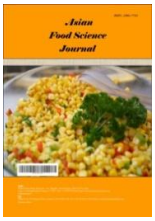

Asian Food Science Journal

19(1): 17-24, 2020; Article no.AFSJ.61989
ISSN: 2581-7752

Sensorial Quality and Physicochemical Properties of Newly Developed Ice-Cream, with Plant Originated Stabilizer; Modified Kithul (*Caryota urens*) Flour

J. A. A. C. Wijesinghe[1*], K. M. P. Manamperi[1] and D. H. M. Nandasiri[1]

[1]Department of Biosystems Engineering, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila, Sri Lanka.

Authors' contributions

This work was carried out in collaboration among all authors. Authors DHMN and KMPM conducted the research as research assistant. Author JAACW supervised the research, analyzed the data and wrote the paper. Further all authors had approved the final version.

Article Information

DOI: 10.9734/AFSJ/2020/v19i130229
Editor(s):
(1) Dr. Samaila James, Federal University of Technology, Nigeria.
(2) Dr. Surapong Pinitglang, University of the Thai Chamber of Commerce, Thailand.
Reviewers:
(1) Sandra Beserra da Silva de Souza, State University of Maringá, Brazil.
(2) Ratmawati Malaka, Hasanuddin University, Indonesia.
(3) Vivekpuri G. Goswami, Government Engineering College, Gujarat Technological University, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/61989

Original Research Article

Received 10 August 2020
Accepted 16 October 2020
Published 12 November 2020

ABSTRACT

Aims: Replacement of existing stabilizer in ice cream industry by using modified Kithul (*Caryota urens*) flour which helps to reduce usage of other ingredients which are used for improve the texture and creaminess of the product was examined. Kithul (*Caryota urens*) flour has better stabilizing ability than other flour and it can be used in product diversification in the food industry. The objective of this study was to use modified Kithul (*Caryota urens*) flour as a new plant origin stabilizer for the production of ice cream which can be easily applied for ice cream machines.
Study Design: Three treatments were prepared as commercial stabilizer based (industrial mixture) as the control (A), and two samples with modified Kithul flour under two condition as without refrigerated (B) and 24 hours refrigerated (C) the modified Kithul flour with milk before preparing ice cream.
Place and Duration of Study: Department of Biosystems Engineering, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, between June 2019 and January 2020.
Methodology: Three samples were evaluated for its sensory properties and selected ice cream

**Corresponding author: Email: jaacwijesinghe@wyb.ac.lk;*

sample from the sensory evaluation (Treatment B) was evaluated for proximate composition and evaluated for physicochemical properties vs industrial ice cream as a control.
Results: The comparison revealed that modified Kithul flour-based ice cream (Treatment B) was better in terms of low cost of production, high overrun and high overall acceptability in the sensory analysis vs industrial ice cream (Treatment A).
Conclusion: According to the results of the evaluation of quality attributes, without refrigerated milk-modified Kithul flour mixture before making ice cream is better than the industrial ice cream due to their low cost of production, high overrun and high overall acceptability in sensory analysis.

Keywords: Kithul flour; Caryota urens; ice cream; stabilizer; melting rate.

1. INTRODUCTION

The ice cream which is derived from earlier meaning with iced cream or cream ice. It is a soft, sweet frozen food made with milk and cream as economical, healthy, nutritive and palatable product. Production of Ice cream is followed by number of processing steps as pasteurization, homogenization, aeration and freezing which is a frozen food typically eaten as a dessert [1]. However it may be made from milk of soy, cashew, coconut or almond other than the dairy milk or cream. Typical composition of ice cream is included of milk, sugar, fat, emulsifiers, stabilizers, water and flavours. It is a compromised by three phase network as air, solid and liquid in final produce. Liquid phase contains ice crystals in surrounded form and air chambers in dispersed form. Milk proteins, soluble and insoluble salts, fat particles, stabilizers and sugars are also present in liquid phase [2].

