

Functional Properties of Cholesterol-removed Compound Whipping Cream by Palm Oil

S. Y. Shim, J. Ahn and H. S. Kwak*

Department of Food Science and Technology, Sejong University, 98 Kunja-dong, Kwangjin-ku, Seoul 143-747, Korea

ABSTRACT : The present study was carried out to examine the changes in functional properties of cholesterol-removed compound whipping cream made by β -CD treated cream and palm oil. Six different ratios of cream to palm oil (10:0 as control, 9:1, 8:2, 7:3, 6:4, and 5:5, v/v) were tested. The overrun percentage increased with an increased amount of palm oil. When the ratio of cream to palm oil was 10:0 (control), the overrun was 130%, which was significantly lower than other ratios reached to 150%. Foam instability was measured as 3.1 ml defoamed cream in control, however, the value of foam instability decreased with an increase of palm oil addition. The TBA value of cholesterol-removed compound whipping cream increased from 0.08 to 0.13 with no addition of palm oil during 4 wk storage. When the ratio of cream to palm oil was 5:5, TBA value increased dramatically at 3 wk and thereafter. Among sensory characteristics, texture value increased with higher amount of palm oil, however, flavor and overall preferences were opposite. Above results indicated that partial substitution of palm oil in manufacture of cholesterol-removed compound whipping cream resulted in a stable foam development with little adverse effect on flavor and lipid oxidation during storage. The present study showed a possible application in manufacture of cholesterol-removed compound whipping cream, which may be effective in other foods. (*Asian-Aust. J. Anim. Sci.* 2004, Vol 17, No. 6 : 857-862)

Key Words : Compound Whipping Cream, Cholesterol Removal, Palm Oil, Functional Properties

INTRODUCTION

Public concern in cholesterol has increased due to the positive correlation of serum cholesterol concentration to the risk of developing coronary heart disease in addition to high dietary fat and low fiber (Grundy et al., 1982; Gurr, 1992; Law et al., 1994). Although the role of dietary cholesterol in human health has not been yet fully understood, factors to raise serum cholesterol, such as dietary cholesterol are generally considered to be unfavorable. Based on above information, physical, chemical and biological methods to reduce cholesterol in foods including dairy products have been studied (Szejtli, 1988; Ahn and Kwak, 1999; Lee et al., 1999; Kwak et al., 2001). Recent studies have indicated that the cholesterol removal in milk, cream and cheese was effectively conducted by β -cyclodextrin (β -CD) (Oakenfull and Sidhu, 1991; Makoto et al., 1992; Ahn and Kwak, 1999; Lee et al., 1999; Kwak et al., 2001). Because β -CD is nontoxic, edible, non-hygroscopic, chemically stable and easy to separate (Nakamoto, 1985), it has positive attributes when used for the cholesterol removal from foods.

Creams for whipping are 3 types such as traditional dairy cream, non-dairy cream and compound cream, which are the mixtures of dairy fat and oil (Smith et al., 2000a). Generally, the requirements of fat for whipping cream are as follows (Nesaretmam et al., 1993): partly solid at 5°C, solids content at ambient temperature related stability

requirements, and melt in the mouth properties which are related to the high fat content.

Recent years have seen the development of products as alternatives to traditional dairy creams. Commercial interest in these products has been stimulated by (a) the opportunity to improve the physical characteristics and gain reproducibility of whip and stability under conditions of the modern factory environment, and (b) economic considerations, especially the replacement of milk fat at lower cost by higher levels of vegetable fat that still retain the full product functionality (Smith et al., 2000a).

Generally, non-dairy whipping cream shows less firmness, flavor and taste than traditional whipping cream, while traditional whipping cream contained a high level of cholesterol and costs high. Whipped cream is a dispersion of gas bubbles that are surrounded by partially coalesced fat at the air/serum interface, and supported by high viscosity in the serum phase (Smith et al., 2000a). Several factors affect the structural properties of whipped cream including fat content, processing conditions and the addition of stabilizers and emulsifiers (Bruhn and Bruhn, 1988).

