# Greek-Style Yogurt and Its Application in Cheesecake

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***Abstract*—The objective of this study was to use Greek-style yogurt as a cream cheese replacement in cheesecake products. Four treatments of Greek-style yogurts with two dried ingredients (skim milk powder: SMP, and sweet whey powder: SWP) and two levels of total solids in milk mixture (TSM: 15 and 25%) were manufactured in triplicate. The mean pH of SWP milk mixtures was lower than SMP milk mixtures. SMP and SWP yogurts had similar pH to CCC, but had higher moisture and lower fat content. Both yogurts at 25% TSM had higher protein content compared to CCC. SWP yogurt at 25% TSM had higher total sugar content as compared to other treatments and CCC. 9-Point hedonic scale was used to monitor sensory evaluation of no-bake cheesecake made with yogurts in comparison to CCC. SMP and SWP cheesecakes had lower smoothness, creaminess, and saltiness scores, while sourness scores were higher as compared to CCC cheesecake. Sweetness scores of SMP and SWP cheesecake at 25% TSM were higher than CCC cheesecake. Although overall acceptance of SMP and SWP cheesecakes were lower than CCC cheesecakes, the scores could still be interpreted as 'like slightly' to 'like moderately'. The results indicate that Greek-style SMP and SWP yogurt could be used instead of cream cheese to make lower-fat cheesecake with acceptable sensory scores.**

***Index Terms*—greek-style yogurt, cheesecake, low fat**

## I. Introduction

Greek yogurt (or yogurt cheese or labneh) is a yogurt that has been drained overnight to remove most of its liquid whey by straining through a cheese cloth. This whey removal results in a product with higher total solid and thick consistency in between traditional yogurt and cheese. Traditionally, Greek yogurt is made with only three main ingredients, which are milk, cream and bacterial cultures. To make traditional Greek-yogurt, it takes about 40 oz of milk, which was strained 3 times to make 16 oz of yogurt. To mimic traditional Greek yogurt, Greek-style yogurt has similar texture to that of Greek yogurt but may be thickened with other dried ingredients or thickening agents [1], [2]. A typical 170 grams serving of Greek and Greek-style yogurt contains 15 to 20 grams of protein, whereas an identical serving of traditional yogurt provides just about 9 grams. Greek and Greek-style yogurt contains 5 to 8 grams per serving of carbohydrate, which is approximately half of the carbohydrate as compared to the traditional yogurt. Since, the straining process removes some of the residual lactose, thus, making Greek and Greek-style yogurt less likely to cause any reaction consumers with lactose intolerance. With all of its nutritional benefits, the frequent consumption of Greek and Greek-style yogurt will make it a potentially ideal snack option for consumers with all ages [3], [4]. As a healthier alternative, Homemakers have often used Greek and Greek-style to replace cream cheese, sour cream, and mayonnaise [5]. Although there is a Standard of Identity for regular yogurt products, there is no Standard of Identity or legal definition to define a distinct manufacturing process for both Greek and Greek-style yogurts. Besides liquid whey removal, thicker consistency in Greek yogurt can also be achieved through addition of other dried dairy ingredients such as milk powders, whey solid products, sodium caseinate, and micellar casein concentrate prior to fermentation [6]-[8]. It was recently reported that it was feasible to incorporate skim milk powder or sweet whey powder to obtain 15 to 25% total solid in the initial milk mixture for Greek-style yogurt production [9]. In order to better understand Greek-style yogurt and its utilization, the objective of this research was to implement Greek-style yogurt with addition of different dried ingredients and to utilized Greek-style yogurt in cheesecake products.

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## II. Materials and Method

### A. Experimental Design

A 2×2 factorial design was utilized to make Greek-style yogurts. This design utilized two different dried ingredients (DI), which were skimmilk powder: SMP, and sweet whey powder: SWP, as shown in Fig. 1, and two levels of total solids in milk mixture (TSM: 15 and 25%) for a total of four treatments. The treatments were; TRT1 - SMP+15%TSM, TRT2 - SMP+25%TSM, TRT3 - SWP+15%TSM, TRT4 - SWP+25%TSM. Each treatment was manufactured Greek-style yogurt in triplicate.

