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RESEARCH ARTICLE

Efficacy of Carrageenan as Emulsifier and Breadfruit Flour as Substitute Ingredient on Physicochemical, Microbial and Organoleptic Properties of Fermented Ice Cream

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Abstract

Breadfruit is a nutritious food but not widely utilized in industrial production. Carrageenan has excellent functionality on phase separation and cryoprotection. Ice cream is a delicious and nutritious frozen dairy product widely consumed. It is a complex microcrystalline network of liquid and solid phases. This study focused on the utilization of carrageenan as stabilizer and breadfruit flour as a substitute ingredient on physicochemical, microbial and organoleptic properties of fermented ice cream. Different supplementation ratio of carrageenan (0.5%, 1.0%, 1.5%, 2.0%, 2.5%) and breadfruit: milk (30%:, 70%; 40:60%, 50%:50%, 60%: 40%; 70%: 30%) were demonstrated. The fermentation process was conducted with *Lactobacillus* sp. starter culture (ratio 0.2%) at loading cell 10^9 cfu/ml at 37°C in 48 hours. Results revealed that carrageenan (2.0%), breadfruit: milk (60%: 40%) were ideal for production of fermented ice cream. From this investigation, consumers have more chance to consume one kind of functional ice cream from breadfruit starch.

Keywords: *Breadfruit, Carrageenan, ice cream, Lactobacillus, physicochemical, Microbial, Organoleptic, fermentation.*

Introduction

Ice cream is a frozen dairy dessert prepared from dairy ingredients, emulsifers, stabilizers and sweeteners [1].The ice cream is a frozen complex colloidal system which is composed of partially coalesced fat droplets, air cells, ice crystals and a continuous aqueous phase, wherein the polysaccharides, proteins, lactose and minerals are dispersed [2]. The main reason of utilizing stabilizers in dairy is to create homogeneity, uniformness, viscosity, shape persistence when melting; avoid whey separation; prevent ice and sugar crystallization. Carrageenan is a sulfated polysaccharide extracted from edible seaweeds [3].

Carrageenan is commonly utilized as emulsifier in ice cream manufacture to created smoothness in texture, reduce ice and lactose crystal accumulation during temperature fluctuation, support uniformity and retard melting. Carrageenan addition in ice cream mixes led to the reinforcement of shear thinning possibly caused by gelation phenomena [4].

It's popularly utilized in stabilizer mixtures to limit wheying off via interaction with milk protein. Carrageenan caused the viscosity increase therefore coarsening of air cells was retarded [5]. Breadfruit (*Artocarpus altilis*) is a seedless, starchy tropical fruit [6] it is a valuable food resource of carbohydrate with low fat, high caloric content with a moderate glycemic index and significant amount of vitamins and minerals [7, 8]. It also contained different phenolic compounds including flavonoids and flavones [9].

An increasing demand of healthier and therapeutic food has led to manufacture ice cream containing special components with recognized nutritional and physicochemical properties [10]. The utilization of starch-based source is popular in ice cream production. Starch inclusion in both full and low fat ice cream provides improved creaminess, enhanced mouth feel, and better freeze-thaw stability [11].

Fermentation of starch-based sources would enhanced the nutritional value of their sources by reducing the anti-nutritional factors [12]. Pupose of our study penetrated on the effectiveness of carrageenan as stabilizer and breadfruit flour as a substitute ingredient on physicochemical, microbial and organoleptic properties of fermented ice cream.

Material and Method

Material

Breadfruit powder, *Lactobacillus* sp. culture and carrageenan were the main ingredients in ice cream production. Breadfruit powder, lecithin, sucrose were obtained from Can Tho city, Vietnam. Carrageenan was purchased from Sigma. *Lactobacillus* sp. culture including two species (*Lactobacillus acidophilus, Lactobacillus plantarum*) was supplied from Pasteur institute. Chemical substances and reagents were all analytical grade supplied from Rainbow Trading Co. Ltd., Vietnam.

Researching Procedure

Breadfruit powder was mixed thoroughly with water (1:3, w/v) and boiled for 10 minutes for gelatination. The boiled mixture would be set ambient temperature (as mixture #1). Lecithin 0.1%, sucrose 12% and milk were mixed together and gently heated at 85^{o}C for 2 minutes as sterilization before adding carrageenan (0.5%, 1.0%, 1.5%, 2.0%, 2.5%) and cooling to 37^{o}C. This mixture was inoculated with *Lactobacillus* sp. starter culture (0.2%) at loading cell 10^{9} cfu/ml (as mixture #2).

Mixture #1 and mixture #2 were combined in different ratio (30%:, 70%; 40:60%, 50%:50%, 60%: 40%; 70%: 30%) to form the final batch. This batch was fermented at 37^{o}C for 48 hours and then kept in chiller for 2 hours at 4^{o}C as aging. Then the cured batch was frozen at -10^{o}C to create ice cream. The analysis was conducted to examined melting rate (%), texture firmness (N), total plate count (cfu/g) and sensory acceptance.