Emulsion instability is sought in developing structure in whipped cream (Goff, 1997). The process of controlled partial coalescence of such emulsions during whipping and air incorporation leads to the formation of complex structures described both as protein-stabilized emulsions and fat-stabilized foams. There are two distinct types of instability are found: 1) Coalescence: a decrease in the number and an increase in the size of individual globules, and 2) Flocculation: a clustering of individual globules into a coherent unit in which the size and identity of individual

* Corresponding Author: Hae-Soo Kwak. Tel: +82-2-3408-3226, Fax: +82-2-497-8931, E-mail: kwakhs@sejong.ac.kr
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globules are retained.

The β -CD treatment for an effective cholesterol removal may extensively reduce cholesterol in cream but may impair foam stability, probably due to a size reduction of fat globules over the point, where they resist partial coalescence and inhibit stiff foam formation. The whipping of cream into stable foam relies on a combination of destabilization and structure building mechanisms (Smith et al., 2000b). Destabilization occurs as the milk fat globule membranes (MFGM) are disrupted in the presence of shear (Stanley et al., 1996) and partial coalescence ensues. However, there has been little literature regarding the whipping characteristics of the β -CD treatment processing in cholesterol-removed cream. Therefore, our objective of this study was to examine the effect of palm oil addition in manufacture of cholesterol-removed compound whipping cream on functional and sensory properties.

MATERIALS AND METHODS

Materials

Raw milk was obtained from Bingare Dairy Plant (Kyonggi-do, Korea), pasteurized at 72°C for 16 s and cooled to 55°C and cream was separated using a cream separator (Elecrem, Vanves, France) and standardized to 36% milk fat content with skim milk. The cream was refrigerated overnight at 5°C.

Emulsifiers and stabilizers were purchased from Il-Shin Company (Seoul, Korea). Commercial β -CD (purity 99.1%) was purchased from Nihon Shokuhin Kaku Co. Ltd. (Osaka, Japan). Cholesterol and 5- α cholestane were purchased from Sigma Chemical Co. (St Louis, MO, USA) and all solvents were gas chromatographic grade.

Cholesterol removal in cream

Cream was treated with 10% (w/v) β -cyclodextrin to remove cholesterol as described earlier (Ahn and Kwak, 1999). The mixture was stirred at 800 rpm for 20 min with a blender (Tops; Misung Co., Seoul, Korea) in a temperature-controlled water bath at 40°C. The mixture was centrifuged (HMR-220IV; Hanil Industrial Co., Seoul, Korea) with 166 \times g for 10 min to remove β -CD-cholesterol complex (Lee et al., 1999). All treatments were run in triplicate.

Extraction and determination of cholesterol

For the extraction of cholesterol from whipped cream, 1 g of sample was placed in a screw-capped glass tube (15 mm \times 180 mm), and 1 ml of 5 α -cholestane (1 mg/ml) was added as an internal standard (Adams et al., 1986). The sample was saponified at 60°C for 30 min with 5 ml of 2 M ethanolic potassium hydroxide solution. After cooling to room temperature, cholesterol was extracted with 5 ml of

hexane. The process was repeated four times. The hexane layers were transferred to a round-bottomed flask and dried under vacuum. The extract was redissolved in 1 ml of hexane and was stored at -20°C until analysis.

Total cholesterol was determined on a silica-fused capillary column (HP-5, 30 m \times 0.32 mm i.d. \times 0.25 μ m thickness) using a gas chromatograph (5880A; Hewlett-Packard, Palo Alto, CA, USA) equipped with a flame-ionization detector. Temperatures of the injector and detector were 270 and 300°C, respectively. Oven temperature was programmed to increase from 200 to 300°C, at 10°C/min, and then was constant for 20 min. Nitrogen was used as carrier gas at a flow rate of 2 ml/min. The sample injection volume was 2 μ l with a split ratio of 1/50. Quantitation of cholesterol was done by comparing sample peak areas with the response of an internal standard.

The percentage of cholesterol reduction was calculated as follows: Cholesterol reduction (%) = amount of cholesterol in β -CD-treated cream \times 100 / amount of cholesterol in untreated cream (control). Cholesterol determination for a control was done with each treatment batch.

Manufacture of compound whipping cream

To manufacture the cholesterol-removed compound whipping cream, first, the mixture of emulsifier and stabilizer was prepared, which were α -cellulose 0.2%, avicell 0.2%, sodium alginate 0.2%, sugar ester 0.1% and sucrose 0.3% (v/v). In our previous study (Shim et al., 2003), above mixture was approved to be adequate for whipping cream.

