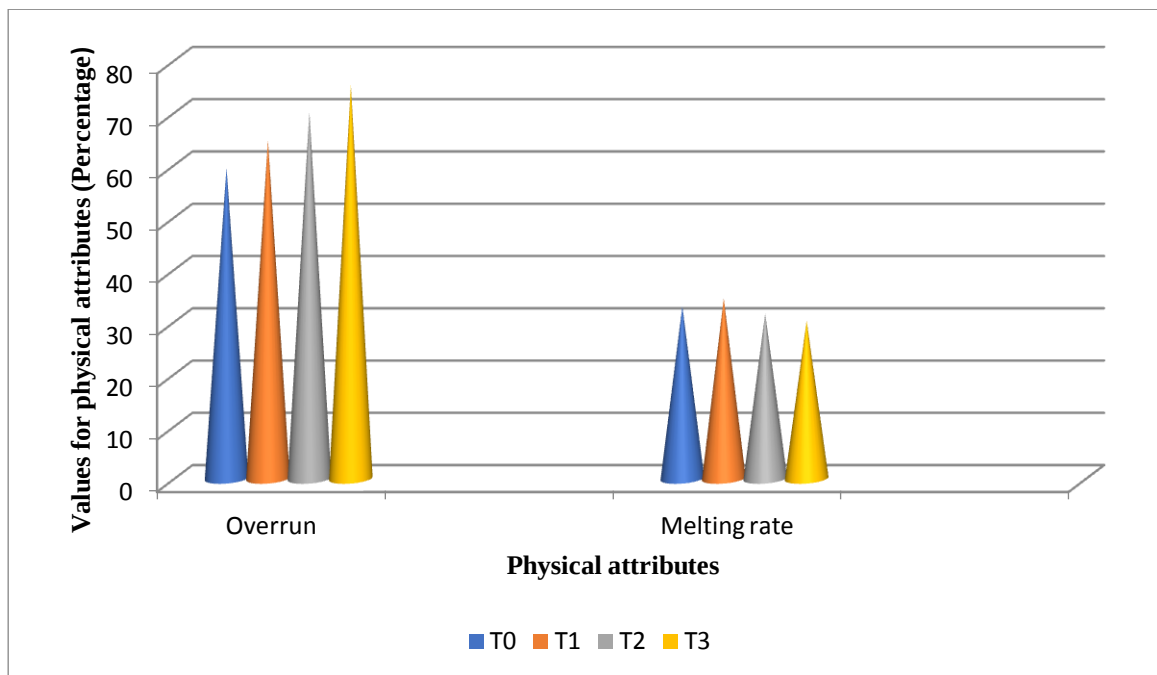


Fig. 4.3: Effect of JP level on physical attributes of ice-cream.