1.1 Composition of Ice Cream

To make this complex structure various ingredients are involved and that have important properties on quality of the ice cream. These are belonging to two categories as in dairy and non-dairy components from many sources. Various ingredients that affect the quality of ice cream include sugar, fat, MSNF, water, emulsifiers and stabilizers [1].

1.2 Sugar

Sugar can be used as either in liquid or solid dry form added in ice cream production up to 12-20% however most preferable level is 14-16%. With the consideration of cost of production Corn syrup is better replacement which can be used to replace 45% sugar in ice cream. However though there are various commercially available sugar blends, need to be careful about how it affect the total solids content. Sucrose shows several functions in ice cream as Optimising palatability by sweetening the products, maintaining handling properties enhancing solid contents and viscosity as well as improving texture and body of the ice cream [3]. At the mean time need to pay more attention to use the correct amount of sugar to avoid bland taste due to lacking sweetness or mask desired flavour by adding more sweetener, make soggy ice cream above 42% Total Solid, depression of the freezing point or slowdown the freezing process etc [1,2].

1.3 Total Solids (TS)

Total solids plays a big role in ice cream process. Typically it includes the totality of all solid and dry raw materials as fat, sugar, MSNF, stabilizers and emulsifiers all contribute to total solids. Basically water in the product is replaced by total solids in dry ice cream mix. Properties of ice cream are specially improved by amount of total solid as texture and body improvement, whip ability improvement and specially increase overrun with increased TS. If the TS up to 40-42% the final texture becomes soggy and heavy structure [2].

1.4 Water

This is very important but mostly ignored in gredient which influence directly texture by maintaining the continuous phase in ice cream. However ingredients of dairy origin also contribute water contents itself. The amount of water in the ice cream mixture act as solvent and provides liquid medium to make palatable mixture [1,2].

1.5 Air

Though it never think that air as an ingredient in food industry in the process of ice cream manufacturing it plays big role. In this process step called overrun is created by combining air in mixture to enhance the volume. Quality and the

quantity of ice cream is subjective by volume of air combined. Texture quality of the ice cream can be regulated by uniform incorporation of air. Being air is an ingredient in this production quality of the air itself is maintained by filters fixed in freezers. Being air directly involved to increasing the volume product and quality of ice cream it need to meet some legal standards [2]. However air incorporation than the certain level makes some shortcomings in ice cream as reduction of ice crystals size, reduction in melting point, lowering the hardness etc. Oxidation is possible error which can occur during the air incorporation. So it's better to use nitrogen like gasses to reduce rate of oxidation [4].

1.6 Stabilizers

Stabilizers use to develop the stability as well as mouth feel of the product. Other than that it is functioning to stabilize the emulsion, aid in suspension of liquid flavours, stabilize the air bubbles and prevent the growth of lactose crystal as well as to reduce the occurrence of shrinkage. However these stabilizers act in response differently with other ingredients hence to get provide required performance characteristics to the products need to use appropriate type of stabilizer [5].

In today food industry two types of stabilizers are used for manufacturing of ice cream as:

i. Animal source: Gelatin from bones and calf/pig skin.
ii. Plant or vegetable source: Gums (agar-agar, carboxymethyl cellulose, sodium alginate, acacia, oat, carrageenan and modified starch) [4].

Once we search for new stabilizer it should have pleasant flavour without showing any colour change of the final product and extreme viscosity and melting. And it should be non-hazardous which facilitate ice cream with essential characteristics as well as be cheap. The quantity and type of stabilizer used in ice cream dependent on its profile [2].

Kithul flour has huge potentials of being used to food industry in order to provide better gelling property with other functional needs. Based on this study Kithul flour can be promoted because of its positive nutritional and Physico-chemical properties for the enhancement of ice cream industry. However, the results from this study can be used by food technology researchers, agro-processors and investors as an input for their work. More specifically, the results can contribute to those who are interested in the production of starch-based product developments which could be helped to empower the Kithul industry [6].