Second, six different ratios of cholesterol-removed cream to palm oil (10:0 as control, 9:1, 8:2, 7:3, 6:4 and 5:5) were mixed with stirrer, and cooled to 4°C. Each sample was aged for 24 h and then whipped by EGS type 06 (E3290 Model 296, Germany) with the third step speed for 2 and 1/2 min. Three replicates were tested on each of the six treatments.

Overrun

Samples (200 ml) were whipped for 2 and 1/2 min to maximum overrun, according to the following equation (Smith et al., 2000a).

Overrun % = (volume of whipped cream - volume of unwhipped cream) \times 100 / volume of unwhipped cream

Foam instability

Foam instability for the cholesterol-removed compound whipping cream was measured as the rate of foam drainage (Mangino et al., 1987). A 100 g foam was stood for 2 h at 24°C and the defoamed cream as liquid form was collected in mass cylinder and measured as ml unit.

Table 1. The change of overrun in different ratios of cholesterol-removed cream to palm oil¹

Ratios (v/v)		Overrun (%)
Cholesterol-removed cream ²	Palm oil	
10	0 ³	130 ^b
9	1	140 ^a
8	2	150 ^a
7	3	150 ^a
6	4	150 ^a
5	5	150 ^a

¹Means within a column with different superscript letter differ (p<0.05). Means of triplicate.

²Cholesterol-removed cream was made as followed: β-cyclodextrin: 10%, stirring temperature: 40°C, stirring speed; 800 rpm, stirring time: 20 min, centrifugation speed: 166×g and centrifugation time: 10 min. ³Control.

Thiobarbituric acid (TBA) test

The cholesterol-removed compound whipping cream was measured using TBA test for fat oxidation during storage at 4°C for 4 wk (Hegenauer et al., 1979). The reagent for TBA test was prepared immediately before use by mixing equal volumes of freshly prepared 0.025 M TBA, which was neutralized with NaOH and 2 M H₃PO₄/2 M citric acid. Reactions of TBA test were started by pipetting 1g of whipped cream into a glass centrifuge tube and mixed thoroughly with 2.5 ml TBA reagent. The mixture was heated immediately in a boiling water bath for exactly 10 min and cooled on ice. Ten mL cyclohexane and 1 ml of 4 M ammonium sulfate were added and centrifuged at 2,490×g for 5 min at room temperature. The orange-red cyclohexane supernatant was decanted and its absorbance at 532 nm was measured spectrophotometrically in a 1 cm length path. All measurements run in triplicate.

Sensory analysis

For the storage test, 10 ml compound whipping cream was stored at 4°C for 2 wk. An eight-person panel, semi-experienced in judging dairy products evaluated the samples throughout the study. Texture and color were scored on a nine-point scale (1=very weak, 3=slightly weak, 5=moderate, 7=slightly strong, and 9=very strong) and flavor and overall preference were also scored on a nine-point scale (1=dislike extremely, 3=dislike moderately, 5=neither like or dislike, 7=like moderately and 9=like extremely).

Statistical analysis

Data for the determination of optimum conditions of cholesterol-removed whipping cream, one-way ANOVA (SAS Institute Inc., 1985) was used. The significance of the results was analyzed by the least significant difference (LSD) test. Difference of p<0.05 were considered to be significant.

Table 2. The change of foam instability in different ratios of cholesterol-removed cream to palm oil¹

Ratios (v/v)		Foam instability (ml)
Cholesterol-removed cream ²	Palm oil	
10	0 ³	3.1 ^a
9	1	2.7 ^a
8	2	1.0 ^b
7	3	1.0 ^b
6	4	0.9 ^b
5	5	0.9 ^b

¹Means within a column with different superscript letter differ (p<0.05). Means of triplicate.

²Cholesterol-removed cream was made as followed: β-cyclodextrin: 10%, stirring temperature: 40°C, stirring speed; 800 rpm, stirring time: 20 min, centrifugation speed: 166×g and centrifugation time: 10 min. ³Control.

