

Use of Green Coconut Pulp as Cream, Milk, Stabilizer and Emulsifier Replacer in Germinated Brown Rice Ice Cream

Naruemon Prapasuwannakul, Supitcha Boonchai, Nawapat Pengpengpit

Abstract—The aim of this study was to determine physicochemical and sensory properties of germinated brown rice ice cream as affected by replacement of cream, milk, stabilizer, and emulsifier with green coconut pulp. Five different formulations of ice cream were performed. Regular formulation of ice cream consisted of GBR juice, milk cream, milk powder, stabilizer, emulsifier, sucrose and salt. Replacing of cream, milk, stabilizer, and emulsifier with coconut pulp resulted in an increase in viscosity and overrun, but a decrease in hardness, melting rate, lightness (L*) and redness (a*). However, there was no significant difference among all formulations on any sensory attributes. The results also showed that the ice cream with replacement of coconut pulp contained less fat and protein than those of the regular ice cream. The findings suggested that green coconut pulp can be used as alternative ingredient to replace fat, milk stabilizer and emulsifier even in a high carbohydrate ice cream formulation.

Keywords—Ice cream, germinated brown rice, coconut pulp, milk, cream.

I. INTRODUCTION

PEOPLE are now more cautious about their diets. There is a global trend towards increased consumption of healthy and functional foods. As a result, there is a great demand for natural organic and reduced fat products. Germinated brown rice (GBR) is currently considered to be a popular health food due to its high nutritional components such as vitamins, minerals, dietary fibers, and essential amino acids and also its bioactive components such as ferulic acid, γ -oryzanol, tocotrienols, and gamma aminobutyric acid (GABA) developed during germination [1]. Previous studies reported that germinated brown rice showed many beneficial effects including antihyperlipidemia, antihypertension, and reduction in the risk of some chronic diseases, such as cancer, diabetes, cardiovascular disease, and Alzheimer's disease [2].

Ice cream is a frozen dessert usually made from dairy products such as milk and cream. The structure of ice cream has been identified as a three components foam made up of a network of fat globule and ice crystals dispersed in a high viscosity aqueous phase [3]. Disruption or absence of fat globule network could impact the texture of ice cream. Other factors including stabilizer and emulsifier also contribute impact on ice cream texture. It has been shown that stabilizer

promote viscosity development and control ice crystal growth [4], [5]. The physical structure of ice cream affects not only melting behavior but also hardness though the mechanism has not been revealed [6].

Green coconut pulp or endosperm of very early maturation stage has been used to replace fat, milk, stabilizer and emulsifier in chocolate ice cream with 93% of sensory approval by panelists. Moreover, it has been revealed that green coconut pulp has foaming and emulsifying capacities that can be used for production of ice cream, even at low pH value [7]. Therefore, the aim of this study was to evaluate the possibility to use green coconut pulp as alternative ingredient in substitution of cream, milk, stabilizer and emulsifier in a high carbohydrate ice cream system in order to produce free milk, low fat, no lactose, and no cholesterol germinated brown rice ice cream.

II. MATERIALS AND METHOD

A. Materials

Germinated glutinous brown rice, produced from Ubolratchathani province, was bought from local supermarket. Green coconuts (*Cocos nucifera* L.), cultivated and collected from Samutsongkram province, were used in this experiment. Sterilised milk cream (25% fat) and skim milk powder (36% protein) were essential fat and milk solids in making ice cream. Carboxy methyl cellulose (Pre gel, Italy) and glycerol monostearate were used as stabilizer and emulsifier in this study.

B. Preparation of Germinated Brown Rice Juice and Green Coconut Pulp

Germinated glutinous brown rice was cleaned and grounded with water as 1:3 ratio. Then it was filtered through stainless sieve and pasturized at 90°C for 10 minutes. The GBR juice was freshly prepared on the day of ice cream produced. Green coconut fruit was cut, and the endocarp or coconut flesh was removed and kept at -18°C prior to use. For ice cream producing, coconut flesh was homogenated with GBR juice.