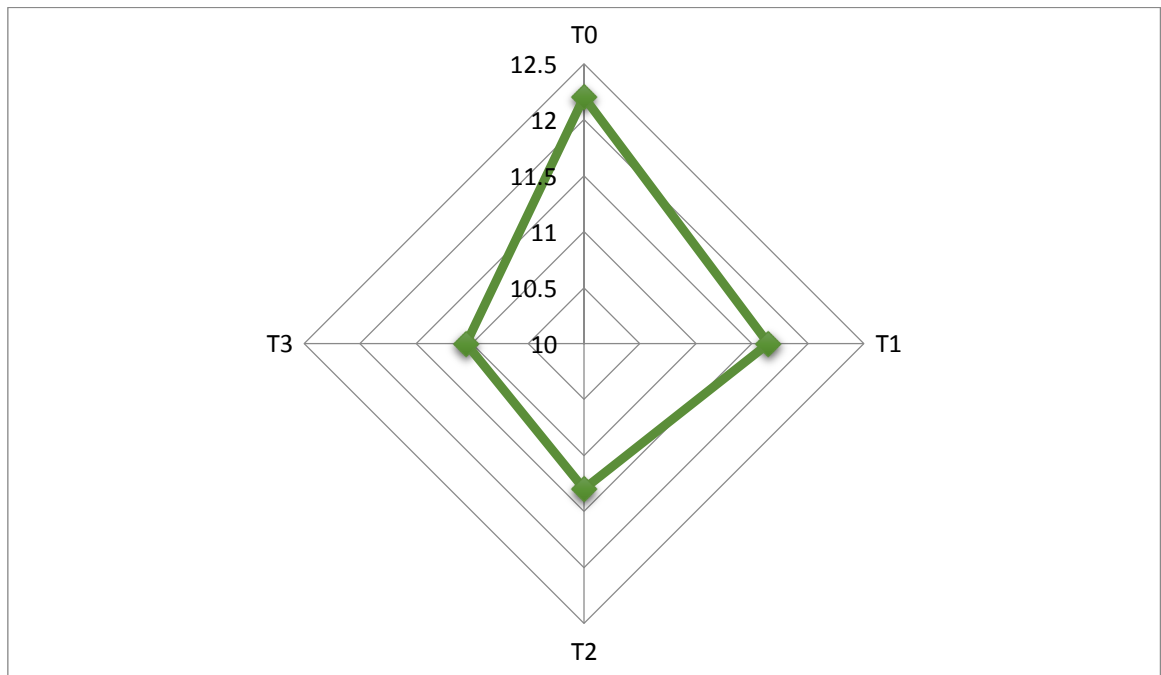


Fig. 4.4 Effect of levels of JP on fat content of ice-cream

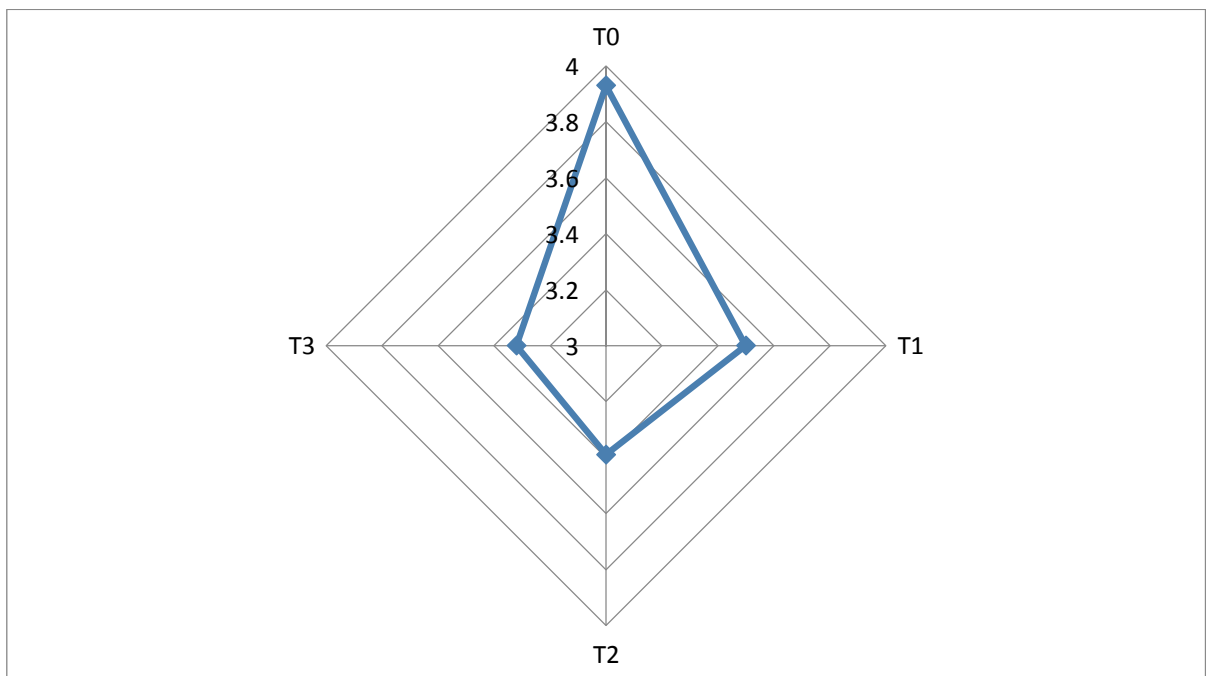


Fig. 4.5 Effect of levels of JP on protein content of ice-cream