As well as there is a huge trend in the global society to shift from artificial life style in to a nature friendly life style. Hence, their food patterns also changing into more natural ingredients. It is very popular in the busy society being portable and easy to handling with natural ingredients. Hence the purpose of this study was to formulate ice cream recipe with better the quality attributes using different ratio of Kithul flour, as a new plant origin stabilizer.

2. MATERIALS AND METHODS

Fresh, raw full cream milk and skim milk powder, commercial grade cane sugar used was of commercial grade was obtained from the local market of Colombo. Cremadan 30 (from France by Cuisine Tech) was used as a commercial stabilizer. Vanilla essence No. 1 (Star brand, Malaysia) was used as the flavouring agent in vanilla ice cream. Kithul flour for prepare the modified flour stabilizer was procured from a local supermarket of Colombo, Sri Lanka.

2.1 Preparation of Treatments

The study was prepared three Sample as,

- Treatment A - Industrial ice cream powder mixture (as of Control).
- Treatment B - Without refrigerated modified Kithul flour-based ice cream powder mixture.
- Treatment C – 24 hour refrigerated modified Kithul flour-based ice cream powder mixture.

2.1.1 Control sample (Treatment A) - (CIM) industrial ice cream powder mixture development process

The sample for processed normally ice cream development process in ice cream production society in Sri Lanka. Firstly get Sugar, Gelatine, cornflour, glucose, milk powder, cremodan 30, vanilla powder, and salt. All ingredients were mixed using a grinder (Waring blender) after measure the needed quantities for the 1L of cow milk ice cream production. Then prepared ice cream powder was stored in an air-tight polythene bag.

After pasteurized One (1) litre of cow milk was heated up to 65°C temperature. Then prepared industrial ice cream powder was added to the one litre of cow milk and mixed by using a waring blender. The next step was stirring and cooling. Finally prepared Industrial ice cream mixture was added to an ice cream machine for the ice cream process.

2.1.2 Treatment B; without refrigerated modified kithul flour-based ice cream

Without refrigerated Modified Kithul flour base Ice cream was developed by using modified Kithul flour (prepared as per the above method) mixed with other ingredients (glucose, sugar, salt, vanilla powder). Then prepared ice cream powder was stored in an air-tight polythene bag.

Volume of One (1) litre of cow milk was pasteurized (heated) up to 65°C temperature. Then prepared modified Kithul flour base ice cream powder was added to the one Litre of cow milk and mixed by using the waring blender. The next step was stirring and cooling. Finally prepared modified Kithul flour base ice cream mixture was directly added to the ice cream machine for the ice cream process without refrigeration.

2.1.2.1 Modified Kithul flour preparation (pre-gelatinized modification)

Freshly prepared Kithul flour (Raw Kithul flour) samples were used for the modification. A 1:1 suspension (100 g Kithul flour for 100 ml deionized water) was incubated at 75°C for 5 minutes, Gelatinized flour was dried in a hot air dryer at 40°C till moisture level dropped from 10% to 15% [7,8,9].

2.1.3 Treatment C; Modified Kithul flour-based ice cream (24 hour refrigerated)

Prepared modified Kithul flour base ice cream powder with one-Litre cow milk mixture was kept for 24 hours in the refrigerator and it was added to the ice cream machine for the ice cream process [7,8,9].

2.2 Sensory Evaluation

The sensory evaluation of ice cream was done by 30 untrained /semi-trained panellists drawn from staff members and undergraduate students of the Faculty of Livestock Fisheries and Nutrition and Faculty of Agriculture and Plantation Management, the Wayamba University of Sri Lanka, using a seven-point scale (7 for “like extremely” down to 1 for “dislike extremely”) to score each attribute [10].

2.3 Proximate Composition Analysis

The treatments were tested for Moisture content, Ash content, Crude Protein (Kjeldhal method), Crude Fat (Gerber Method), Crude Fiber [11] and Carbohydrate content by calculation [11].

