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Development of Cholesterol-reduced Mayonnaise with Crosslinked β-Cyclodextrin and Added Phytosterol

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가교화 β-Cyclodextrin과 식물성 Sterol을 이용한 콜레스테롤 저하 마요네즈의 연구

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Abstract

The objective of the present study was to develop cholesterol-reduced and phytosterol-supplemented mayonnaise using crosslinked β-cyclodextrin and examine its physicochemical and sensory attributes during 10 months of storage. The composition of cholesterol-reduced phytosterol-supplemented mayonnaise was similar to the control. The amount of cholesterol removed ranged from 90.67 to 92.47%. The TBA absorbance of the samples showed that the more phytosterol the sample contained, the lower the TBA absorbance value. The viscosity of cholesterol-reduced mayonnaise with 2.0% phytosterol decreased significantly during storage ($p<0.05$). The color changes of mayonnaise during storage showed a decrease in the L- and b-values, and an increase in the a-value. The experimental mayonnaise maintained emulsion stability, which was significantly lower in 2.0% phytosterol-supplemented mayonnaise. With regard to sensory attributes, most characteristics were similar to the control mayonnaise, however, the addition of phytosterol had a negative effect on stickiness and bitterness. These results indicate that the cholesterol-reduced and phytosterol-supplemented mayonnaise has decreased oxidation and maintains most of its physicochemical and sensory properties during storage.

Key words: mayonnaise, crosslinked b-cyclodextrin, cholesterol removal, phytosterol

Introduction

Mayonnaise is probably one of the most widely used sauces or condiments in the world today. It has been in existence for centuries, although its exact origin is a matter of dispute. It was first produced commercially in the early 1900s, becoming popular in America from 1917 to 1927 (Harrison & Cunningham, 1985). And more recently in Japan where sales increased by 21% in the years from 1987 to 1990 (Brabant, 1992).

Despite concerns about its cholesterol content, egg yolk is still the most commonly used emulsifying agent because of its outstanding qualities both for forming the emulsion and for the way that egg-yolk emulsions flocculate to give the correct texture. Liquid egg yolk is itself an emulsion comprising hydrophobic granules suspended in an aqueous phase containing most of the protein (Harrison and Cunningham, 1985). Since liquid egg yolk can only be stored for a limited time, manufactures often substitute frozen or dried yolk. However, it appears that many of the emulsifying properties of egg yolk depend on its structure and that any processing that disrupts this structure reduces its utility as an emulsifying agent. This may be the reason why egg yolk reconstituted from individual components is not as effective as fresh egg yolk.

Recently, consumers have increasingly demanded the cholesterol-removed mayonnaise, so egg-yolk-substituted products by egg white has been shown in market place. However, those products has serious problem with sensory defects. Food companies have developed many methods to reduce

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cholesterol, however, most of these methods are relatively nonselective and remove flavor and nutritional components when cholesterol is removed. Moreover, some methods require high investment and operation costs. A number of studies have indicated that cholesterol removal from dairy products was most effectively achieved by powdered β-CD (Lee *et al.*, 2007; Jung *et al.*, 2005; Shim *et al.*, 2003; Kwak *et al.*, 2002; Lee *et al.*, 1999; Ahn and Kwak, 1999). Whereas β-CD provides advantages when used for cholesterol removal over 90%, powdered β-CD is an ineffective way for separation from food system and recovery. One method to overcome these problems could be a crosslinking of β-CD. Our previous study showed cholesterol-reduced milk and cream using crosslinked β-CD and an effective recycling efficiency (Han *et al.*, 2005; Han *et al.*, 2007; Kim *et al.*, 2004).

The plasma cholesterol lowering properties of phytosterols has been known since the early 1950s, and there have been a plethora of studies reporting their hypocholesterolemic effects (Ling and Jones, 1995). Increased cholesterol concentrations can be lowered by changing the fatty acid composition of diet, however, through consumption of products enriched with plant sterols (Expert panel on detection, 2001). In recent years, phytosterols have gained much attention as nutraceuticals for their blood cholesterol lowering efficacy (Leeson and Floter, 2002; Ling and Jones, 1995). This interest has now been translated into a range of health-promoting functional products, such as vegetable oil-based table spreads. Typically, the sterol content is between 6 and 10% to provide sufficient daily intake for the blood cholesterol lowering effect (Lesson and Floter, 2002). The plasma cholesterol lowering effect of a phytosterol ester-containing margarine has been confirmed in humans (Weststrate and Meijer, 1998), which have been re-esterified with unsaturated fatty acids to increase fat solubility.

