Short Communication

ASSESSMENT OF PHYSICO-CHEMICAL AND RHEOLOGICAL PROPERTIES OF FUNCTIONAL ICE CREAM INFUSED WITH RED SEAWEED (*KAPPAPHYCUS ALVAREZII*) CONCENTRATE AS A STABILIZER

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ABSTRACT

Ice cream, a well-known frozen delicacy, is prone to fluctuations in both physical and sensory characteristics in spite of its complex composition. Many highly processed stabilizers and emulsifiers that are chemically purified and modified, individually or in combination, were used in food industries to develop a product with desired physical, chemical and textural stability. In this study, the viability of minimally processed hydrothermal extract of red seaweed (Kappaphycus alvarezii) was tested to replace sodium alginate in ice cream. The functional carrot flavoured ice cream stabilized by 0.4%w/w sodium alginate and 0.1%w/w glycerol monostearate was taken as control. The stabilizer was replaced by Red seaweed (Kappaphycus alvarezii) extract at concentration of 0.5% (S_1) and 1.0% w/v (S_2). The addition of red seaweed extract at 1.0% w/v (S_2) in ice cream increased the overrun from 46% to 57% (S_2) in the batch freezer and melting resistance was also notably decreased from 1.90 to 0.62 (S_2) g/min. Significance of the research was that minimally processed extracts of red seaweed (Kappaphycus alvarezii) are highly effective to replace processed stabilizer and emulsifiers used in food industries.

Key words: Ice cream, red seaweed, natural stabilizer and carrot juice

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INTRODUCTION

Formulation of typical ice cream includes lipids, proteins, hydrocolloids, carbohydrates, stabilizers, and emulsifiers in the formulation matrix. The formulations are frozen together with simultaneous mixing and aeration in a subsequent manufacturing step that creates the structure of the ice cream. The stabilizing emulsifiers, partially coalesced milk fat, ice crystals, air cells and matrix viscosity all contribute to the stability of this aerated structure. Ice cream's sensory quality depends on its physico-chemical features, such as overrun, air bubble size, and ice crystal morphology, which impact texture development (Caillet *et al.,* 2003). Ice cream is a highly structured food that incorporates air molecules in the suspended phase of partially frozen milk ingredients that affects optimum rheological properties

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(Dogan and Kayacier, 2007). Commercially available stabilizer/emulsifier food additives are highly processed through chemical and physical modifications used in the food industry (Marshall *et al.,* 2003). Alternative to this, in the last few years, microalgae were used globally as an additive in ice cream production to improve the physico-chemical properties and to modify the sensory characteristics and appearance of the ice cream (Durmaz *et al.,* 2020). *Kappaphycus alvarezii* is a notable seaweed used for production of carrageenan, which performs as a emulsifier, stabilizer and alters the rheological properties of the food (Irawan, 2021). Thus, the objective of the present research was to assess the physico-chemical properties of carrot flavoured ice cream infused with aqueous extract of Red seaweed (*Kappaphycus alvarezii*) to replace sodium alginate.

MATERIALS AND METHODS

Raw materials

Milk, butter and skim milk powder were obtained from the Aavin®. Juice was extracted from 300 g of Carrot (*Daucus carota*) devoid of any physical infestations using juice extractor. Sodium alginate was used in control ice cream at 0.5% (w/w).

Seaweed Extraction

Red seaweed (*K. alvarezii*) was washed with distilled water to remove epiphytes and immediately frozen at -18ºC till usage. Then, the seaweed was cabinet dried at a controlled condition of 40°C for 24 hrs. Dried red seaweed was grounded and sieved to form finest powder and vacuum sealed in polypropylene pouches. For extraction purpose, seaweed powder was mixed with potable water at the ratio of 1:1.5 and subjected to heating at 90°C for 50 minutes with continuous stirring and concentrated. The concentrate was packed in a 200 ml glass bottle and stored at refrigerated temperature.

Ice Cream Mix Preparation

The ice cream mix was formulated as per Table 1.The wet ingredients (milk, butter, and carrot juice) were weighed and heated to 60ºC and followed by mixing of dry ingredients (SMP, sugar and stabilizer). The mix was pasteurized by heating at 80ºC, holding for 20 minutes, and cooling to 70ºC, followed by addition of sodium alginate (0.4%) and Glycerol monostearate (0.1%) in control (S_0) and seaweed extract in treatments. The stabilizer was replaced by Red seaweed (*Kappaphycus alvarezii*) extract at concentration of 0.5% (S_1) and 1.0% w/v (S_2). The mix was homogenized in ultra turrax for 15 minutes and aged overnight at 4ºC. The mix was frozen in a batch freezer (capacity of 3 litres) and subsequently stored at -28ºC in the deep freezer.

Physico-chemical Analysis

Total Soluble Solids (TSS): Samples were dried for three hours at 105°C in a drying oven, until constant weight was reached. Measurements of samples before and after drying were calculated.

Titratable acidity (TA): Titratable acidity was determined as lactic acid percentage by titrating with 0.1 N NaOH, using phenolphthalein as an indicator.

pH Coefficient: A pH meter was used to analyze the pH of the prepared ice cream sample. The values for the samples were analyzed by inserting the meter's probe.