### B. Manufacturing of Greek-Style Yogurt

Four Greek-style yogurts were manufactured with three replicates. For each replicate, commercial pasteurized whole milk (Dutch Mill Co., Ltd., Bangkok) was standardized with commercial spray dried SMP and


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SWP (Special Baker, Special Food Co., Ltd., Samutprakarn, Thailand) to obtain 15, 25, and 35% TSM. The milk mixture was batch-pasteurized at 65 ℃ for 30 min, homogenized with commercial blender (Electrolux Cruzo Blender EBR2601, Electrolux Thailand Co., Ltd., Bangkok), cooled down to 40-43 ℃ and inoculated with 5% starter culture from commercial natural yogurt (Yolida®, Sunrise Dairy Limited, Nakhonratchasima). The mixture was incubated at 43-45 ℃ for 6 hours, and was drained with the cheese cloth for 16 hours to remove liquid whey to obtain the final Greek-style yogurts.

### C. Compositional Analysis

The milk mixtures from four treatments were analyzed for pH prior to yogurt incubation. Greek-style yogurt samples obtained were analyzed for pH, moisture, protein, fat and total sugar in comparison to commercial cream cheese (CCC). pH of milk mixtures and yogurt samples was measured using a combination glass electrode and pH meter (Consort C830, Consort bvba, Turnhout, Belgium). Moisture content was analyzed gravimetrically, by drying 2.0g of Greek-style yogurt at 100 ℃ in a forced draft oven (Memmert Universal Oven UIS, Memmert GmbH + Co.KG, Germany) for 16h. Total protein was determined by measuring total nitrogen in Greek-style yogurts using the Kjeldahl method from AOAC official methods 991.20. Fat content was determined by using acid hydrolysis and petroleum ether extraction methods from AOAC official methods 948.15 and 945.16. Total sugar content was analyzed by using an HPLC-based method from AOAC Official Methods 980.13.

### D. Cheesecake Manufacture

A CRD design with five treatments was utilized to make no-bake cheesecakes according to recipe and direction from Ref. [10]. This design utilized four different treatments from SMP and SWP yogurts as cream cheese replacement and one control treatment from CCC (Kraft Original Philadelphia Cream Cheese, Mondelez International, Australia) for a total of five treatments. No-bake cheesecakes were manufactured as follows; twenty pieces of crackers were crushed until fine (Hup Seng Cream Crackers, Hup Seng Perusahaan Makanan (M) SDN. BHD., Malaysia), and crumbs of crushed crackers were mixed with 12 grams of sugar (Pure Refined Sugar, Mitr Phol, Thailand) and 12 grams of melted butter (Orchid Butter Blends Salted, The Thai Dairy Industry C., Ltd.) until well combined. The crumb mixture was pressed into a 9-inch pan, and chilled in freezer for 10 minutes. To make the filling, 450 grams of cream cheese (or Greek-style yogurts), 375 grams of sweetened condensed milk (Mali Sweetened Condensed Milk, The Thai Dairy Industry Co., Ltd.), 60 grams of fresh lime juice, and 3 grams of vanilla extract were beat using an electric mixture set at a medium-high speed until well combined. The filling was poured onto the crust and refrigerated for 3 hours before sensory analysis.

### E. Sensory Evaluation of Cheesecakes

9-Point hedonic scale was used to monitor sensory evaluation of no-bake cheesecake made with SMP and SWP yogurts in comparison to CCC. Sensory attributes were categorized into two groups: texture (firm, smooth, creamy) and taste (sour, salty, sweet, overall acceptance). A ballot for 9-point hedonic scale was adapted from Lawless and Heymann (1999).

*Panelist:* Ten judges from students and staff of the Food Science and Technology Program, Muban Chombueng Rajabhat University were recruited.

*Testing:* Five treatments with three replicates of cheesecakes were tested. The panelists were provided with one slice of chilled cheesecake one treatment at a time. The panelists were asked to indicate their hedonic response (liking response) to the sample on the 9-point scale.

### F. Statistical Analysis

*Compositional Analysis:* A 2×2 factorial model with three replications was used for statistical analysis, which involved 2 factors (DI and TSM) as class variables, and mean separation ($P$<0.05) by Tukey HSD Test, were used for the data analyses (Statistix 9).

*Sensory Evaluation:* Cheesecakes were manufactured in triplicate according to a CRD design. One-way ANOVA and mean separation $P$<0.05) by Tukey HSD Test, were used for the data analyses (Statistix 9).