However, littler information is available in the chemical and sensory properties of mayonnaise when crosslinked β-CD was applied and phytosterol added. The objective of this study was to compare the chemical and sensory properties of regular mayonnaise, and cholesterol-reduced and phytosterol-added mayonnaise manufactured using crosslinked β-CD or powdered β-CD and stored for 10 months.

Materials and Methods

Materials

Egg was purchased from retail store as needed and egg yolk was separated. Beta-cyclodextrin (β-CD, purity 99.1%) was obtained from Nihon Shokuhin Cako Co., Ltd. (Osaka, Japan). Phytosterol (90% soybean origin; 40% β-sitosterol, 2-% campesterol, and 10% stigmasterol) was obtained from Dasol International (Seoul, Korea). Cholesterol and 5α-cholestane were purchased from Sigma Chemical Co. (St. Louis, MO, USA), and all solvents were gas-chromatographic grade.

Cholesterol removal and determination

Crosslinked β-CD was produced by the method of Han *et al.* (2005). Cholesterol removal in egg yolk and cholesterol determination were followed by Jung *et al.* (2005).

Manufacture of mayonnaise

Cholesterol-reduced mayonnaise consisted of a cholesterol-removed egg yolk, soybean oil and vinegar. First a dispersion was prepared by mixing the egg yolk with water at room temperature. Then the aqueous mixture including egg yolk was first emulsified with oil and later with vinegar to an oil-in-water emulsion. The emulsion was then passed through a blender to produce a stable mayonnaise. All mayonnaises were stored in the refrigerator at 7°C for 10 months.

Experimental mayonnaises were divided into 6 different groups. Control group was neither treated by crosslinked β-CD nor added by phytosterol. All Trt groups were treated by crosslinked β-CD and subdivided by the amount of phytosterol addition (0, 0.5, 1.0, 1.5 or 2.0%).

Analysis of chemical composition

Mayonnaise was analyzed for moisture, fat and protein using the methods of the Association of Official Analytical Chemists (AOAC, 1990).

Thiobarbituric acid (TBA) test

Oxidation products were analyzed spectrophotometrically using the TBA test (Hegenauer *et al.*, 1979). The TBA reagent was prepared immediately before use by mixing equal volumes of freshly prepared 0.025 M TBA, which was neutralized with NaOH and 2 M H_3PO_4/2 M citric acid. Reactions of the TBA test were started by pipetting 5.0 mL of milk samples into a glass centrifuge tube and mixed thoroughly with 2.5 mL of TBA reagent. The mixture was heated immediately in a boiling water bath for exactly 10 min and cooled on ice. Ten milliliters of cyclohexanone 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 cyclohexanone supernatant was decanted and its absorbance at 532 nm measured spectrophotometrically in a 1-cm light path. All measurements were run in triplicate.

Color

Color values were compared between the control and the cholesterol-reduced mayonnaise with the colorimeter (CR210, Minolta, Tokyo, Japan) after calibrating its original value with standard plate (X=97.83, Y=81.58, Z=91.51). Measured L-, a-, and b-values were regarded as indicator of lightness, redness and yellowness, respectively.

Viscosity

Sample (50 mL) was placed and viscosity was measured with spindle 1 using viscometer (VISCO STAR-L, J.P. Selecta S.A., Spain) with 200 rpm at 5°C. All samples were measured in triplicate.

Sensory analysis

For the sensory test, cholesterol-reduced mayonnaise was stored at 7 for 0, 2, 4, 6 and 8 months. A ten-trained panel evaluated randomly coded mayonnaise. The texture, appearance, flavor and taste were evaluated on a 7-point scale (1=very slight, 2=slight, 3=slight-moderate, 4=moderate, 5=moderate-strong, 6=strong and 7=very strong). A randomized, balanced, complete block design was used (Cochran and Cox, 1957) that resulted in two replications for all samples.

Statistical analysis

One-way ANOVA (SAS, 1985) was used. The significance of the results was analyzed by the least significant difference (LSD) test. Difference of $p<0.05$ was considered to be significant.

