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The effect of partial replacement of non-fat dry milk with sodium caseinate on qualities of yogurt ice cream from coconut milk

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Abstract: Qualities of yogurt ice cream from coconut milk as affected by partial replacement of non-fat dry milk (NFDM) with sodium caseinate (SC) at a ratio of 15:0, 14:1, 13:2 and 12:3 were investigated. The sample which replaced NFDM by 1% (w/w) SC contained the highest viable yogurt bacteria counts and lactic acid content. Overrun of the yogurt ice creams decreased with increasing levels of SC replacement. The partial replacement of NFDM by SC could improve physical properties of yogurt ice cream from coconut milk. The results indicated that melting rate of the yogurt ice creams decreased and hardness increased with increasing the SC replacement. Moreover, data from sensory evaluations showed that body and texture, flavor and taste of the samples significantly increased with increasing SC concentration ($p<0.05$). However, the total scores of the samples as replacement of NFDM by 1%, 2% and 3% (w/w) SC were not significantly different ($p\geq0.05$) but higher than the sample without SC. Thus, the level of replaceable of NFDM by SC at 1% (w/w) was suggested for yogurt ice cream making from coconut milk.

Keywords: Sodium caseinate, yogurt ice cream, non-fat dry milk, coconut milk

Introduction

Coconut milk is milky white oil in water emulsion extracted from the grating of coconut with or without addition of water (Chiewchan *et al*., 2006). It is an extremely important ingredient for many traditional foods of Asian and Pacific regions (Simuang *et al*., 2004). The previous works had developed yogurt from coconut milk and found that the average score of the coconut milk yogurt in term of texture was higher than cow milk yogurt. The coconut milk yogurt was able to store in a 4 – 10°C at least 14 days without syneresis. Its consistency remained thick and smooth (Siripanporn *et al*., 2000).

Ice cream is a popular product of cow milk. The cow milk or NFDM is the major ingredient, which the latter contains lactose about 15 – 17% (w/w) of total dry matter of ice cream (Guner *et al*., 2007). Many consumers suffered lactose intolerance mistakenly believe that they have to avoid all dairy products (Bannan and Levitt, 1996). The conversion of milk to yogurt should make it possible for these groups to consume appreciable quantities of milk with minimal symptoms of lactose intolerance. During fermentation, lactose is reduced in approximately 30% (Chandan and Shahani, 1993; Tamime and Robinson, 2007). Also, yogurt is generally recognized that an optimum "balance" in microbial population in the digestive tract is associated with good nutrition and health (Rybka and Kailasapathy, 1995; Tamine and Robinson, 2007).

Frozen yogurt is prepared by freezing a pasteurized mix containing milk fat, NFDM, sweetener, stabilizers and yogurt. Previous works have focused on yogurt ice cream made only from animal's milk. Martinou-Voulasiki and Zerfiridis (1990) studied the effect of some stabilizers on textured and sensory characteristics of yogurt ice cream from sheep milk. Guner *et al*. (2007) studied the production of yogurt ice cream from cow milk at different acidity. Several workers have investigated yogurt ice cream from animal's milk, but no work has been done on coconut milk yogurt ice cream. Therefore, the aim of the present study was to determine the effect of partial replacement NFDM with sodium caseinate (SC) on yogurt ice cream from coconut milk. Because of the protein types of coconut milk and cow milk were different, there is a need to add NFDM as a nutrient for lactic acid bacteria, leading eventually to yogurt ice cream making from coconut milk. In addition, SC stimulated the growth of lactic acid bacteria (Supavititpatana, 2007). The information obtained from the study could be used to develop healthy product, as a value added coconut milk product.

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Materials and Methods

Coconut milk preparation

Fresh coconut milk without added water was purchased from local market, Phitsanulok province, Thailand. The coconut milk was filtered through a clean muslin cloth to remove hull particles. The coconut milk was kept at 5°C until use.

Starter cultures

Commercial freeze-dried mixed yogurt culture (Code FD-DVS YC-380-Yo-Flex Chr.Hansen, Denmark) composed of *Streptococcus salivarius* subsp. *thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. The 0.03% (w/v) freeze-dried cultures were inoculated to sterile milk medium, which contained 12% (w/v) NFDM (DEMLAC 8000, Lacfalis Ingredients, France). The inoculum was incubated at 37°C for 18 h and kept at 5°C until use (Akin *et al*., 2007; Supavititpatana *et al*., 2008).