## III. Results and Discussion

### A. Compositional Analysis

From Table I, pH of milk mixture was significantly affected ($P$<0.05) only by DI, while pH of yogurt and total sugar were significantly affected ($P$<0.05) by DI, TSM and an interaction between DI and TSM. pH values of milk mixture with SWP addition were significantly lower than pH values of milk mixture with SMP addition at both TSM levels (Table II). Since SWP is a by-product of liquid whey from cheese manufacture, its acidity is lower than that of SMP from normal milk. In addition, the handling and storage condition of liquid whey during SWP processing could also cause the continuing fermentation of liquid whey, which could also cause SWP to reach lower acidic pH [11]. pH values of yogurt samples with SWP addition were significantly higher when TSM levels were increased. The higher pH obtained could be due to the buffering capacity of yogurt. In general, yogurts have maximum buffering capacity at two pH ranges, which are 3.6 and between 5 and 6. The addition of dried ingredients in the milk mixture could provide additional buffering capacity in the final yogurt due to the buffering action of the additional proteins, phosphates, citrates, lactates and other milk components; thus, resisting a pH reduction in yogurt [12]. Mean moisture content from both SMP and SWP yogurts decreased with increased amount of TSM, which was probably due to an addition of dried ingredients that could contribute to more total solid in the final yogurts. Protein content from both SMP and SWP yogurts increased with increased amount of TSM. This phenomena was simply due to the addition of dried ingredients since the amount of protein was as high as 34-

37% in SMP [13] and 11-14.5% in SWP [14]. Fat content from both SMP and SWP yogurts decreased with increased amount of TSM, which could be due to a dilution effect of higher moisture content and higher total solids in the treatments with higher TSM.

TABLE I. MEAN SQUARES AND PROBABILITIES (IN PARENTHESES) OF PH, MOISTURE (%), PROTEIN (%), FAT(%), AND TOTAL SUGAR OF GREEK-STYLE YOGURT FROM DIFFERENT TREATMENTS.

| Factors | df | pH of Milk Mixture | pH of Yogurt | Moisture (%) |
|---|---|---|---|---|
| DI | 1 | 0.85* (<0.001) | 0.12* (0.002) | 0.30 (0.58) |
| TSM | 1 | $1.33\times10^{-2}$ (0.17) | $7.84\times10^{-2}$* (0.005) | 64.15* (<0.001) |
| DI×TSM | 1 | $5.30\times10^{-4}$ (0.72) | $4.44\times10^{-2}$* (0.002) | $6.39\times10^{-2}$ (0.79) |
| Error | 6 | $3.73\times10^{-3}$ | $4.28\times10^{-3}$ | 0.87 |
| Factors | df | Protein (%) | Fat (%) | Total Sugar (%) |
| DI | 1 | 1.84* (<0.001) | 4.08×10-2 (0.26) | 32.67* (<0.001) |
| TSM | 1 | 5.47* (<0.001) | 5.47* (<0.001) | 22.40* (<0.001) |
| DI×TSM | 1 | 0.14 (0.07) | 4.08×10-2 (0.26) | 10.45* (<0.001) |
| Error | 6 | 2.89×10-2 | 2.64×10-2 | 2.81×10-2 |

*Statistically significant at *P*-value < 0.05.

Total sugar content in final yogurts were significantly highest with SWP yogurt at 25% TSM, which could be due to the higher amount of initial lactose in the milk mixture. Normally, commercial yogurts contain approximately 4-5% residual lactose [15]; thus, available lactose in the milk mixture is only partially utilized by starter lactic bacteria with the production of lactic acid during yogurt manufacture. With the amount of lactose as high as 70% in SWP [16], this could result in higher residual lactose left in the final yogurts. In addition, it has been reported that the level of TSM in excess of 25% could inhibit starter culture activity by affecting the availability of moisture content. Thus, lactose content is less fermented and lactic acid production is reduced, thus, resulting in higher residual lactose and higher pH in final yogurts [17]. As compared to CCC, SMP and SWP yogurts with both TSM had similar pH to that of CCC. Moisture content from both SMP and SWP yogurts were about 10-15% higher than that from CCC, which could be due to the lower total solid content in yogurts. Protein content from SMP yogurts with both TSM were slightly higher than that from CCC, while only SWP yogurt with 25% had slightly higher protein content as compared to that from CCC, which was probably due to the protein content from added dried ingredients. Fat content from both SMP and SWP yogurts were more than 20% lower than fat content from CCC, which was an exceptional benefit of Greek-style yogurt. Since most of the sugar in milk and dairy products is lactose, it is probably safe to assume that total sugar from SMP yogurts with both TSM and total sugar from SWP yogurt at 15% TSM were similar that from CCC as expressed in % lactose. However, total sugar in SWP yogurt with 25% TSM was significantly higher than that of CCC, which was clearly due to the high amount of lactose (about 70%) in SWP [16].