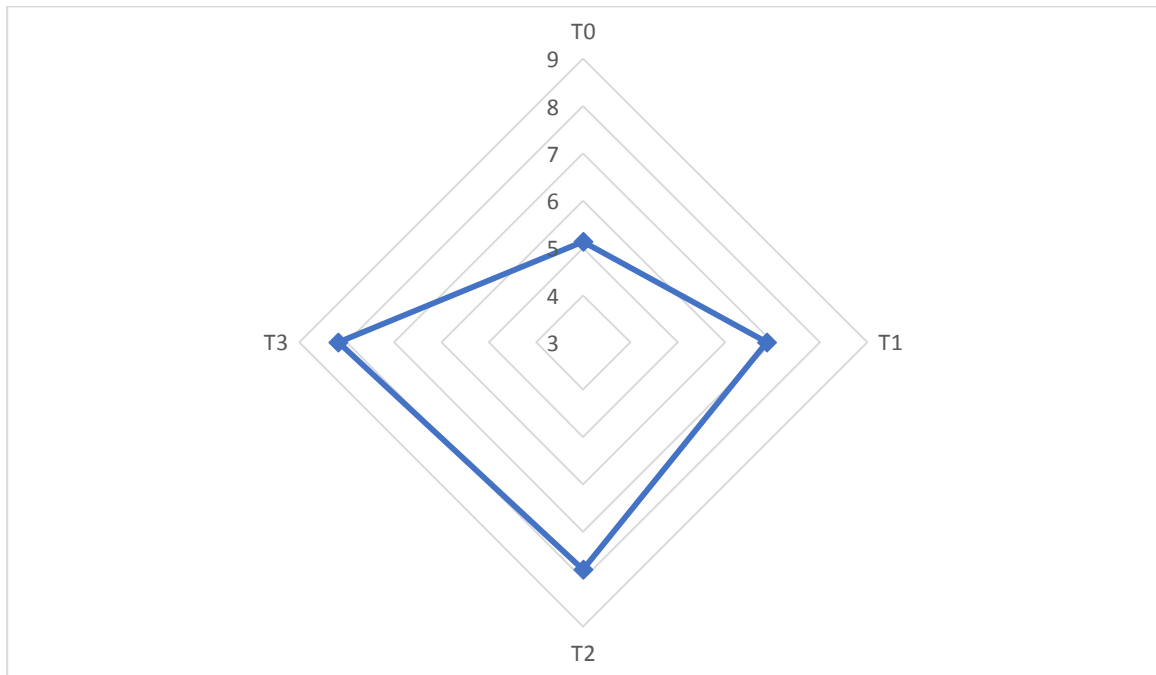


Fig. 4.6 Effect of levels of JP on reducing sugar content of ice-cream

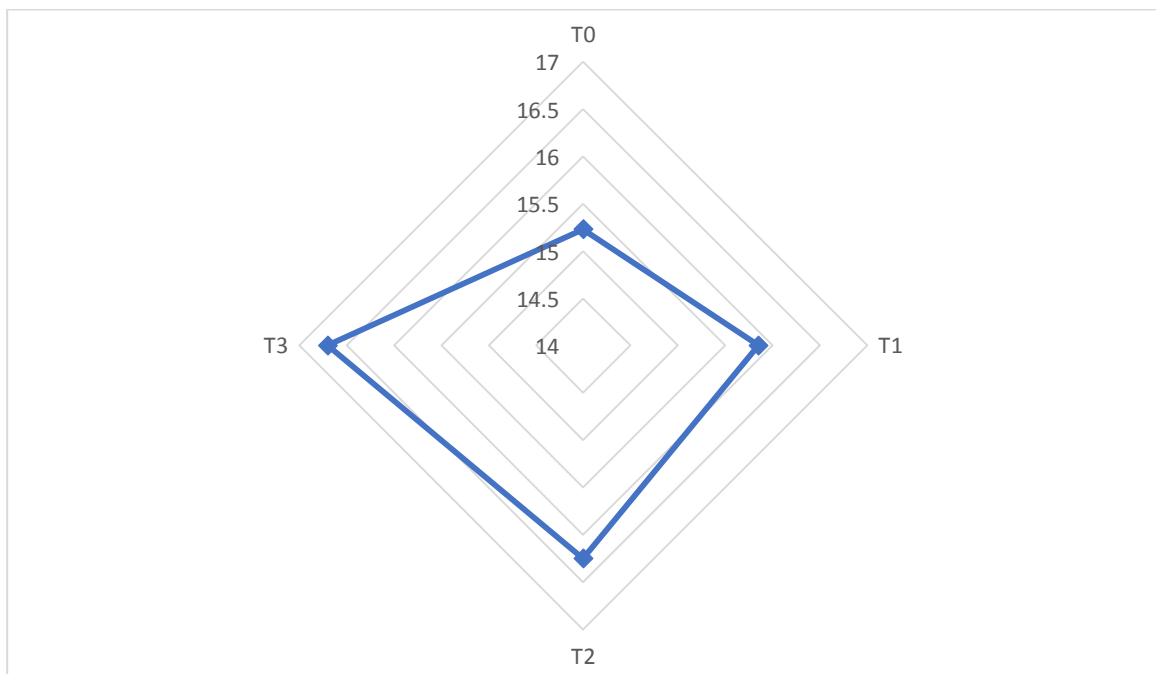