2.4 Physiochemical Analysis of the Ice Cream

2.4.1 Determination of pH of ice creams

The pH of ice cream samples (CIM and KIM) was determined through direct reading with a digital Benchtop pH meter (Model ST 3000, OHAUS, USA). It has been calibrated to pH 4.0 and 7.0 using the standard solution.

2.4.2 Melt down-rate of ice cream

The melt-down rate of ice cream determined by placing 100 g samples of CIM and KIM (without refrigerated). Samples were put on a wire-mesh screen at room temperature and measuring the rate of fluid accumulation beneath the screen (used funnel with 100 ml graduated measuring cylinder) [12]. As the ice cream melts, heat transfers from the warm air surrounding the product into the ice cream to melt the ice crystals. Initially, the ice melts at the exterior of the ice cream and there was a local cooling effect (in the vicinity of the melting ice). The water from the melting ice must diffuse into the viscous unfrozen serum phase and this diluted solution then flows downwards (due to gravity) through the structural elements (destabilized fat globules, air cells, and remaining ice crystals) to drip through the screen on which the ice cream rests. During melting, the flow of this diluted solution is initially over the exterior of the ice cream.

2.4.3 Overrun of ice cream

The overrun of ice cream samples was calculated by using the method given by Dervisoglu and Yazıcı, [12]. Overrun is usually defined as the volume of ice cream obtained more than the volume of the mix. It is usually expressed as “percent overrun”. The increased volume is composed mainly of air incorporated during the freezing process.

Method of calculation percent overrun

By volume % Overrun = [{(Volume of ice cream) – (Volume of mix)}/ Volume of mix] x 100 (1) [12]

2.5 Statistical Analysis

Results were analysed using one-way analysis of variance (ANOVA) at 0.05 probability level using MINITAB software package (version 17 for Windows).

3. RESULTS AND DISCUSSION

Because of ice cream being a complex colloidal system, there is need to consider many aspects during its processing regarding its anticipated taste, mouth feel, flavour and texture. Minor changes in any of the component of the ice cream may result in faults that can terminate the structure of ice cream. Besides, some components affect ice cream in several ways such as stabilizers which thickens the texture, increase whip ability, bind free water, reduce melting rate, help avoiding whey separation and uphold structure.

3.1 Sensory Evaluation

Typically stabilizers were given the functions as holders, binders, fillers or improvers due to its behaviour as hydrocolloids with specific functionality of persuading the fig and texture of the product. It was identified by previous scientists that stabilizers produce smooth texture and body of ice cream by preventing crystals and ice formation inconsiderable extent. Further they have reported that the texture smoothness and melting resistance of the ice cream are directly proportional to the viscosity increase.

Sensory tests were done to determine the preference of panellists for Treatment B without refrigerated modified Kithul flour base ice cream and 24 hours refrigerated modified Kithul flour base ice cream Treatment C with using industrial ice cream Treatment A as control Table 1.

Except for the control (industrial ice cream sample A), the colour of the new formulation was significantly less rank while sample A had the highest rank as 5.6. The highest score for the odour was achieved by sample B as 5.8 while sample C was higher than sample A.

Considering the odor of the three samples, Sample B and C were more acceptable compared to the control A. The result indicates that the odor was affected by Kithul flour.

Treatment A and Treatment C were the same and exhibit a score (5.5) for appearance while sample B showed a less score (5.4). Among sensory attributes, the flavour is one of the important characteristics of the product. The best score for flavour was obtained by Treatment B as (5.9). Treatment A and Treatment B displayed the same score (5.6) for creaminess and sample C was less than them.

The texture is one of the most important characteristics of the product to attract consumers. The texture of sample B without modified refrigerated Kithul flour base ice cream had the highest score (5.5) than sample A industrial ice cream (5.3). 24 hour refrigerated modified Kithul flour base ice cream occupied less texture as it had ice crystals in refrigerated Kithul flour base ice cream. The texture of Sample B without refrigerated modified Kithul flour was attracted by consumers due to not refrigerated Kithul flour base mixture.