Results and Discussion

Cholesterol removal and composition

To find out whether a difference existed in cholesterol removal among treatments, cholesterol content was measured as shown in Table 1. The cholesterol content of the control mayonnaise was 82.4 mg/100 g. The cholesterol reduction reached 90.8-92.5% when treated with 20% crosslinked β-CD. Our previous studies showed similar reduction in egg (Jung *et al.*, 2005) and milk (Han *et al.*, 2005) when they were treated with crosslinked β-CD. In control mayonnaise, the moisture content was 13.8% and the fat content 78.5%. Cholesterol-reduced mayonnaise showed similar composition in terms of moisture, total fat and protein.

Table 1. Mean chemical composition of cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months[1]

Component	Moisture (%)	Fat (%)	Protein (%)	Cholesterol removal (%)	Cholesterol, mg/100 g mayonnaise
Control[2]	13.8^b	78.5^a	1.2^a		82.4
Trt 1	14.4^b	78.7^a	1.3^a	92.5^a	6.18
Trt 2	15.9^a	78.5^a	1.0^a	90.7^a	7.66
Trt 3	13.8^b	79.0^a	1.1^a	91.7^a	6.84
Trt 4	14.2^b	78.4^a	1.2^a	91.7^a	6.84
Trt 5	13.5^b	79.3^a	1.3^a	90.8^a	7.58

[1] Means within a column with different letters differ significantly ($p<0.05$).

Control: no treatment with crosslinked β-CD and no addition of phytosterol.

Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.