C. Substitution of Milk Cream, Milk Powder, Emulsifier and Stabilizer with Green Coconut Pulp in Ice Cream Process

Five formulations of ice cream were performed. Ice creams were prepared with 50% GBR juice, 13% sucrose, 7.5% milk cream, 29% skim milk powder, 0.2% stabilizer, 0.2% emulsifier, and 0.1 % salt. Green coconut pulp was substituted cream, skim milk powder, emulsifier and stabilizer in the

Prapasuwannakul N., Boonchai S. and Pengpengpit N. are with the Faculty of Science and Technology, Suan Sunandha Rajabhat University, 1 U-Tong Nork Road, Dusit, Bangkok 10300, Thailand (e-mail: naruemon.pr@ssru.ac.th, supitcha.bo@ssru.ac.th, nawapat.pe@ssru.ac.th).

formula as shown in Table I. Formulation 1 was the control formula that contained all original ingredients. Other formulations (formulation 2-5), cream and milk powder were totally replaced with green coconut pulp. However, emulsifier, stabilizer, and both emulsifier and stabilizer were not added in formulation 3, 4 and 5 respectively. Liquid ingredients were stirred and heated to 45-50 °C, then the dry ingredients were added. The mixture was pasteurized at 85°C for 5 minutes and homogenized with the blender at maximum speed for 2 minutes. Then it was cooled down and aged at 4 °C for 24 hours and was frozen in an ice cream maker, Nemox Model Gelato Pro 2500, for 15 minutes. The product was further hardened at -20°C in a plastic container. Physicochemical and sensory analyses of ice cream were performed to study the effect of cream, milk, emulsifier and stabilizer replacement with green coconut pulp.

TABLE I
FORMULATIONS OF ICE CREAM SAMPLES WITH GREEN COCONUT PULP
SUBSTITUTION

Ingredient	Formulation				
	1	2	3	4	5
GBR juice	50	50	50	50	50
Cream	7.5	-	-	-	-
Milk powder	29	-	-	-	-
Coconut pulp	-	36.5	36.5	36.5	36.5
Stabilizer	0.2	0.2	0.2	-	-
Emulsifier	0.2	0.2	-	0.2	-
Sucrose	13	13	13	13	13
Salt	0.1	0.1	0.1	0.1	0.1

D. Sensory Analyses

Sensory evaluation was conducted by 30 untrained taste panelists. The samples were evaluated for color, aroma, flavor, sweetness, smoothness, melting and total acceptability based on 9-point hedonic scale (1=extremely dislike and 9=extremely like). Analysis of variance (ANOVA) was used to determine the statistical difference of the sensory data with a significant level of 95% ($\alpha=0.05$).

E. Physical Analyses

The overrun of ice cream sample was determined using the following formula [8].

$$\text{overrun} = \frac{w_1 - w_2}{w_2} \times 100$$

where W_1 = weight of unit mix; W_2 = weight of same volume of ice cream.

Hardness measurement was obtained at 25°C using a texture analyzer (TAPlus, Lloyd Ltd.,UK) equipped with a 10-mm stainless steel cylinder probe. The penetration speed was 2.0mm/s to a distance of 20mm.

Viscosity of ice cream mix after aging was measured using a viscometer (Brookfield viscometer, Model LVDV-II+, USA) (DV II, Brookfield, USA) equipped with spindle number 1 at 70 rpm.

Color measurements (L^* a^* b^*) of ice cream mix was determined using Spectrophotometer (Color Quest XE, Hunter Lab, USA).

Melting rate of ice cream samples was determined according to Rosalina et al [9]. Ice cream samples (30g, -20°C) were placed on a mesh attached to a cylinder and maintained under controlled temperature at 25°C. The dripped volume was recorded every 10 minutes until all ice cream was melted down to determine the melting rate.

F. Proximate Composition

Green coconut pulp was determined for moisture, ash, protein and lipid contents according to AOAC methods [10]. The carbohydrate content was calculated by the difference. The product with substitution of green coconut pulp and the original true ice cream were determined for protein and lipid contents according to AOAC methods.

III. RESULTS AND DISCUSSION

A. Proximate Composition of Green Coconut Pulp

Proximate composition of green coconut pulp is presented in Table III. Carbohydrate was the major component of the dry pulp. The composition of the pulp in this study varied from that used in chocolate ice cream [11] and ice cream of acid fruit but agreed to other previous study [7]. This variation may be due to composition changes during maturation [12]. The higher content of protein, lipid and ash of the pulp in this study indicated that the coconuts in this work were more mature than those used in chocolate ice cream and high acid ice cream.