RESULTS

Cholesterol removal rate of cream

Cholesterol removal process was performed according to our previous study (Ahn and Kwak, 1999) as follows: 10% β-CD, 40°C stirring temperature, 20 min stirring time, 800 rpm stirring speed, 166×g centrifugal speed and 10 min centrifugal time. The cholesterol removal rate of the cream under the above conditions reached 90% or higher (data not shown).

Functional properties

Overrun : When the ratio of cholesterol-removed cream to palm oil was 10:0 (no addition of palm oil), the overrun value was 130%. The overrun value increased with an increase of palm oil ratio and reached 150% at 8:2 (cholesterol-removed cream to palm oil) (Table 1). Bruhn and Bruhn (1988) indicated that whipping time required to reach maximum overrun varied significantly according to processing method and stabilizer addition. The addition of stabilizer resulted in a lower overrun as seen in our whipping data and also previously reported (Bruhn and Bruhn, 1988). This effect is supported by an expected decrease in bubble size.

Foam instability : The effect of palm oil addition on foam instability of cholesterol-removed compound whipping cream is shown in Table 2. In two treatments containing high amount of cholesterol-removed cream (10:0 as control and 9:1), there was a significantly higher instability over 2.7 ml. However, other treatments which containing lower ratio of cream showed a significantly lower instability as 0.9-1.0 ml and no difference was found among treatments. This data indicated that lower addition of cholesterol-removed cream to manufacture compound whipping cream makes better foam instability.

TBA test during storage : The effect of whipping in cream on chemical oxidation (as measured by the TBA test) during 4 wk storage is shown in Figure 1. During 4 wk storage, TBA absorbance increased steadily and was not

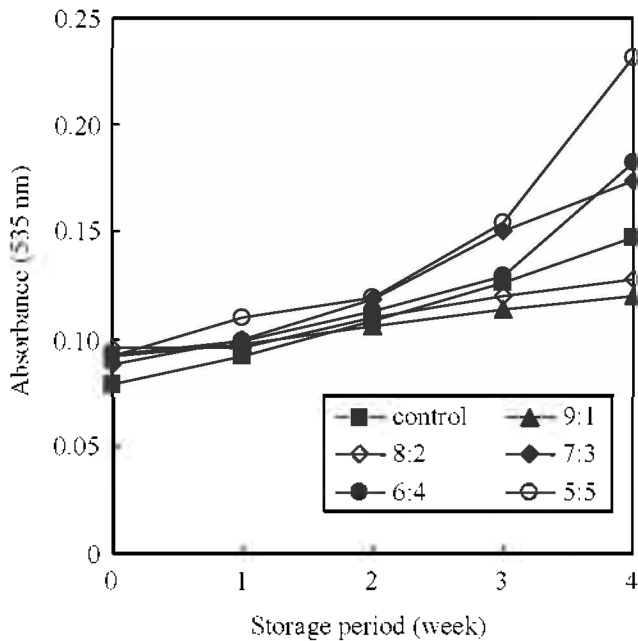


Figure 1. Change of TBA value in cholesterol-removed compound whipping cream stored for 4 wk at 4°C. The ratios of cholesterol-removed cream to palm oil were 10:0 as control, 9:1, 8:2, 7:3, 6:4 and 5:5. Factors for β -cyclodextrin treatment for making cholesterol-removed whipping cream were 10% β -CD added, 800 rpm stirring speed, 20 min stirring time, 166 \times g of centrifugation speed and 10 min centrifugation time.

significantly different among three treatments such as 10:0, 9:1 and 8:2 (cholesterol-removed whipping cream to palm oil). However, a dramatic increase of TBA value was observed in other three treatments (7:3, 6:4 and 5:5) for 4 wk storage. TBA value especially increased at 2 wk and thereafter. It has been well known that polyunsaturated fatty acid is susceptible to oxidation. Thus, it can be easily expected that the treatments with high ratio of palm oil amount may cause the dramatic increase of TBA value with storage.

Sensory analysis

The sensory properties of compound whipping creams with 6 different treatments were evaluated for 2 wk storage at refrigerated temperature (Tables 3, 4, 5 and 6). Six treatments were determined according to the ratios of cholesterol-removed cream to palm oil as 10:0 as control, 9:1, 8:2, 7:3, 6:4 and 5:5.