Production of yogurt ice cream from coconut milk

Distilled water was added to the coconut milk in a ratio of 1:3, coconut milk to distilled water. The dry matter content in the milk was adjusted by adding NFDM, SC (BBA, France) and sugar (Mitpol, Thailand). Yogurt ice cream from coconut milk was formulated with the following composition (percentage by weight) for a total batch of 10 kg

coconut milk added distilled water in a ratio of 1:3	73% (w/w)
NFDM:SC (15:0, 14:1, 13:2, 12:3)	15% (w/w)
sugar	10% (w/w)
starter cultures	2% (w/w)

All ingredients were divided into 2 portions. The first portion, coconut milk contained 75% (w/w) distilled water, 50% (w/w) sugar and 50% (w/w) of the mixture of NFDM with SC of the total ice cream mix. The ingredients were mixed by blender (Moulinex, Spain) at the highest speed for 5 min. The mixture was heated at 85°C for 30 min then cooled down to 40°C. Consequently, 2% (w/w) of starter cultures were inoculated. The inoculum was incubated at 40°C until pH 4.4 – 4.6 was reached. The fermented milk was kept at 4°C for 24 h. The second portion, the ice cream ingredients were heated at 85°C for 30 min. Then, the mixture was cooled to 4°C and kept overnight. After that both portions were mixed with blender at the highest speed for 5 min. The freezing of the ice cream mix was carried out in ice cream maker (MUSSO L3, Italy) for 40 min. The frozen ice cream in plastic cups (100 and 180 mL in volume) was transferred to a freezer at -18°C for hardening and storage. The experiments of the ice cream production were done in triplicate at different times.

Microbiological determination

For viable numbers of starter culture in the products, *S. thermophilus* was enumerated using M17 agar acidified to pH 6.8 with 1 M HCL (IDF, 1997), and subsequently incubated at 37±1°C for 48 h under aerobic condition. The number of *L. delbrueckii* subsp. *bulgaricus* was determined using MRS agar acidified to pH 5.4 with 100% glacial acetic acid then incubated to 37±1°C for 72 h under anaerobic condition (IDF, 1997).

Acidity

Titratable acidity as % lactic acid of the yogurt ice cream from coconut milk was measured according to AOAC methods No. 947.05 (AOAC, 2000).

Overrun

The overrun measurement was taken per sample by comparing the weight of ice cream mix and ice cream in a fixed volume container (Muse and Hartel, 2004). Overrun was calculated as follows.

$$\text{Overrun (\%)} = [(\text{weight of mix} - \text{weight of ice cream}) / \text{weight of ice cream}] \times 100$$

Melting

Ice cream samples (100 g) were removed from the containers, put on a wire screen with 2 mm openings supported by a funnel on a ring stand with a 100 mL graduated cylinder underneath. The sample and test assembly were placed immediately in a thermostatically controlled incubator at 25°C, and the volume of serum collected was measured for a period of 30 min, when total volume of serum and serum weight were recorded (Cody *et al*., 2007; Lee and White, 1991). Melting rate was calculated as follows.

$$\text{Melting (\%)} = (\text{weight of serum} / \text{weight of ice cream}) \times 100$$

Instrumental hardness

Hardness of yogurt ice cream was conducted using a Texture Analyser (TAXT2, Stable Microsystems Ltd., UK). The yogurt ice cream was collected directly into 180 ml plastic cups and carefully leveled to avoid compaction. The conditions for analysis were as follows: a 6-mm diameter cylinder probe (P/6), set up to record the force used to penetrate the sample to a depth of 25 mm at a speed of 1 mm/s (modified from Soukoulis *et al*., 2008). Hardness (N) of the samples was determined as the peak compression force during penetration.

Sensory evaluation

The samples were organoleptically assessed by twenty panelists, using a sensory rating scale of 1-10 for flavor and taste, and 1-5 for consistency and 1-5 for colour and appearance, as described by Akin *et al*. (2007). The properties evaluated included: (a) three terms describing colour and appearance (no criticism: 5, dull colour: 4-1, unnatural colour: 3-1), (b) seven characteristics and body and texture (no criticism: 5, crumbly: 4-2, coarse: 4-1, weak: 4-1, gummy: 4-1, fluffy: 3-1, sandy: 2-1) and (c) seven attributes for flavor and taste (no criticism: 10, cooked flavor: 9-7, lack of sweetness and too sweet: 9-7, lack of flavor: 9-6, yogurt/ probiotic flavor: 8-6, rancid and oxidized: 6-1, and other: 5-1).