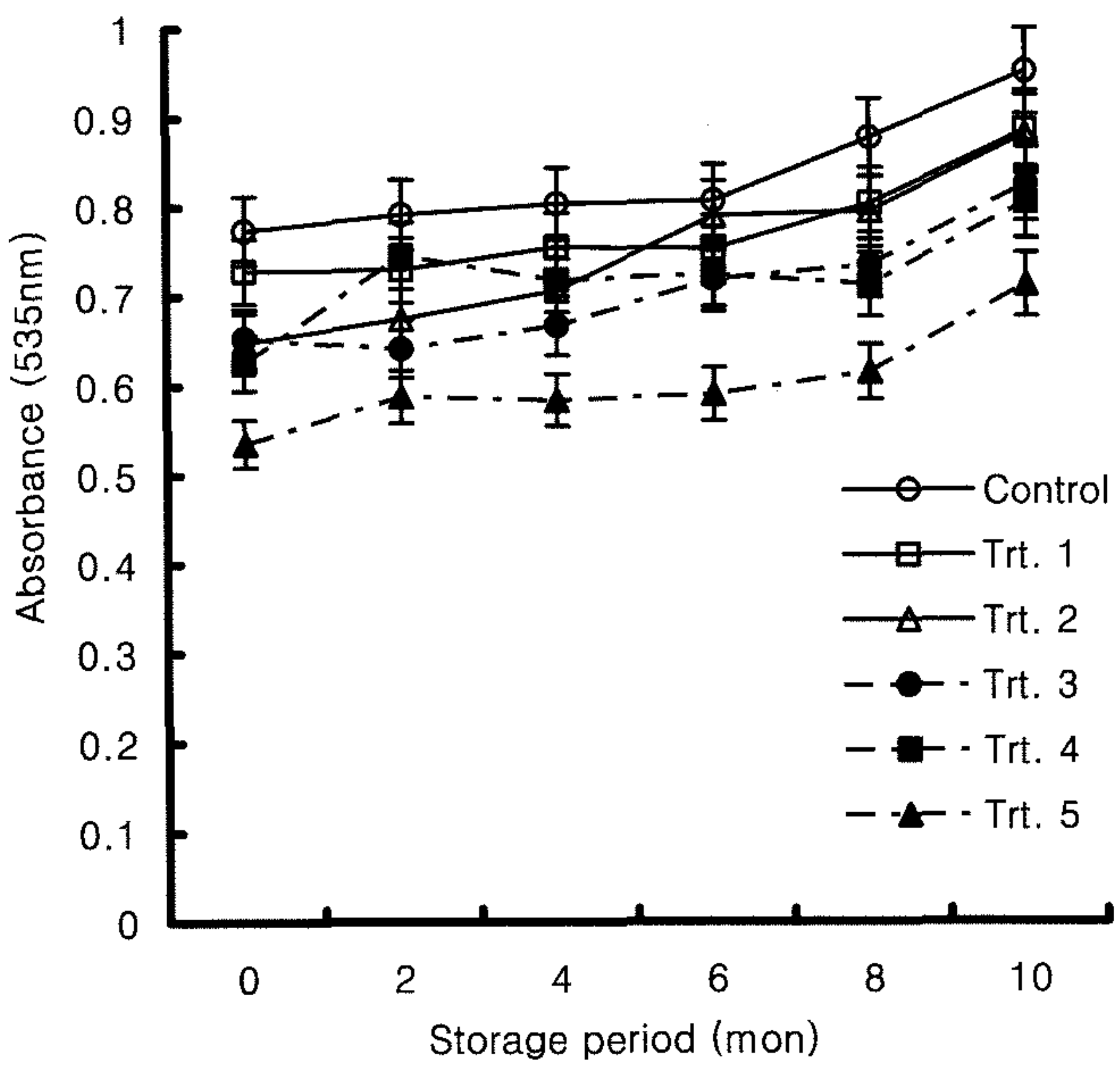

Fig. 1. Changes in TBA of cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months. Control: no treatment with crosslinked β-CD and no addition of phytosterol. Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.

TBA value

The TBA value decreased with the increasing proportion of phytosterol added (Fig. 1). The increasing pattern was similar and the TBA value was maintained up to 6 months and increased thereafter. While the control group showed the highest value of TBA throughout the storage period, Trt 5 which cholesterol-reduced mayonnaise containing 2.0% of phytosterol was the lowest. The TBA value was increased more dramatically in the control group than those in other groups. Therefore, this result may indicate that lipid oxidation proceeded more slowly in cholesterol-reduced and phytosterol-added mayonnaise than the control.

As is the case with all fat-containing foods, mayonnaise is susceptible to spoilage through auto-oxidation of the unsaturated and polyunsaturated fats in the oil (Depree and Savage, 2001). The nature of mayonnaise means that a very large area of the oil is exposed to an aqueous phase, which may contain substantial dissolved oxygen. In addition, the blending process tends to introduce air bubbles, which become trapped within the emulsion. Given these potential problems, it appears to have been surprisingly little work done on spoilage of mayonnaise through auto-oxidation.

Table 2. Color changes in cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months[1]

Storage periods (mon)	Treatment	L-value	a-value	b-value
0	Control	4.8[a]	4.6[a]	3.2[b]
	Trt 1	4.3[a]	4.4[a]	5.2[a]
	Trt 2	3.7[a]	5.2[a]	4.7[ab]
	Trt 3	4.2[a]	4.8[a]	4.9[a]
	Trt 4	4.0[a]	5.0[a]	4.7[ab]
	Trt 5	2.8[b]	4.8[a]	4.2[ab]
2	Control	4.3[a]	4.3[a]	4.2[a]
	Trt 1	4.1[a]	4.3[a]	4.1[a]
	Trt 2	4.0[a]	4.6[a]	3.4[a]
	Trt 3	3.8[a]	4.3[a]	4.2[a]
	Trt 4	2.8[b]	4.9[a]	3.0[a]
	Trt 5	3.5[ab]	4.6[a]	3.2[a]
4	Control	4.7[a]	4.6[a]	4.8[ab]
	Trt 1	4.1[a]	4.4[a]	5.1[a]
	Trt 2	4.0[ab]	5.2[a]	3.1[c]
	Trt 3	4.3[ab]	4.8[a]	4.9[ab]
	Trt 4	3.1[b]	5.0[a]	3.6[bc]
	Trt 5	3.0[b]	4.8[a]	3.8[abc]
6	Conrol	3.7[a]	4.3[a]	4.6[a]
	Trt 1	3.7[a]	4.3[ab]	4.3[ab]
	Trt 2	3.1[ab]	4.6[a]	4.3[ab]
	Trt 3	3.9[a]	4.3[a]	4.0[ab]
	Trt 4	2.8[ab]	4.9[a]	3.3[ab]
	Trt 5	2.4[b]	4.6[a]	3.1[b]
8	Control	4.7[a]	4.4[a]	4.2[a]
	Trt 1	4.8[a]	4.8[a]	4.4[a]
	Trt 2	4.7[a]	4.8[a]	3.8[a]
	Trt 3	4.6[a]	4.6[a]	3.4[a]
	Trt 4	3.6[b]	4.9[a]	3.1[a]
	Trt 5	4.0[ab]	5.0[a]	3.6[a]
10	Control	4.7[ab]	4.8[a]	4.1[a]
	Trt 1	4.8[a]	5.1[a]	4.3[a]
	Trt 2	4.7[ab]	5.1[a]	3.3[ab]
	Trt 3	4.7[ab]	4.9[a]	3.3[ab]
	Trt 4	3.7[b]	5.2[a]	2.8[b]
	Trt 5	3.7[b]	5.3[a]	2.6[b]

[1] Means within a column with different letters differ significantly ($p<0.05$).