All sensory characteristics showed a similar trend, which scores decreased with an increase amount of palm oil addition to manufacture for compound cream (Tables 3, 4, 5 and 6). The texture score showed a decreasing trend with storage time in all treatments, especially, significant difference was found in treatment without adding palm oil from 0 wk (4.8) to 2 wk (4.0) (Table 3). The flavor score was not different in all treatments at every storage time, however, when the ratio of cholesterol-removed cream to

Table 3. The change of texture in different ratios of compound whipping creams for 2 wk storage at 4°C

Treatment	Storage time (wk)		
	0	1	2
Control	4.8 ^a	4.8 ^a	4.0 ^b
9:1	4.8 ^a	4.8 ^a	4.5 ^{ab}
8:2	4.8 ^a	4.7 ^a	4.4 ^{ab}
7:3	4.9 ^a	4.7 ^a	4.5 ^{ab}
6:4	5.0 ^a	4.7 ^a	4.4 ^{ab}
5:5	5.2 ^a	5.0 ^a	4.9 ^a

^{a, b} Means within a column with different superscript letter differ ($p < 0.05$). Means of triplicate.

Table 4. The change of flavor in different ratios of compound whipping creams for 2 wk storage at 4°C

Treatment	Storage time (wk)		
	0	1	2
Control	5.2 ^a	5.0 ^a	5.1 ^a
9:1	5.2 ^a	5.0 ^a	5.0 ^a
8:2	5.2 ^a	4.9 ^a	4.8 ^a
7:3	5.0 ^d	4.9 ^d	4.7 ^{ab}
6:4	4.8 ^a	4.5 ^{ab}	4.3 ^{ab}
5:5	4.7 ^{ab}	4.7 ^{ab}	4.7 ^{ab}

^{a, b} Means within a column with different superscript letter differ ($p < 0.05$). Means of triplicate.

Table 5. The change of color in different ratios of compound whipping creams for 2 wk storage at 4°C

Treatment	Storage time (wk)		
	0	1	2
Control	4.9 ^a	4.9 ^a	4.8 ^a
9:1	4.9 ^d	4.9 ^d	4.7 ^d
8:2	4.9 ^a	4.8 ^a	4.8 ^a
7:3	4.8 ^a	4.5 ^{ab}	4.3 ^b
6:4	4.5 ^{ab}	4.7 ^a	4.7 ^{ab}
5:5	4.2 ^b	4.5 ^{ab}	4.3 ^b

^{a, b} Means within a column with different superscript letter differ ($p < 0.05$). Means of triplicate.

palm oil was 6:4, flavor score decreased significantly from 4.8 (0 wk) to 4.3 (2 wk) (Table 4).

The similar trend was found in color. In the treatment containing the ratio of 7:3, color score decreased significantly during 2 wk. Another thing is that the ratio of 5:5 showed the lowest score in every period (Table 5). The overall acceptability score decreased with storage time in all treatments. Especially, higher amount of palm oil containing treatments showed a significantly lower score throughout the storage (Table 6). This result indicates that storage for 2 wk did not adversely affect the sensory characteristics, however, the significant changes on color and overall acceptability in cholesterol-removed compound cream attributed to too much amount of palm oil addition to cream.

DISCUSSION

In the past two decades, evidence has been gathered to suggest that an excess of cholesterol might be deleterious.

Table 6. The change of overall acceptability in different ratios of compound whipping creams for 2 wk storage at 4°C

Treatment	Storage time (wk)		
	0	1	2
Control	4.9 ^a	4.8 ^a	4.4 ^{bc}
9:1	4.8 ^a	4.6 ^{ab}	4.4 ^{bc}
8:2	4.7 ^a	4.5 ^{ab}	4.3 ^b
7:3	4.5 ^{ab}	4.3 ^b	4.7 ^a
6:4	4.3 ^b	4.0 ^b	3.8 ^c
5:5	4.1 ^b	3.8 ^{bc}	3.5 ^c

^{a,b} Means within a column with different superscript letter differ ($p \leq 0.05$). Means of triplicate.

Therefore, cholesterol has been removed from milk and dairy products by a β -CD-based process, and the resulting low-cholesterol dairy products appeared to be indistinguishable from conventional products (Ahn and Kwak, 1999; Lee et al., 1999; Kwak et al., 2001; Shim et al., 2003).