Statistical analysis

Microbiological, acidity, overrun, melting and hardness data were determined for an Analysis of Variance using a Completely Randomized Design (CRD). If the F value from the Analysis of Variance was significant, Least Significant Difference (LSD) was used to determine the differences between the treatment means.

The collected data from the sensory evaluation were analyzed by an Analysis of Variance using a Randomized Complete Block Design (RCBD). If the F value from the Analysis of Variance was significant, the means were separated with LSD.

Results and Discussion

Microbiological count

The numbers of viable yogurt bacteria in the yogurt ice cream from coconut milk were found to be in the range of 7.73-7.94 and 7.89-8.65 log CFU/g for *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus*, respectively, for various types and levels of milk protein (Figure 1). Akin *et al*. (2007) reported close range of these cultures in probiotic ice cream. The numbers of starter cultures increased as NFDM level increased ($p<0.05$) due to the possible effective of lactose in NFDM (Tamine and Robinson, 2007). However, the highest viable bacteria numbers were in the samples with 14% NFDM and 1% SC. This could be explained by the synergist of amino acid from SC and nutrients from NFDM which increases the growth of *S. thermophilus* (Oliveira *et al*., 2001; Shihata and Shah, 2000; Cheng *et al*., 1990; Karleskind *et al*., 1991), leading to enhance the levels of formic acid and CO_2, due to the increase number of *L. delbrueckii* ssp. *bulgaricus*. However, the number of lactic acid bacteria of the yogurt ice cream added SC more than 1% was reduced. For the reasons might be due to the rigid structure of the ice cream, led to delay in the microorganism growth.

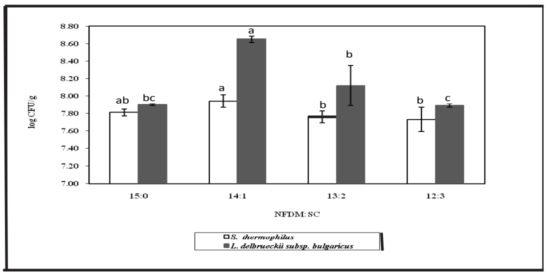

Figure 1. Number of viable yogurt bacteria in the yogurt ice cream from coconut milk added SC as replacement of NFDM. Bars with different superscript were significantly difference ($p<0.05$)

Acidity

The effects of type and concentration of milk proteins on acidity showed a similar trend as observed in the numbers of starter culture. Figure 2 shows an increase in the concentration of NFDM, significantly increased product acidity ($p<0.05$) although at NFDM concentrations of 14% and 15% (w/w), the acidities were similar. These results agree with those of Supavititpatana (2007) who reported that the acidity of a corn milk yogurt increased with increased levels of NFDM. However, the addition of more than 1% (w/w) SC resulted in the decrease of lactic acid content. It might be affected by the delayed growth of starter cultures in the samples.

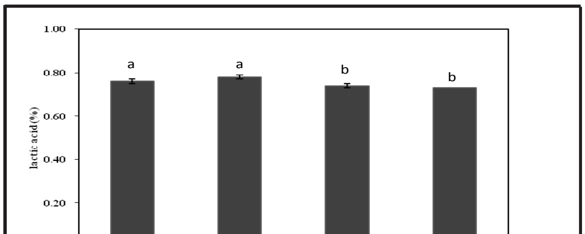

Figure 2. Total acidities of the yogurt ice cream from coconut milk added SC as replacement of NFDM. Bars with different superscript were significantly difference ($p<0.05$)

Overrun and melting

The percentage of overrun among samples differed significantly ($p<0.05$). Overrun ranged widely from7.06 to 91.19%. Our results indicated that the increased additions of SC to yogurt ice cream mixes decreased the overrun and melting (Figure 3). The results for melting characteristics suggest that SC may act as an emulsifier due to its one end of the molecules consists mostly of hydrophilic amino acids (such as serine and glutamic acid) whereas the other consists mostly of hydrophobic ones (for example, leucine, valine and phenylalanine). Moreover, the SC can stabilize water-continuous emulsions because it is surface active (Clarke, 2004). The results due to the water molecules become immobilized and unable to move freely among other molecules of the mix. The ice-cream melting process may also be described in relation to the freedom of movement of molecules (Akin *et al*., 2007).