Fig. 4.7 Effect of levels of JP on non-reducing sugar content of ice-cream

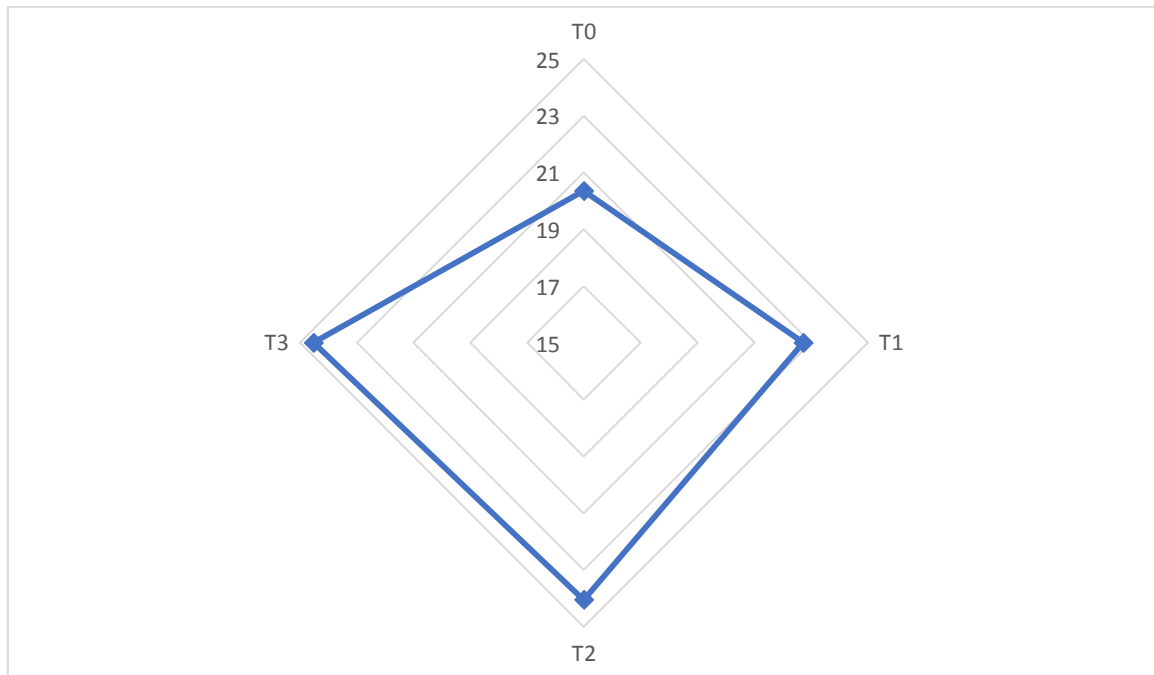


Fig 4.8 Effect of levels of JP on total sugar content of ice-cream