Control: no treatment with crosslinked β-CD and no addition of phytosterol.

Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.

The scale of appearance, flavor, texture and taste: 1=very slight, 2=slight, 3=slight-moderate, 4=moderate, 5=moderate-strong, 6=strong and 7=very strong. The scale of overall score: 1=dislike extremely, 4=neither like nor dislike and 7=like extremely.

Color

Table 2 compared the color value between the control and cholesterol-reduced mayonnaise. Discoloration of milk was observed in all Trts and it was significant. L-value was decreased significantly in Trts 4 and 5, which contained 1.5 and 2.0% phytosterol, respectively, after 2 month storage periods. When a-value in experimental groups were maintained throughout 10 month storage, however, it was significantly increased in the control at 6 months and plateaued thereafter. A-value showed the slight increasing trend in all groups. However, b-value was decreased slowly in cholesterol-reduced and phytosterol-added groups, but it was dramatically decreased in the control at 4 month storage.

Viscosity

Fig. 2 described changes in the viscosity of the control and cholesterol-reduced mayonnaise. The control represented

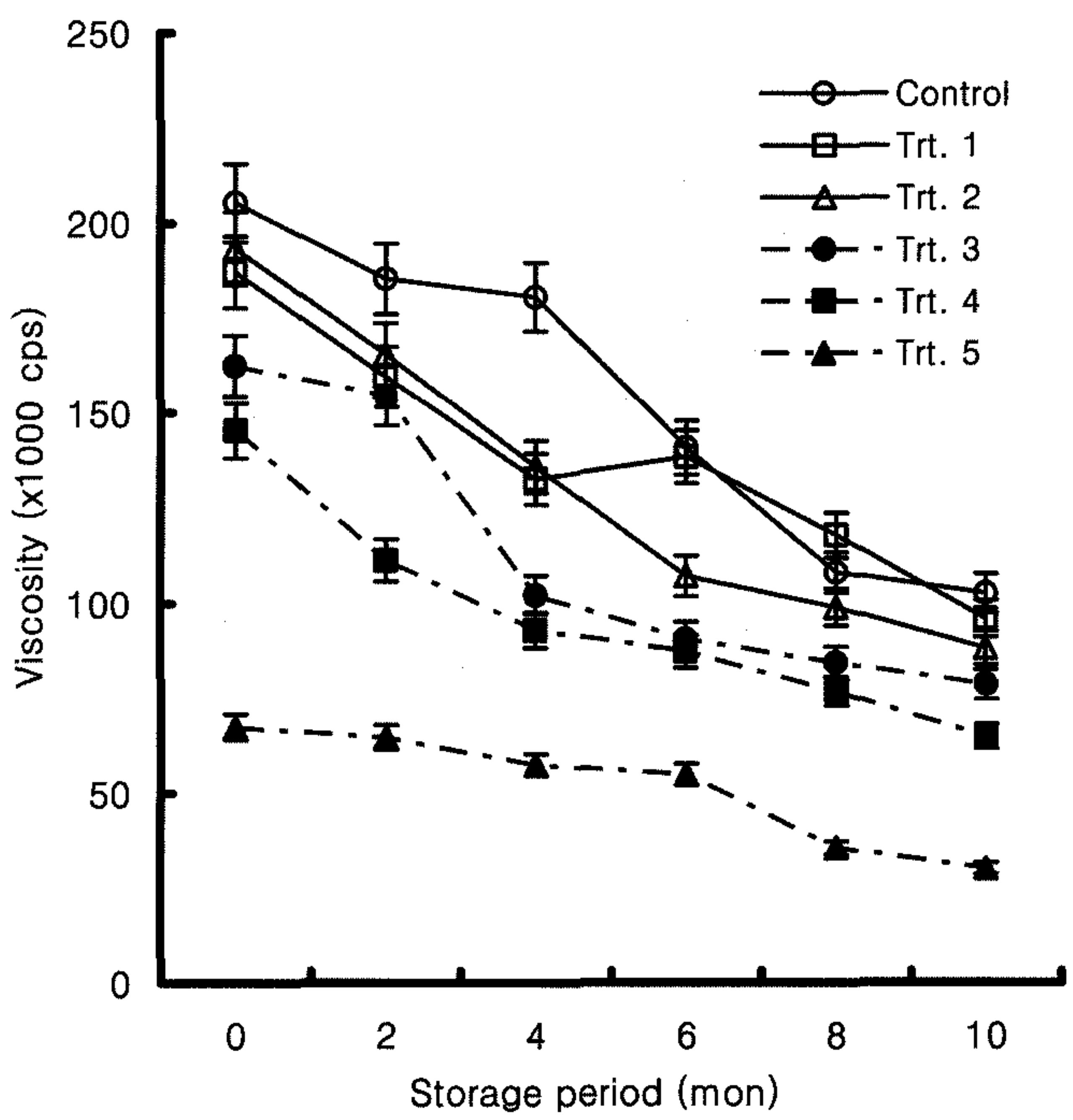

Fig. 2. Changes in viscosity of cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months. Control: no treatment with crosslinked β-CD and no addition of phytosterol. Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.

208×10^3 cps at 0 month storage, however, Trt 5 showed 65 $\times 10^3$ cps. There was a significant difference among groups, especially between the control and cholesterol-reduced and phytosterol-added groups. Among groups, the control, Trt 1 and 2 showed the dramatic decrease throughout the storage periods, whereas the viscosity of Trt 5 was slightly decreased during the same period. The present study indicated that less than 0.5% of phytosterol addition could be acceptable to be a qualified mayonnaise in cholesterol-reduced mayonnaise.