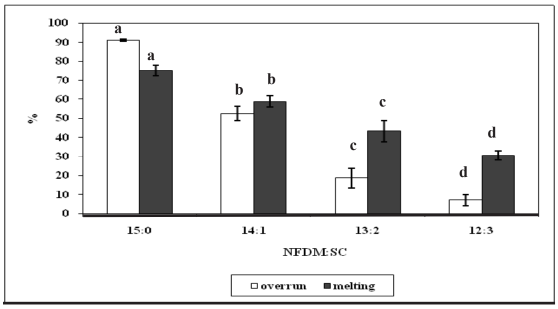

Figure 3. Overrun and melting rate of the yogurt ice cream from coconut milk added SC as replacement of NFDM. Bars with different superscript were significantly difference ($p<0.05$)

Hardness

Figure 4 shows the effect of milk protein on hardness of the yogurt ice cream and the higher concentration of SC was observed to be considerably harder than that of the low concentration. This might be due to the reason that SC acted as emulsifier and increased interaction force between different molecules. Therefore the networks of ice cream were stronger. The hardness and overrun results were oppositely tended. These results confirmed those of Sofjan and Hartel (2004) where increased overrun caused a decrease in hardness of ice cream.

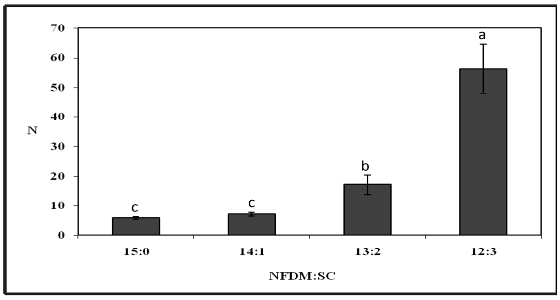

Figure 4. Hardness of the yogurt ice cream from coconut milk added SC as replacement of NFDM. Bars with different superscript were significantly difference ($p<0.05$)

Sensory evaluation

The sensory scores of the samples are demonstrated in Table 1. The points allocated for colour, body-texture and taste showed the effects of milk protein concentration. Colour and appearance scores were lower with addition of SC ($p<0.05$) implied that the samples which increasing of SC addition were also increase the dull in colour. The body and texture scores of the samples significantly increased with increasing SC concentration ($p<0.05$) due to the increase of gummy texture. The instrumental analysis of hardness (Figure 4) supported the findings of the sensory panel that the higher replacement of SC, the more acceptance in the term of body and texture. For flavor and taste scores, the data showed that the samples which increasing of SC addition, increased the yogurt/ probiotic flavor and reduced sweetness. However, the total scores of the samples added 1%, 2% and 3% (w/w) SC were not significantly different ($p\geq0.05$) and higher than that without SC.

Table 1. Organoleptic property scores of the yogurt ice cream from coconut milk added SC as replacement of NFDM

NFDM: SC	Colour and appearance (1-5)	Body and texture (1-5)	Flavor and taste (1-10)	Total (1-20)
15:0	4.48 ± 0.60^a	2.80 ± 0.86^d	7.63 ± 1.68^b	14.90 ± 2.12^b
14:1	3.80 ± 0.55^b	3.30 ± 0.66^c	8.58 ± 1.41^a	15.68 ± 1.83^a
13:2	3.73 ± 0.60^b	4.03 ± 0.73^b	8.40 ± 1.08^{ab}	16.15 ± 0.68^a
12:3	3.53 ± 0.92^b	4.55 ± 0.56^a	8.70 ± 1.24^a	16.78 ± 0.91^a

* Values followed by the different letter are significantly different ($p<0.05$).

Conclusion

The addition of SC led to the yogurt ice cream products from coconut milk with better properties. However, the optimum concentration of NFDM and SC for yogurt ice cream were 14% and 1% (w/w), respectively. The reason for this suggestion could be explained which the sample provided the highest viable yogurt starter culture counts as well as better body and texture, flavor and taste, and total score from sensory evaluation in terms of more gummy texture, increase yogurt/ probiotic flavor and reduce sweetness.

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