TABLE II
PROXIMATE COMPOSITION OF GREEN COCONUT PULP

Composition	Content in wet basis (%)	
	Content in wet basis (%)	Content in dry Basis (%)
Water	89.0	-
Protein	1.40	12.73
Lipid	2.65	24.09
Ash	0.58	5.27
Carbohydrate	6.37	57.30

B. Effect of Milk Cream, Milk Powder, Emulsifier and Stabilizer Replacement with Green Coconut Pulp on Ice Cream Properties

Physical properties of different ice cream formulations are shown in Table III. Viscosity of all ice cream samples with coconut pulp substituted (formula 2-5) were much higher than that of the regular formula (formula 1), and the viscosity of sample formula 2 was highest among all formulations. The high increasing viscosity of these samples might be caused by the high content of carbohydrate in the pulp. This result agreed with the previous work reporting that modified starch could promote viscosity development in the aqueous phase [3]. The high viscosity of the samples allowed low air incorporation in the mixes and led to low overrun. The sample formula 5, which stabilizer and emulsifier were not included, had the highest overrun among all formulations. This result might suggest that coconut pulp alone could provide good foaming capability for

ice cream manufacturing. The hardness of all ice cream samples with coconut pulp substituted excluding formula 5 were greater than that of the regular formula. The increasing of hardness might due to more ice crystals produced from water in the pulp (83%). This result agreed to the work indicating that the presence of ice crystals was responsible for the detection of firmness [3]. However, ice cream sample formulation 5 was as soft as the real ice cream. This result might indicate that both emulsifier and stabilizer should be excluded when coconut pulp was applied since coconut pulp itself also had foaming and emulsifying capabilities [7].

TABLE III
PHYSICAL PROPERTIES OF ICE CREAM WITH GREEN COCONUT PULP SUBSTITUTION

Physical properties	Formulation				
	1	2	3	4	5
Viscosity (cp)	192.0 ^e	3141.0 ^a	2477.5 ^b	2378.5 ^c	1318.0 ^b
Overrun (%)	16.33 ^b	10.63 ^c	14.22 ^c	12.83 ^d	26.56 ^a
Hardness (N)	6.94 ^{bc}	22.89 ^a	9.64 ^b	20.25 ^a	5.09 ^c
L*	73.97 ^a	67.81 ^b	64.32 ^c	64.30 ^c	58.35 ^c
a*	5.15 ^a	3.24 ^b	2.61 ^c	2.44 ^d	2.43 ^d
b*	4.12 ^d	4.37 ^c	4.47 ^b	4.37 ^c	4.86 ^a

L* = lightness (0-100) a* = redness b* = yellowness

Means with different letters in the same row indicate significant differences (p<0.05)

The melting behavior of different ice cream formulations is presented in Fig. 1. The half life time of melt down was 28, 52, 40, 40, and 50 minute for sample formulation 1, 2, 3, 4 and 5 respectively. The regular formula showed the highest melt down rate while formula 2 showed the slowest melt down rate. The decreasing of melt down rate might due to many factors such as high viscosity, high hardness and low overrun. Small significant difference was observed between formula 2 and 5.

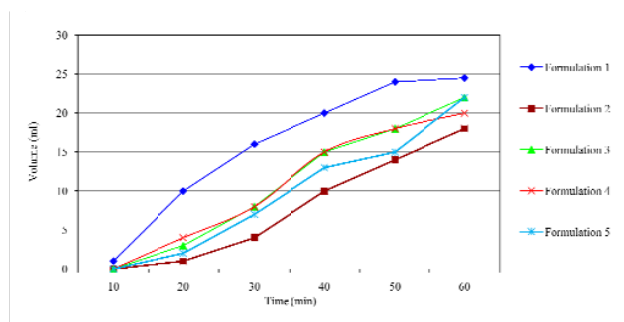


Fig. 1 Melting curves for ice cream with different formulations

The pulp decreased lightness (L*) and redness (a*) of the ice cream samples since coconut pulp itself had darker color than that of cream and milk.

Table IV represents the sensory 9 point hedonic score test on total acceptability of 5 different ice cream formulation. It was found that there was no significant difference among all formulations in all sensory attributes. Moreover, the formulation which milk fat, milk, emulsifier and stabilizer

were replaced with coconut pulp showed the same level of acceptability as the true regular ice cream.