One of the keys to preparing a stable mayonnaise is to form small oil droplets in a continuous water phase with sufficiently high viscosity to prevent coalescence of the oil droplet (Wendin *et al.*, 1999). The oil droplets and the oil phase are the most important (Pons *et al.*, 1994; Arnell, 1990), but both the continuous and the dispersed phases have an impact upon the rheological function (Bohlin *et al.*, 1982). The distribution and size of the particles (oil droplets) can be changed by homogenization. The oil droplets will be reduced in size and the exposed fat surface area will increase.

Emulsion stability

Emulsion stability measured by the separated oil weight during 10 month storage was shown in Table 3. Control group did not show any separation up to 4 months and started to be separated at 6 months and prolonged thereafter. All cholesterol-reduced and phytosterol-added mayonnaise resulted in the oil separation and separated oil weight was increased with the storage time. Especially groups containing over 1.0% phytosterol (Trts 4 and 5) showed the dramatically increased separated oil weight even at the initial period. The reason why the highest separated oil weight could be explained by insufficient blending of phytosterol under the mayonnaise manufacturing process. Therefore, the present results indicated that cholesterol-reduced mayonnaise containing 0.5% phytosterol may show an acceptable quality in terms of oil separation from mayonnaise throughout the storage period.

Table 3. Chages in separated oil weight of cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months[1]

Storage period (mon)	Control	Trt 1	Trt 2	Trt 3	Trt 4	Trt 5
0	-	0.23^b	0.10^b	0.50^b	0.55^b	14.87^a
2	-	0.22^b	0.13^b	0.70^b	1.03^b	19.80^a
4	-	0.24^b	0.22^b	1.47^b	1.52^b	16.23^a
6	0.15^b	0.29^b	0.26^b	1.30^b	1.50^b	20.72^a
8	0.33^c	0.41^c	0.27^c	1.14^b	1.27^b	25.70^a
10	0.35^b	0.43^b	0.41^b	1.27^b	1.30^b	31.80^a

[1] Means within a column with different letters differ significantly ($p < 0.05$).
Control: no treatment with crosslinked β-CD and no addition of phytosterol.
Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.

Traditional mayonnaise is a mixture of egg, vinegar, oil and spices (especially mustard). Mayonnaise made in this fashion typically contains 70-80% fat. Generally, mayonnaise stability is dependent on several factors such as amount of oil, amount of egg yolk, viscosity, relative volume of oil phase to aqueous phase, method of mixing, water quality and temperature (Liu *et al.*, 2007).