A number of studies in our laboratory have indicated that the removal of cholesterol from milk and cream was effectively conducted by treatment with β -CD (Ahn and Kwak, 1999; Lee et al., 1999). Over 90% of the cholesterol was removed from commercial milk at refrigerated temperature with 1% β -CD (Lee et al., 1999). To apply this method to dairy product, milk must be homogenized prior to the processing because the rate of cholesterol removal from unhomogenized milk by β -CD is low (30%, unpublished). Thus, we tried new approach, which cream (36% milk fat) was separated from milk and treated with 10% β -CD and mixed with skim milk. By this process, cholesterol removal was successfully improved upto 92% in cheese manufacture (Kwak et al., 2002).

Generally, creams for whipping, either traditional dairy or their alternatives, contain significant proportions of fat. In the UK, dairy whipping cream must legally contain a minimum of 350 g/kg (fresh wt.) butterfat (Davis, 1976). There is no such restriction placed upon dairy alternatives, which are normally based on vegetable fats. The fat components greatly influence the whipping properties and stability of the cream (Towler, 1982). Optimum performance is normally obtained in dairy cream with 380-400 g/kg (fresh wt.) butterfat. At lower fat levels the whip tends to be softer and have greater tendency to leak whey.

Recent years have seen the development of products as alternatives to traditional dairy creams. Commercial interest in these products has been stimulated by the opportunity to improve the physical characteristics and gain reproducibility of whip and stability under conditions of the modern factory environment and by economic considerations, especially the replacement of milk fat at lower cost by lower levels of vegetable fat that still retain the full product functionality. Our previous study (Shim et al., 2003) has focused to examine whether the functional

properties were changed by β -CD treatment. Results indicated that β -CD treatment did not show a profound adverse effect on functional properties of cream after whipping

Based on above information, this study was designed to develop cholesterol-removed compound whipping cream, which palm oil was partially substituted for milk fat. The cholesterol removal rate reached above 90% in cream.

The most aspects will be functional properties of cholesterol-removed whipped cream, when palm oil was substituted for milk fat with different ratios. Cholesterol-removed compound whipped creams showed significantly higher overrun values than that of control (no palm oil addition). In addition, more palm oil added, higher overrun value. This phenomenon could be explained by the higher solubility of palm oil due to higher contents of unsaturated fatty acids.

Another property, foam instability, was significantly higher in treatments containing small amount of palm oil. The stability of foams is usually dependent on the nature of proteins at the air/serum interface, and on the viscosity of serum phase (Smith et al., 2000a). The bubble interface, formed by β -casein, has been shown to exhibit a lower shear viscosity and shear elastic modulus so that they form films readily but are less stable than an interface of globular proteins (Damadaran, 1990). The persistence of bubbles relies on the stabilizing influence of casein micelles and denatured whey proteins to support the β -casein film by increasing the thickness and rigidity of the interface (Smith et al., 2000b).

In addition, foam instability is greatly affected by rheological properties of the continuous phase of air bubble as well as by the viscoelastic properties of the interfacial film. In whipped dairy creams, fat globules are partially aggregated in the aqueous phase and evenly distributed around the air/serum interface, thus giving stability and firmness to the foam (Noda and Shiinoki, 1986).

Since palm oil contains a high amount of palmitic and oleic acids, fat oxidation was considered to influence on TBA value and sensory aspects such as oxidized or stale flavor during storage. Therefore, the present study designed to examine whether oxidation was processed during storage. The result indicated that high amount of palm oil added treatments showed a higher increase of TBA value during 4 wk storage. O'Sullivan and Keogh (1967) reported that the chemical problem limiting the storage life of whipping cream was the development of oxidative rancidity which resulted in an objectionable oxidized or stale flavor. In addition, they detected a pronounced cooked and oxidized flavor during storage.

The significant difference in sensory aspects was in texture and color, especially, between control (no addition of palm oil) and treatment 5:5 (milk fat: palm oil). The

changes in texture and color characteristics as soft and less viscous and yellowish color may be resulted by palm oil addition. However, there was not profound adverse effect of palm oil addition on other sensory properties during 2 wk storage. Therefore, the present study showed a possible application in manufacture of cholesterol-removed compound whipping cream, which may be applied effectively in other foods.

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