Antioxidant Capacity and Statistical Analysis

Melting rate (%) was measured by method described as Sofjan and Hartel [13].

Texture firmness (N) was estimated by texture analyzer. Total plate count (TPC, cfu/g) was enumerated by 3M-Petrifilm. Sensory acceptance was evaluated by a group of panelist using 9 point-Hedonic scale. The experiments were run in triplicate with three different lots of samples. Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Effect of Carrageenan Replacement to Physicochemical, Microbial and Sensory Characteristics of Fermented Ice Cream

Carrageenan strongly influenced the melting rate owing to their water holding capacity and improved micro viscosity (see Table 1). Moreover, thermal conductivity, melting onset, thermal fusion could affect the melting rate [14]. The lowest melting rate was noted by replacement of carrageenan (2.0%) representing a good melting resistance in ice cream. Firmness of ice cream also significantly decreased by addition of carrageenan related to cryo-protective role.

This finding was similar to result reported by Halim et al [15].Inclusion of κ-carrageenan in formulations decreased the values of instrumental hardness and improved the smoothness of ice cream [4]. It's applied in many stabilizer blends at levels of 0.01-0.02% to prevent phase separation through its interaction with milk protein [16].It has ability to manage recrystallization in the presence of milk proteins [17].

All samples had excellent score of organoleptic acceptance (6.03 to 7.25) that was increased with carrageenan supplementation in formulations. It could be explained via viscosity and smoothness. Casein gets precipitated by forming linkages with carrageenan. Ice cream containing carrageenan has smaller sized air cells owing to the improved shear force with enhanced viscosity causing the less entrapment of air in cells [5].

Fermented cassava ice cream with hydrocolloid addition showed the good quality in terms of its pH value, overrun, total plate count and overall acceptability [15].

Table 1: Effect of carrageenan replacement to physicochemical, microbial and sensory characteristics of fermented ice cream

Parameter		Carrageenan replacement ratio (%)				
	Control	0.5	1.0	1.5	2.0	2.5
Melting rate (%)	61.43±0.02^{a}	48.75±0.02^{b}	41.42±0.01^{c}	36.57±0.02^{d}	32.80±0.03^{e}	32.87±0.01^{e}
Firmness (N)	3.59±0.01^{a}	3.03±0.00^{b}	2.87±0.00^{bc}	2.52±0.02^{c}	2.19±0.02^{d}	3.18±0.02^{d}
TPC (10^{12} cfu/g)	1.35±0.00^{c}	2.04±0.01^{bc}	2.46±0.03^{b}	2.83±0.01^{ab}	3.11±0.00^{a}	3.15±0.00^{a}
Sensory score	4.74±0.03^{d}	6.03±0.02^{c}	6.75±0.01^{b}	6.94±0.03^{ab}	7.23±0.00^{a}	7.25±0.03^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Effect of Breadfruit Flour Replacement to Physicochemical, Microbial and Sensory Characteristics of Fermented Ice Cream

Starch-based supplementation created the binding of free water therefore flow rate get decreased, consistency coefficient and viscosity improved. Binding of water caused in less availability of its molecules; freezing point rised and melting point decreased [5]. Different starch-based sources were utilized to as supplementation in ice cream production such as rice flour [11], finger millet [18], tapioca starch [19], casava starch [2], yam [20]. In our research, the optimal breadfruit flour: milk was noted at 60%: 40%.

Table 2: Effect of breadfruit flour replacement to physicochemical, microbial and sensory characteristics of breadfruit ice cream

Parameter		Breadfruit flour %: Milk %				
	Control	30: 70	40:60	50:50	60:40	70:30
Melting rate (%)	32.80±0.03^{a}	28.75±0.00^{b}	24.82±0.00^{c}	21.46±0.03^{e}	20.53±0.03^{f}	22.79±0.02^{d}
Firmness (N)	2.19±0.02^{a}	2.08±0.01^{ab}	1.95±0.01^{b}	1.84±0.01^{bc}	1.51±0.02^{d}	1.79±0.01^{c}
TPC (10^{12} cfu/g)	3.11±0.00^{d}	4.73±0.03^{c}	5.74±0.02^{bc}	6.55±0.02^{b}	7.34±0.01^{a}	6.83±0.03^{ab}
Sensory score	7.23±0.00^{d}	7.94±0.00^{c}	8.03±0.03^{bc}	8.26±0.00^{b}	8.61±0.02^{a}	8.45±0.00^{ab}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%)

Conclusion

Ice cream is a dairy aerated dessert that is frozen prior to consumption. It contains air cells entrapped in liquid phase and various other ingredients. Supplementation of *Lactobacillus* sp. culture into breadfruit powder during lactic fermentation results in the breakdown of the complex components, accelerating the feasibility of the nutritional utilization, speeding up their bioavailability, releasing innovative active compounds through microbial metabolism. Breadfruit was identified as an ideal ingredient substitute for milk during the incorporation of edible ice cream.

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