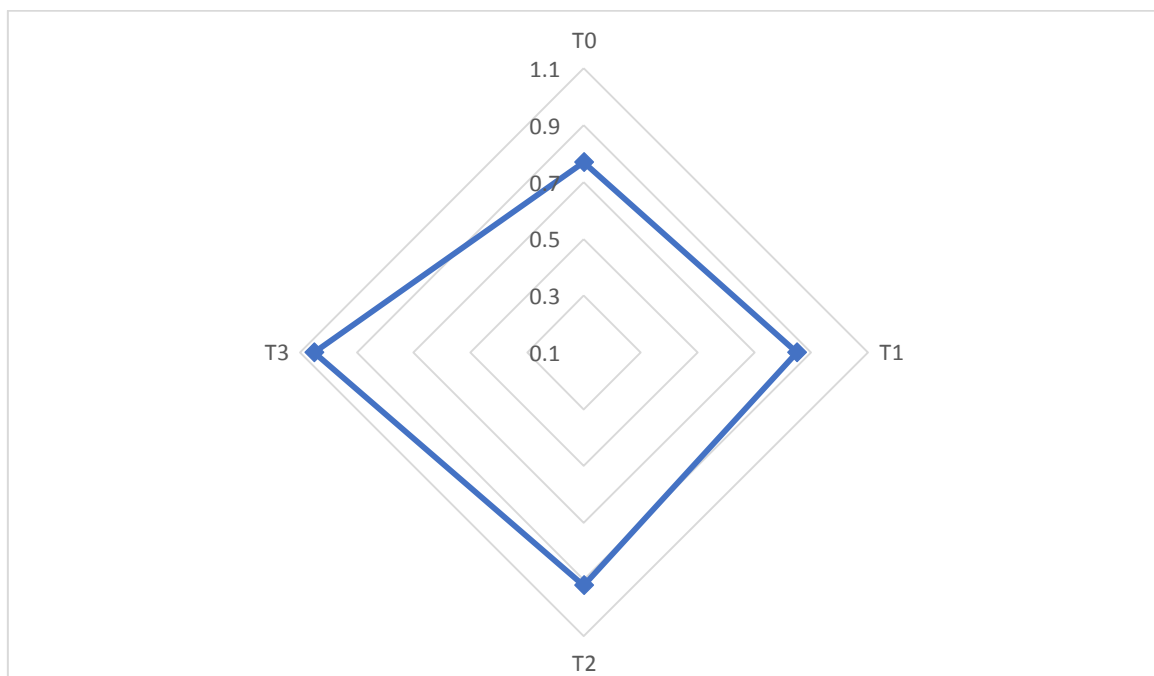


Fig. 4.9 Effect of levels of JP on ash content of ice-cream

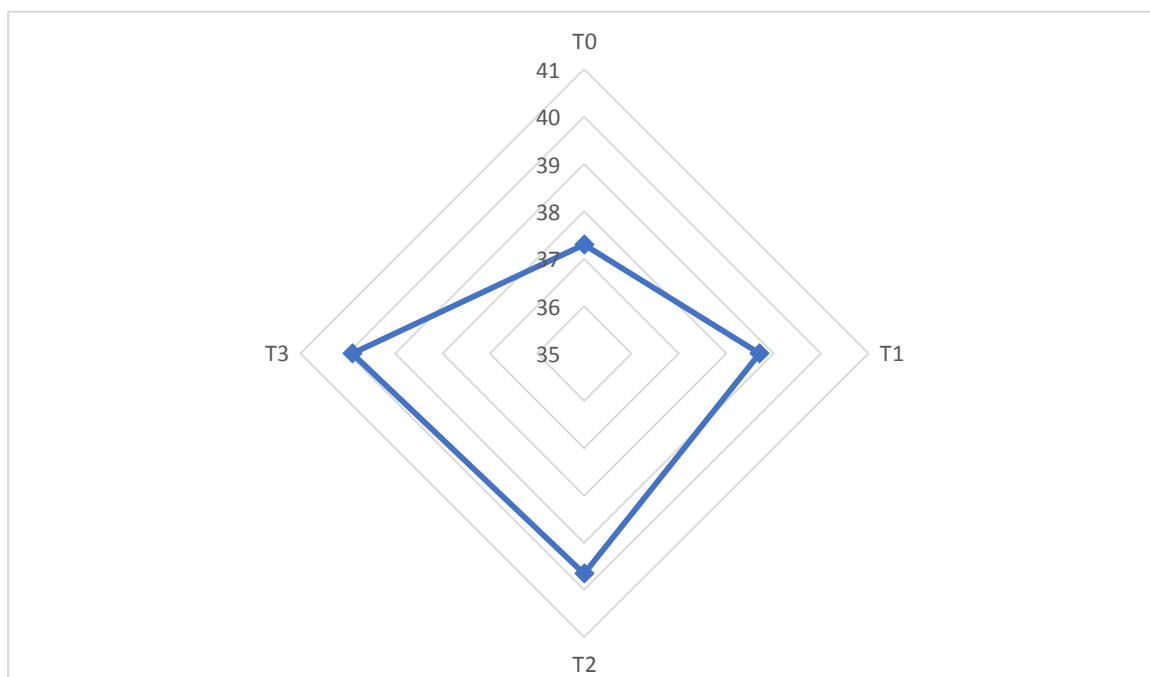


Fig. 4.10 Effect of levels of JP on