Table 1. Sensory properties of different ice cream samples

Sensory Aspect	(A) Industrial ice cream	(B) Without refrigerated modified Kithul flour base ice cream	(C) 24 hrs refrigerated modified Kithul flour base ice cream
Color	5.6 ±2.05^{a}	5.5±1.05^{a}	5.5±0.15^{a}
Odor	5.6±1.15^{b}	5.8±2.05^{a}	5.7±2.19^{b}
Appearance	5.5±1.18^{a}	5.4±2.05^{a}	5.5±2.25^{a}
Flavor	5.4±2.05^{c}	5.9±2.05^{a}	5.8±2.05^{b}
Creaminess	5.6±1.08^{a}	5.6±2.05^{a}	5.4±1.05^{b}
Texture	5.3±1.14^{b}	5.5±2.05^{a}	5.2±0.05^{b}
Overall acceptability	5.7±2.05^{b}	5.8±0.05^{a}	5.7±1.19^{b}

Values are mean ± SD; n = 3. The values in a column, within a set, followed by same superscript letters are not statistically different at the significance level of 5%; Scale: 7-Like extremely to 1-Dislike extremely

When considering the sensory attributes, overall acceptability is the most important parameter to select the best sample. According to the overall sensory acceptability, the best consumer attracted sample was sample B without refrigerated modified Kithul flour base ice cream.

3.2 Proximate Composition of Tested Ice Cream Sample

When it comes to the proximate analysis of ice cream, the moisture, ash, fat, protein, fiber, and carbohydrate content were determined to analyze the proximate composition. According to the results obtained from statistical data, (Table 2) there was not any significant difference in protein content of Treatment A, industrial ice cream, and sample B, modified Kithul flour base ice cream. The fiber content of Treatment B modified Kithul flour base ice cream was higher than the sample A, industrial ice cream. There was no significant difference between moisture content and an ash content of Treatment B modified Kithul flour base ice cream compared to Treatment A industrial ice cream. Considering the fat content of the ice cream there were significant differences in Treatment B modified Kithul flour base ice cream. There was no visualized fat content in the modified Kithul flour base ice cream. Both sample A industrial ice cream and sample B modified Kithul flour base ice cream were made by using cow milk, but the milk fat content was also not reported in Treatment B modified Kithul flour base ice cream. It was clear, that there should be a considerable amount of fat in modified Kithul flour base ice cream also. But fat content was not identified in Gerber methods and the fat analyzer method. It may be happened due to the starch of the Kithul flour. There should be found a method to find out the fat content of the modified Kithul flour base ice cream.

3.3 pH of Tested Ice Cream Samples

The physicochemical properties of tested ice cream samples are illustrated (Table 3). Treatment B modified Kithul flour base ice cream was more or less similar to that of Treatment A industrial ice cream and they were within the recommended limits for ice cream of Sri Lankan standards. The pH of both ice cream were the same. Some researchers mentioned that the normal pH value of ice cream is about 6.2 – 6.3 [12,13,14]. Therefore, the pH value of Modified Kithul flour base ice cream is within the recommended range.

3.4 Overrun of Tested Ice Cream Samples

According to the results obtained from statistical data, (Table 3) the overrun of Treatment B modified Kithul flour base ice cream was higher than the overrun of Treatment A industrial ice cream. The incorporation of air is called overrun and contributes to the lightness or denseness of ice cream. Treatment B without refrigerated modified Kithul flour ice cream showed 41.53% overrun. Treatment A industrial ice cream showed a 38.46% overrun. The over the run of ice cream is affected by fat source and fat content. Both ice creams were made by using cow milk, as well as the major fat source is cow milk. The amount of air that should be incorporated depends upon the composition of the mix and the way it is processed and is regulated to give that percent overrun which gives proper body, texture, and palatability to the ice cream. Too much air will produce a snowy fluffy ice cream while too little air on the other hand will lead to soggy, heavy ice cream [10,15].