TABLE II. MEAN VALUES OF PH OF MILK MIXTURE, PH OF YOGURT, MOISTURE (%), PROTEIN (%), FAT (%), AND TOTAL SUGAR (%) OF GREEK-STYLE YOGURTS FROM DIFFERENT TREATMENTS.

| Mean value* | Commercial Cream Cheese** | Treatments | | | |
|---|---|---|---|---|---|
| | | Skimmilk Powder | | Sweet Whey Powder | |
| | | Total Solid in Milk Mixture (%) | | Total Solid in Milk Mixture (%) | |
| | | 15 | 25 | 15 | 25 |
| pH of Milk Mixture | NA | $6.60^{a}$ | $6.55^{a}$ | $6.08^{b}$ | $6.00^{b}$ |
| pH of Yogurt | 4.4-4.9 | $4.45^{b}$ | $4.49^{b}$ | $4.53^{b}$ | $4.81^{a}$ |
| Moisture (%) | 55 | $71.44^{a}$ | $66.67^{b}$ | $71.61^{a}$ | $67.14^{b}$ |
| Protein (%) | 8-10 | $10.07^{c}$ | $11.20^{a}$ | $9.07^{d}$ | $10.63^{b}$ |
| Fat (%) | 33 | $10.63^{a}$ | $9.40^{b}$ | $10.87^{a}$ | $9.40^{b}$ |
| Total Sugar (%) | (% Lactose) 2-3 | $2.20^{c}$ | $3.30^{b}$ | $3.63^{b}$ | $8.47^{a}$ |

*$^{a,b,c}$ Means within the column not sharing common superscripts are different (Tukey's HSD at $P < 0.05$).
**Adapted from Phadungath (2005).

### B. Sensory Evaluation of Cheesecakes

A CRD design with five treatments was utilized to make no-bake cheesecakes according to recipe and direction from Ref. [10]. Cheesecakes obtained are shown in Fig. 1. 9-Point hedonic scale was used to monitor sensory evaluation of no-bake cheesecakes.

Sensory attributes were categorized into two groups, which were texture (firm, smooth, creamy) and taste (sour, salty, sweet, overall acceptance). A ballot for 9-point hedonic scale was adapted from Ref. [18]. The mean squares and P-values of sensory attributes are shown in Table III, and mean values are shown in Fig. 2. Smoothness, creaminess, sourness, sweetness, and overall acceptance were significant different (P<0.05) among treatments, while firmness and saltiness were not different.

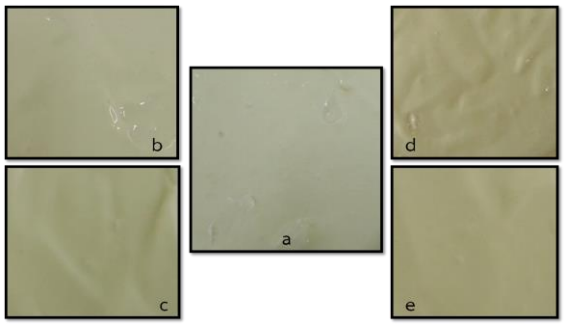


Figure 1. Cheesecakes from five treatments: a). TRT1 - control, b). TRT2 - 15%SMP cheesecake, c). TRT3 - 25%SMP cheesecake, d). TRT4 - 15%SWP cheesecake, e). TRT5 - 25%SWP cheesecake.

From Fig. 2, cheesecakes from TRT 4 and 5, which were cheesecakes made with 15 and 25% SWP had the lowest smoothness scores. According to Ref. [19], smoothness attribute could be described as 'the degree of