Low-fat, low-cholesterol egg products could be used for the development of acceptable foodstuffs (Paraskevopoulou *et al.*, 1999) since substitution of yolk with other functional ingredients in food formulations impairs the flavor and mouthfeel of a product (Paraskevopoulou *et al.*, 1999). The stability and textural properties of highly concentrated emulsions such as mayonnaise (up to 80% oil content) depend to a great extent on the presence of whole egg or egg yolk constituents which stabilize the oil droplets against coalescence while at the same time are involved in complex interactions with the emulsion oil droplets resulting in the formation of a network that determines the rheological properties of the emulsion and especially its viscoelasticity (Paraskevopoulou *et al.*, 1999).

Sensory evaluation

The sensory aspects of cholesterol-reduced and phytosterol-added mayonnaise are shown in Table 4. Most of sensory aspects including yellowish color, spreadibility, mouthfeel, greasiness and overall acceptability did not show a significant difference among Trts throughout the storage periods. In the case of rancidity, Trts 2, 3 and 4 showed the lower rancidity score at 0 month storage than other groups. The score of stickiness in Trts 4 and 5 were significantly lower at all storage periods. Also, cholesterol-reduced groups showed the significantly lower score in bitterness at 0 and 2 month storage. The present study indicated that cholesterol-reduced mayonnaise containing less than 1.0% phytosterol could be developed as a commercial product in regarding of sensory aspects.

Acknowledgements

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Table 4. Sensory characteristics in cholesterol-reduced and phytosterol-added mayonnaise by crosslinked β-CD during storage at 7°C for 10 months[1]