Rheological analysis

Melting Resistance: 30g sample was placed at top of the bottle using a Buchner funnel and left to melt for 15 minutes at 24 ± 1°C. The melted volume of ice cream was weighed.

Overrun: The overrun (OR) of ice cream was calculated based on the weight difference between fixed volumes of ice cream mix and frozen ice cream, using the following equation:

$$OR(\%) = mix(g) - ice\ cream(g)/ice\ cream(g) \times 100$$

Statistical analysis

Data were analysed using SPSS software as per the standard methods. Experimental trials were replicated thrice with duplicates for analysis of proximate parameters (n:3). Data obtained were subjected to analysis of variance (ANOVA) and F test for comparing means at 5% level ($p<0.05$) for significance (Kim, 2014).

RESULTS AND DISCUSSION

Physico-chemical properties

Main source of carrageen anused in food industries was processed Red seaweed *(K. alvarezii*) fractions. Aqueous concentrate of *K. alvarezii* was able to effectively replace the processed sodium alginate and glycerol monostearate at minimal concentration evidently from the present research. The result given in Table 2 implies that pH co-efficient was not significantly ($P\leq 0.05$) changed by addition of seaweed. The pH of infused ice cream was found to be 6.474±0.522, 6.817±0.824 and 6.869±0.449 for S_0, S_1 and S_2 respectively. Contradictive to the study, the pH of ice cream with κ-carrageenan processed from sauna-dried seaweed increased from 7.79 to 7.92, that had highest pH as reported by Irawan (2021).

Addition of stabilizers and emulsifiers greatly affects the pH and acidity of the ice cream mix. No appreciable difference in acidity was found. Similar study by Kot *et al.* (2023) stated that carrageenan and its hydrolysates had significantly improved the ice cream mix properties without affecting the acidity and pH of the product. No significant changes in TSS of the treatments were observed. These studies demonstrate *K. alvarezii* concentrate's potential to enhance ice cream quality through improved physico-chemical characteristics.

Rheological properties

Results from table 2, have shown the impact of addition of *K. alvarezii* concentrate on melting resistance and overrun of the functional ice cream. The melting resistance of the control ice cream was 1.90g/min, while it was found to be comparatively decreased to 0.62 and 0.63 in 0.5% and 1.0% added *K. alvarezii* concentrate. Same results were observed in icecream added with κ-carrageenan from sun-dried seaweed that had the fastest melting rate at 1.10 g/min, while sauna-dried seaweed resulted in a slower melt at 0.72 g/min (Irawan, 2021). The Overrun is an important property of are effective stabilizer to retain the texture and consistency. In such a way, the *K. alvarezii* aqueous concentrate had a highly significant effect of increasing the overrun of the ice cream from 46.34% to maximum of 57.25 in 1.0% (w/v) concentrate in the batch freezer. Hayta (2007) estimated that the normal ice cream overrun range was 60 to 90%, comparable to the results of the current work. The overrun increased with the rise in the proportion of soy and lupine milk.

CONCLUSION

The acceptance of seaweed in functional ice cream was investigated in this study, which helped to illuminate the possibility of this unusual culinary invention. The addition of red seaweed extract at 1.0% w/v (S_2) in ice cream increased the overrun from 46% to 57% (S_2) in the batch freezer and melting resistance was also notably decreased from 1.90 to 0.62 (S_2) g/min. Since ice cream is so widely enjoyed for its sensory qualities, it is a great way to introduce healthy ingredients like seaweed. The advantages of seaweed's functional property and bioactive components match consumer preferences for functional foods. The ice cream with seaweed infusions appear promising and help to develop a clean label ingredient.

Table 1. Formulation of ice cream preparation

Ingredients	Ice cream mix		
	Control	S_1	S_2
Milk (ml)	500	500	500
SMP (g)	50	50	50
Sugar (g)	100	100	100
Milk fat (g)	40	40	40
Sodium alginate (%)	0.4%	-	-
Glycerol monostearate (%)	0.1%		
Red Seaweed concentrate (%)	-	0.5	1.0
Carrot milk (%)	10	10	10
Vanilla essence (%)	2	2	2

S_1 – 0.5% of Red Seaweed concentrate; S_2 - 1% of Red Seaweed concentrate

Table 2. Physico-chemical analysis of ice cream with infused seaweed as an emulsifier

Physico-chemical properties	S_0	S_1	S_2	F-test
pH co-efficient	6.474±0.522	6.817±0.824	6.869±0.449	34.984NS
Titratable Acidity (%)	0.243±0.205	0. 414±0.433	0.477±0.876	4.499*
Total soluble solids (TSS) (%)	38±0.141	35±0.562	36±0.932	829.102 NS
Rheological properties				
Melting resistance (g/min)	1.90±0.654	0.63±0.654	0.62±0.232	58.302**
Over-run(%)	46.34±0.177	53.76±0.341	57.25±0.444	489.249**

NS- Non significant; * - significant; **- highly significant.
(Mean average of three trials)
S_0 – 0.4% of Sodium alginate + 0.1% glycerol monostreate; S_1 – 0.5% of Red Seaweed concentrate;
S^2 - 1% of Red Seaweed concentrate

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