TABLE IV
SENSORY ATTRIBUTES OF ICE CREAM WITH GREEN COCONUT PULP SUBSTITUTION

Sensory attributes	Formulation				
	1	2	3	4	5
Color ^{ns}	6.76	7.40	7.35	7.16	7.30
Aroma ^{ns}	6.43	6.96	6.70	6.60	6.83
Flavor ^{ns}	6.50	6.90	6.60	6.70	6.70
Sweetness ^{ns}	6.96	6.40	6.20	6.60	6.63
Smoothness ^{ns}	6.80	6.73	7.00	6.83	7.16
Melting ^{ns}	6.96	6.83	7.13	6.63	6.96
Total acceptability ^{ns}	7.40	6.96	7.10	6.93	7.36

ns indicates no significant differences (p<0.05)

Protein and lipid content of the regular ice cream sample and ice cream substituted with coconut pulp is shown in Table V. The ice cream sample, which milk fat, milk, emulsifier and stabilizer were replaced, contained less fat and protein than those of regular formula because of low protein and lipid content in the pulp. Therefore, the ice cream which coconut pulp substituted is good for health due to its low fat content, no cholesterol, lactose, and chemicals free.

TABLE V
PROTEIN AND LIPID CONTENT OF REGULAR ICE CREAM AND COCONUT PULP SUBSTITUTED ICE CREAM

Composition	Content in wet basis (%)	
	regular ice cream	Coconut pulp substituted ice cream
Protein	10.44	0.80
Lipid	2.65	2.01

IV. CONCLUSION

Green coconut pulp in this study contains 89% moisture, 1.4% protein, 2.65% lipid, 0.58% ash, and 6.37% carbohydrate. The composition of coconut pulp, with protein, lipid and carbohydrate, made it possible to be used as an alternative ingredient to substitute fat, milk, emulsifier and stabilizer in an ice cream system containing high starch in order to produce healthy ice cream which contains low fat, no lactose, and no cholesterol.

Despite the significant difference in physical properties, there is no significant difference for sensory properties between the true regular formula and the pulp substituted formulas.

ACKNOWLEDGMENT

The financial support was provided by the Research and Development Institute, Suan Sunandha Rajabhat University.

REFERENCES

- [1] K. Ohtsubo, K. Suzuki, Y. Yasui, and T. Kasumi "Bio-functional components in the processed pregerminated brown rice by a twin screw extruder," *J. Food Composition and Analysis*, vol.18, pp.303-316, 2005.
- [2] F. Wu, N. Yang, A. Tourne, Z. Jin, and X. Zu, "Germinated brown rice and its role in human health," *Critical Rev Food Sci Nutr*, vol. 53, pp. 451-463, 2010.

- [3] D. B. Aime, S. D. Arntfield, L. J. Malcomson, and D. Ryland, "Textural analysis of fat reduced vanilla ice cream products" *Food Research International*, vol. 34, pp.237-246, 2001.
- [4] R. Jimenez, N. Klipfel, and J. Tobias, "Ice Cream and Frozen Desserts," In Y. H. Hui, *Dairy Science and Technology Handbook, volume 2: product manufacturing*. (pp. 57-157), New York: VCH Publishers Inc. 1993.
- [5] D. W. Stanley, H. D. Goff, and A. K. Smith, "Textural-structure relationship in foamed dairy emulsions," *Food Research International*., vol. 29, pp.1-13, 1996.
- [6] M. R. Muse and R. Hartel, "Feasibility Ice cream structural elements that affect melting rate and hardness," *J. of Dairy Science*,vol.12,1-10, 2004.
- [7] I. A. Santana, E. P. Ribeiro, and A. M. Iguti, "Evaluation of green coconut (*Cocos nucifera* L.) pulp for use as milk, fat and emulsifier replacer in ice cream," *Procedia Food Science in 11th International Congress on Engineering and Food (ICEF11)*, pp. 1447-1453 , 2011.
- [8] R. T. Marshall and W. S. Arbuckle, "Ice cream," 5th ed, New York: Chapman & Hall, 222 p.
- [9] P. S. Rosalina and W. H. Ricard, "Effect of overrun on structural and Physical Characteristics of Ice Cream," *In Dairy Journal*, vol.14, pp.255-262, 2004.
- [10] Official methods of analysis, *The Association of Official Analytical Chemists (AOAC)*, ed. 18th. 2005.
- [11] A. M. Iguti, C. I. Pereira, L. Fabiano, A. F.Regina, and E. P. Ribeiro, "Substitution of ingredients by green coconut (*Cocos nucifera* L.) pulp in ice cream formulation," *Procedia Food Science in 11th International Congress on Engineering and Food (ICEF11)*, pp. 1610-1617 , 2011.
- [12] Z. N. Sierra and C.F. Balleza, "Proximate Analysis of the coconut endosperm at progressive stage of development," *National Institute of Science and technology, Annual report 1971-1972:3, apud Carandang E.V., Health benefits of virgin coconut oil explained*, v.31 n1, 2006.