Storage periods (mon)	Treatment	Appearance	Flavor	Texture			Taste		Overall acceptability
		Yellow color	Rancidity	Spreadability	Mouthfeel	Stickiness	Bitterness	Greasiness	
0	Control	3.9^{a}	3.6^{ab}	5.2^{a}	4.8^{a}	4.8^{a}	3.6^{a}	4.6^{a}	3.2^{b}
	Trt 1	3.4^{a}	3.4^{ab}	5.4^{a}	4.8^{a}	4.3^{a}	2.0^{b}	4.4^{a}	5.2^{a}
	Trt 2	3.2^{a}	2.3^{b}	5.3^{a}	5.1^{a}	3.7^{a}	1.4^{b}	5.2^{a}	4.7^{ab}
	Trt 3	3.6^{a}	3.0^{b}	5.0^{a}	5.1^{a}	4.2^{a}	2.8^{b}	4.8^{a}	4.9^{a}
	Trt 4	3.1^{a}	2.7^{b}	4.9^{a}	5.1^{a}	4.0^{a}	1.6^{b}	5.0^{a}	4.7^{ab}
	Trt 5	3.3^{a}	4.8^{a}	5.3^{a}	5.1^{a}	2.8^{b}	2.6^{ab}	4.8^{a}	4.2^{ab}
2	Control	3.7^{a}	3.8^{a}	5.6^{a}	5.1^{a}	4.3^{a}	2.8^{b}	4.3^{a}	4.2^{a}
	Trt 1	3.1^{a}	3.7^{a}	5.7^{a}	5.6^{a}	4.1^{a}	2.8^{b}	4.3^{a}	4.1^{a}
	Trt 2	2.8^{a}	3.1^{a}	5.7^{a}	5.1^{a}	4.0^{a}	2.8^{b}	4.6^{a}	3.4^{a}
	Trt 3	2.9^{a}	3.8^{a}	5.6^{a}	5.4^{a}	3.8^{a}	2.7^{b}	4.3^{a}	4.2^{a}
	Trt 4	2.9^{a}	4.3^{a}	5.4^{a}	4.8^{a}	2.8^{b}	3.7^{ab}	4.9^{a}	3.0^{a}
	Trt 5	2.8^{a}	4.2^{a}	5.6^{a}	5.1^{a}	3.5^{ab}	4.2^{a}	4.6^{a}	3.2^{a}
4	Control	3.6^{a}	3.6^{a}	5.7^{a}	4.6^{a}	4.7^{a}	2.8^{a}	4.6^{a}	4.8^{ab}
	Trt 1	3.6^{a}	3.9^{a}	5.6^{a}	4.7^{a}	4.1^{a}	2.9^{a}	4.4^{a}	5.1^{a}
	Trt 2	3.0^{a}	3.3^{a}	6.2^{a}	4.7^{a}	4.0^{ab}	3.2^{a}	5.2^{a}	3.1^{c}
	Trt 3	3.2^{a}	4.0^{a}	5.6^{a}	5.2^{a}	4.3^{ab}	2.7^{a}	4.8^{a}	4.9^{ab}
	Trt 4	3.4^{a}	4.4^{a}	5.6^{a}	4.4^{a}	3.1^{b}	3.6^{a}	5.0^{a}	3.6^{bc}
	Trt 5	3.0^{a}	3.8^{a}	5.6^{a}	5.3^{a}	3.0^{b}	3.3^{a}	4.8^{a}	3.8^{abc}
6	Conrol	3.2^{a}	3.7^{a}	5.7^{a}	4.4^{a}	3.7^{a}	3.6^{ab}	4.3^{a}	4.6^{a}
	Trt 1	3.7^{a}	3.9^{a}	6.0^{a}	5.0^{a}	3.7^{a}	3.6^{ab}	4.3^{ab}	4.3^{ab}
	Trt 2	3.6^{a}	3.2^{a}	5.9^{a}	5.1^{a}	3.1^{ab}	3.4^{b}	4.6^{a}	4.3^{ab}
	Trt 3	3.4^{a}	3.4^{a}	5.7^{a}	5.1^{a}	3.9^{a}	3.7^{ab}	4.3^{a}	4.0^{ab}
	Trt 4	3.4^{a}	3.7^{a}	5.9^{a}	5.3^{a}	2.8^{ab}	3.8^{ab}	4.9^{a}	3.3^{ab}
	Trt 5	3.3^{a}	3.9^{a}	6.2^{a}	5.1^{a}	2.4^{b}	4.8^{a}	4.6^{a}	3.1^{b}
8	Control	3.7^{a}	3.8^{a}	5.4^{ab}	5.1^{a}	4.7^{a}	3.6^{a}	4.4^{a}	4.2^{a}
	Trt 1	3.6^{a}	3.8^{a}	6.1^{a}	5.6^{a}	4.8^{a}	3.6^{a}	4.8^{a}	4.4^{a}
	Trt 2	3.0^{a}	4.0^{a}	5.8^{ab}	5.3^{a}	4.7^{a}	3.3^{a}	4.8^{a}	3.8^{a}
	Trt 3	3.4^{a}	3.8^{a}	5.8^{ab}	5.1^{a}	4.6^{a}	4.1^{a}	4.6^{a}	3.4^{a}
	Trt 4	3.4^{a}	3.9^{a}	5.3^{b}	5.0^{a}	3.6^{b}	3.8^{a}	4.9^{a}	3.1^{a}
	Trt 5	3.2^{a}	3.9^{a}	6.0^{ab}	5.1^{a}	4.0^{ab}	4.3^{a}	5.0^{a}	3.6^{a}
10	Control	3.6^{a}	3.8^{a}	5.4^{a}	5.1^{a}	4.7^{ab}	3.7^{a}	4.8^{a}	4.1^{a}
	Trt 1	3.4^{a}	3.9^{a}	5.3^{a}	5.4^{a}	4.8^{a}	3.7^{a}	5.1^{a}	4.3^{a}
	Trt 2	3.0^{a}	3.6^{a}	6.0^{a}	5.3^{a}	4.7^{ab}	3.6^{a}	5.1^{a}	3.3^{ab}
	Trt 3	3.2^{a}	3.9^{a}	5.3^{a}	5.2^{a}	4.7^{ab}	4.2^{a}	4.9^{a}	3.3^{ab}
	Trt 4	3.8^{a}	4.0^{a}	5.3^{a}	5.1^{a}	3.7^{b}	4.0^{a}	5.2^{a}	2.8^{b}
	Trt 5	3.3^{a}	4.0^{a}	5.3^{a}	5.1^{a}	3.7^{b}	4.6^{a}	5.3^{a}	2.6^{b}

[1]Means within a column with different letters differ significantly ($p < 0.05$).
Control: no treatment with crosslinked β-CD and no addition of phytosterol.
Trts 1-5: treatment with crosslinked β-CD and addition of 0, 0.5, 1.0, 1.5 or 2.0% phytosterol, respectively.
The scale of appearance, flavor, texture and taste: 1=very slight, 2=slight, 3=slight-moderate, 4=moderate, 5=moderate-strong, 6=strong and 7=very strong. The scale of overall score: 1=dislike extremely, 4=neither like nor dislike and 7=like extremely.

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