Table 2. Comparison of proximate composition of tested treatment a industrial ice cream and treatment B modified Kithul flour base ice cream

Proximate Analysis	Industrial ice cream %	Modified Kithul flour base ice cream %
Moisture	68.87 ±0.19^{b}	71.12 ±0.12^{a}
Ash	0.81 ±0.12^{a}	0.68±0.42^{a}
Protein	8.75 ±0.02^{a}	8.02 ±0.78^{a}
Fat	3.7±0.12^{a}	0.23±0.18^{b}
Fiber	1.83±0.82^{b}	2.37±0.12^{a}
Carbohydrate	16.05±0.12^{b}	17.58±0.85^{a}

Values are mean ± SD; n = 3. The values in a column, within a set, followed by same superscript letters are not statistically different at the significance level of 5%

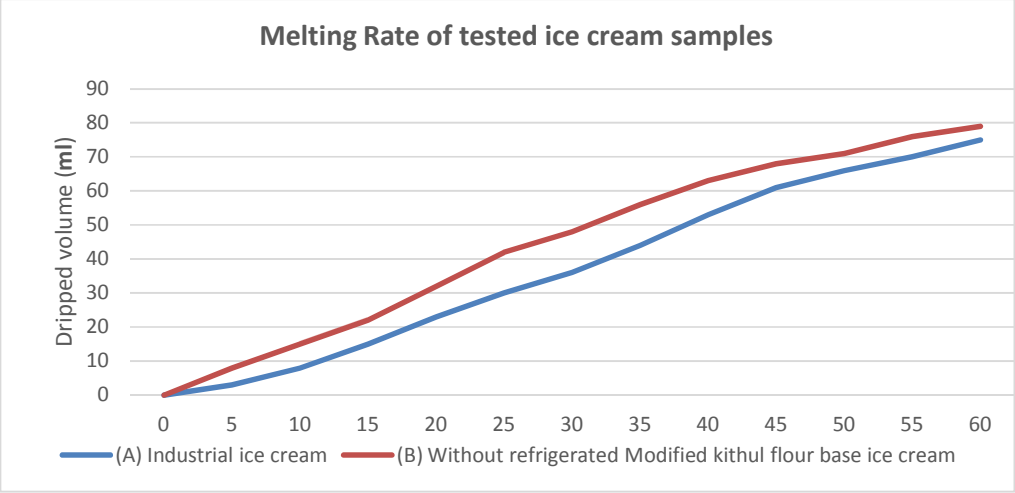

Fig. 1. The melting rate of sample A (industrial ice cream), and sample B (without refrigerated modified Kithul flour base ice cream)

Table 3. Comparison of physicochemical properties of sample B modified Kithul flour ice cream with sample a industrial ice cream

Physiochemical properties	Industrial ice cream Sample A	Without refrigerated modified Kithul flour base ice cream Sample B
pH	6.62 ±0.12[a]	6.62 ±0.82[a]
Over run %	38.46 ±0.18[b]	41.53 ±0.12[a]

Values are mean ± SD; n = 3. The values in a column, within a set, followed by same superscript letters are not statistically different at the significance level of 5%

3.5 Melting Rate of Tested Ice Cream Samples

From the meltdown curves (Fig. 1), it can be observed that the melting rate of without refrigerated modified Kithul flour base ice cream sample B was higher than that of Treatment A industrial ice cream. Low freezing point is the primary cause of rapid melting, and environmental conditions as well as ice creams contain a high amount of air or fat tend to melt slowly. Melting rates of two samples were observed in the same environmental condition within 5 minutes interval of one hour).

4. CONCLUSION

According to the present findings, it can be concluded that without refrigerated milk-modified Kithul flour mixture before making ice cream is a very successful healthy product, which has a good rating from the sensory evaluation. This product can target the health-conscious group in the society by replacing cremodan with modified Kithul flour as a natural plant-based stabilizer. Due to the low cost of production, this is a profitable product for the ice cream industry.

According to the results of the evaluation of quality attributes, without refrigerated milk-modified Kithul flour mixture before making ice cream is better than the industrial ice cream due to their low cost of production, high overrun, and high overall acceptability in sensory analysis.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/61989