dissolving and melting in the mouth without sensation of coarseness'. Since lactose in SWP might exist in both crystalline and amorphous forms [20], it is likely that lactose crystalline from SWP contributed to the coarseness of the sample, which caused the lowest smoothness score. Creaminess score of cheesecake from TRT 1, which was made with CCC was significantly highest when compared to others. It has been reported that fat-related attributes, including fatty mouthfeel and creamy texture, increased with increasing fat content [21]. Since cream cheese had more than 20% fat content than SMP and SWP yogurts (Table II), it is likely that cheesecake made with cream cheese would exhibit creamier texture than cheesecakes made with SMP and SWP yogurts. For the sweetness scores, it is as expected that cheesecake from TRT 5, which was cheesecake made with 25% SWP, would have the highest sweetness score, since SWP yogurt with 25% TSM had the highest amount of total sugar (Table II). Finally, although overall acceptance of cheesecakes made with SMP and SWP yogurts were lower than that of CCC cheesecakes, the scores could still be interpreted as 'like slightly' to 'like moderately'. The results indicated that Greek-style SMP and SWP yogurt at 15 and 25% TSM could be used instead of cream cheese to make lower-fat cheesecake with acceptable sensory scores.

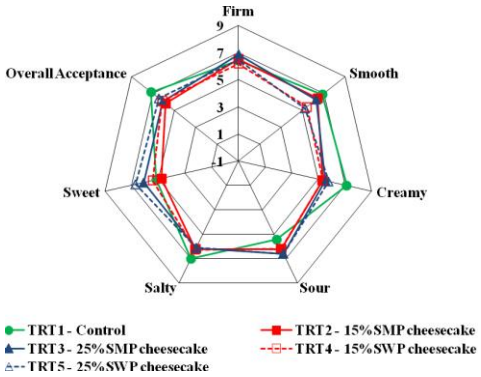


Figure 2. Sensory evaluation of cheesecakes. Five treatments are: (●) TRT1 - Control cheesecake, (▲) TRT2 - 15%SMP cheesecake, (■) TRT3 - 25%SMP cheesecake, (△) TRT4 - 15%SWP cheesecake, (□) TRT5 - 25%SWP cheesecake.

TABLE III. MEAN SQUARES AND PROBABILITIES (IN PARENTHESES) OF SENSORY ATTRIBUTES FROM 9-POINT HEDONIC SCALE OF CHEESECAKES FROM DIFFERENT TREATMENTS.

| Factors | df | Firm | Smooth | Creamy | Sour |
|---|---|---|---|---|---|
| Treatments | 4 | 1.72 (0.47) | 32.72* (<0.001) | 17.13* (<0.001) | 6.81* (0.04) |
| Replicate | 2 | 0.17 | 0.72 | 5.46 | 0.09 |
| Error | 143 | 1.93 | 2.96 | 2.12 | 1.75 |
| Factors | df | Salty | Sweet | Overall Acceptance | |
| Treatments | 4 | 4.13 (0.07) | 18.27* (<0.001) | 8.24* (0.04) | |
| Replicate | 2 | 1.13 | 1.34 | 1.22 | |
| Error | 143 | 1.89 | 1.49 | 2.08 | |

*Statistically significant at *P*-value<0.05.

## IV. CONCLUSIONS

Different dried ingredients and different level of initial total solid in the milk mixture had an impact on pH of final yogurt samples, moisture content, protein content, fat content and total sugar content. As compared to CCC, SMP and SWP yogurts with both TSM had similar pH to that of CCC. Moisture content from both SMP and SWP yogurts were about 10-15% higher than that from CCC. Protein content from SMP yogurts with both TSM were slightly higher than that from CCC, while only SWP yogurt with 25% had slightly higher protein content as compared to that from CCC. Fat content from both SMP and SWP yogurts were more than 20% lower than fat content from CCC, which was an exceptional benefit of Greek-style yogurt. In addition, 9-point hedonic scale was used to monitor sensory evaluation of no-bake cheesecake made with SMP and SWP yogurts in comparison to CCC. Sensory scores indicated that SMP and SWP cheesecakes had lower smoothness, creaminess, and saltiness scores, while sourness scores were higher as compared to those of CCC cheesecake. Sweetness scores of SMP and SWP cheesecake at 25% TSM were higher than that of CCC cheesecake. Although overall acceptance of SMP and SWP cheesecakes were lower than that of CCC cheesecakes, the scores could still be interpreted as 'like slightly' to 'like moderately'. The results suggest that Greek-style SMP and SWP yogurt could be used instead of cream cheese to make lower-fat cheesecake with acceptable sensory scores.

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Her current research interests include processing and utilization of Greek and Greek-style yogurt, and she was recently awarded a research grant on the study of local wisdom and nutritional value of Karen chili paste in Ratchaburi Province, Thailand from Office of the Higher Education Commission, Thailand.