total solid content of ice-cream

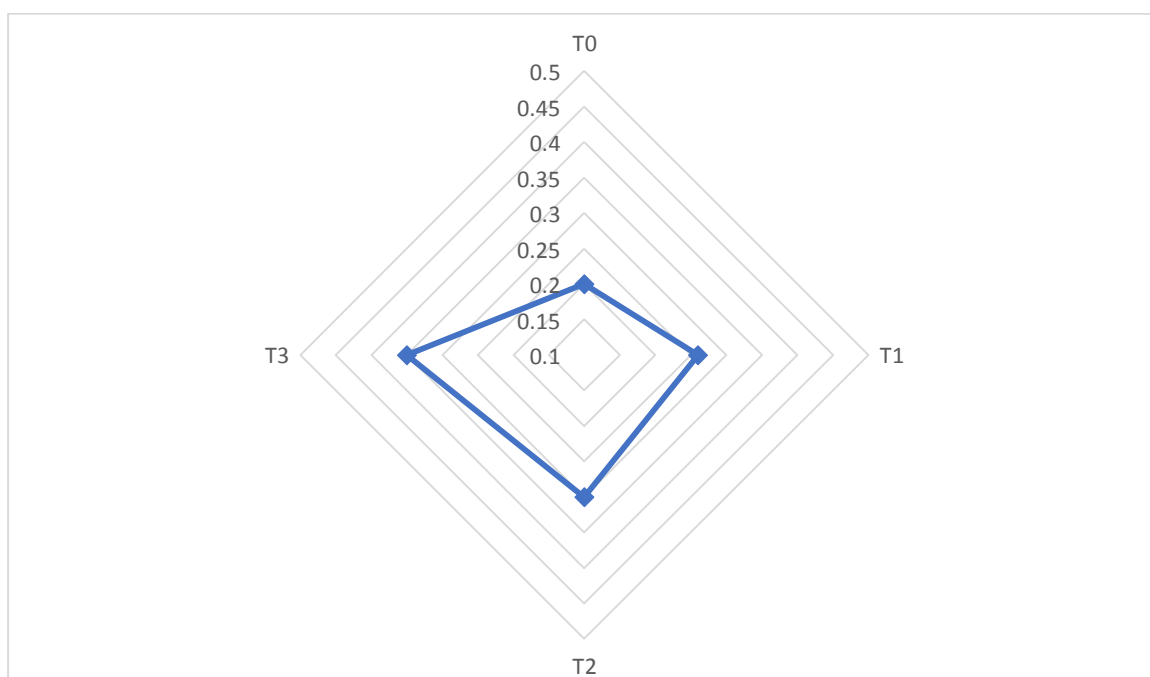


Fig. 4.11 Effect of levels of JP on acidity content of ice-cream

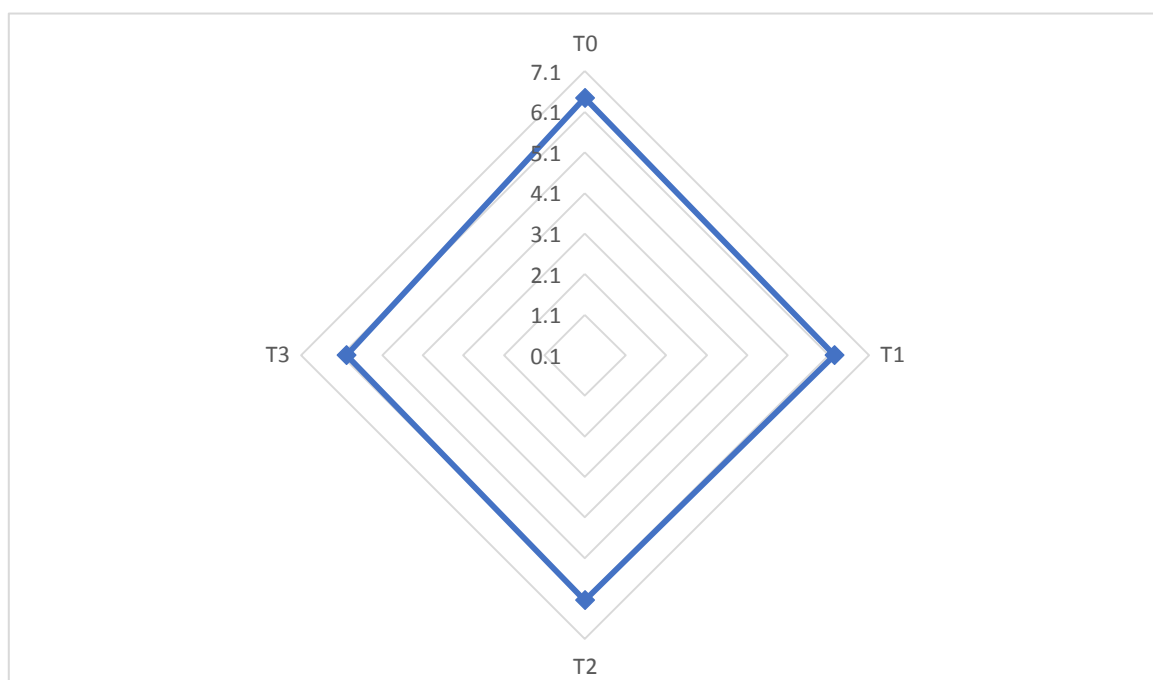


Fig. 4.12 Effect of levels of JP on value pH of ice-cream

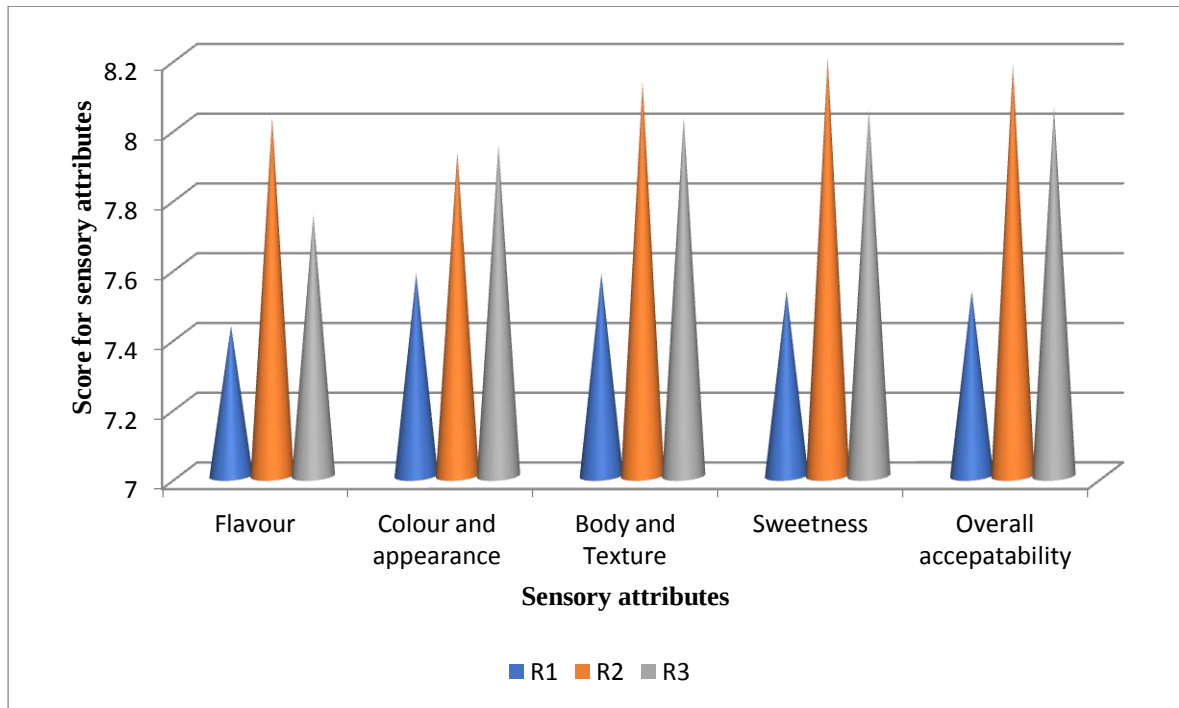


Fig. 4.13: Effect of different sugar level on sensory attributes of ice-cream.

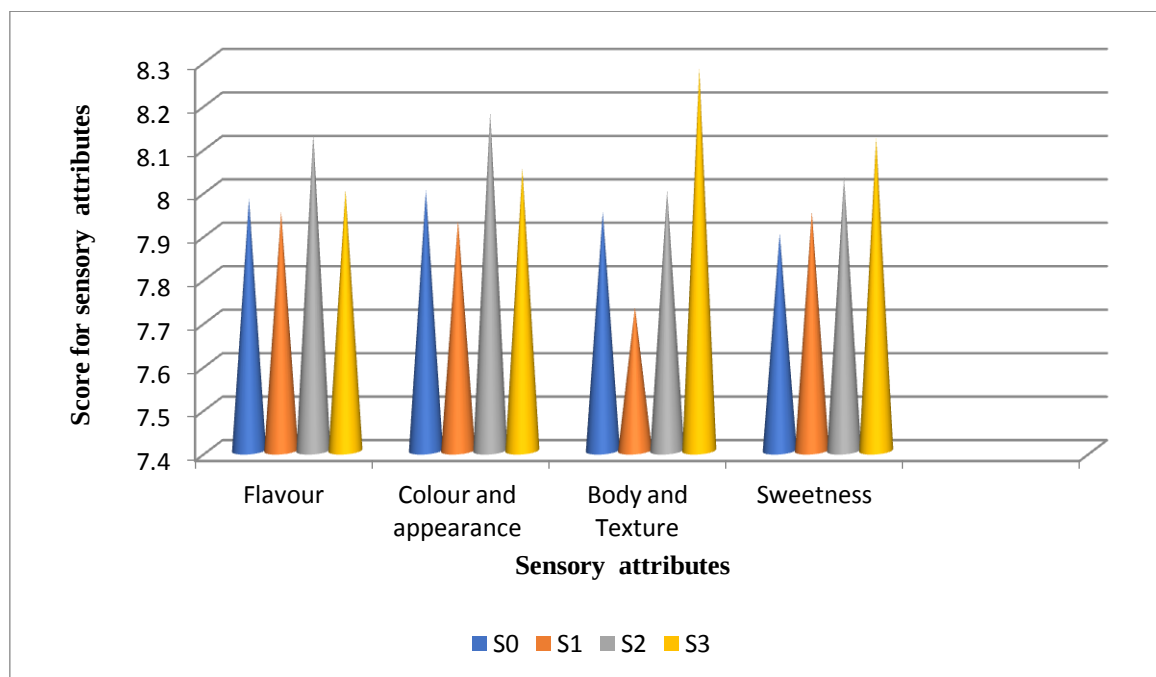


Fig. 4.14: Effect of different stabilizer level on sensory attributes of ice-cream.

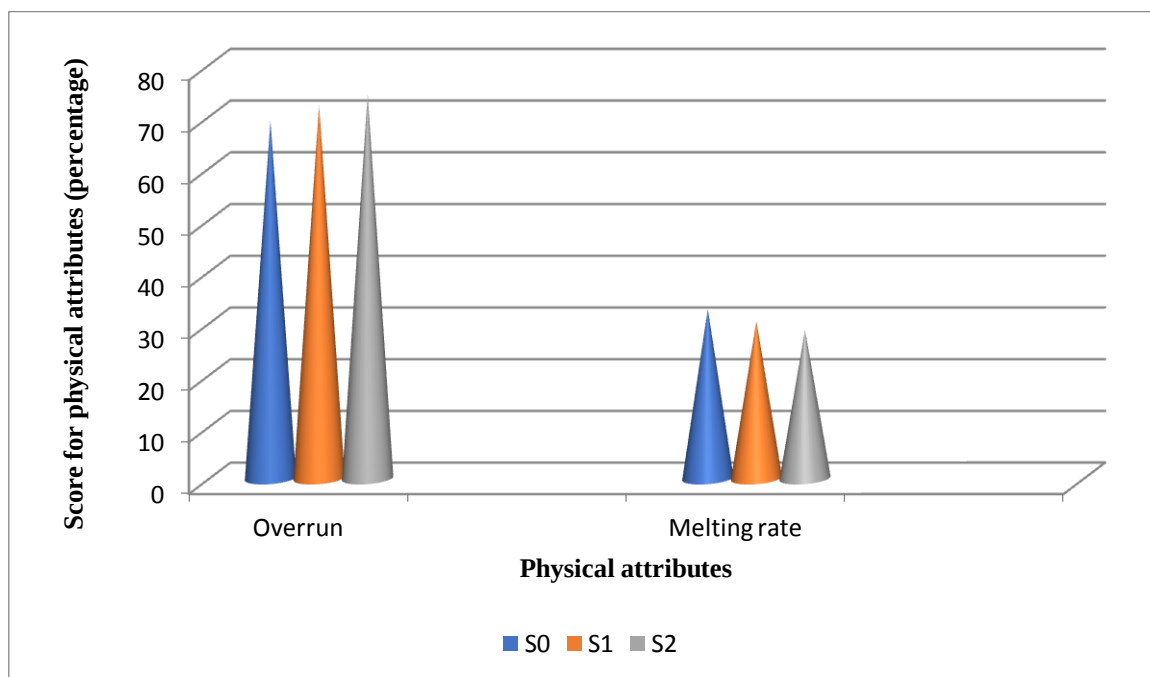


Fig. 4.15: Effect of different stabilizer on physical attributes of ice-cream.