Reconstituted yogurt from yogurt cultured milk powder mix has better overall characteristics than reconstituted yogurt from commercial yogurt powder

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ABSTRACT

For manufacture of commercial yogurt powder, yogurt has to go through a drying process, which substantially lowers the yogurt culture counts, so the potential health benefits of the yogurt culture bacteria are reduced. Also, upon reconstitution, commercial yogurt powder does not taste like yogurt and has an off-flavor. The objective was to study the microbial, physicochemical, and sensory characteristics of reconstituted yogurt from yogurt cultured milk powder (YCMP) mix and reconstituted yogurt from commercial yogurt powder (CYP). The CYP reconstituted yogurt was the control and YCMP mix reconstituted yogurt was the treatment. Microbial and physicochemical characteristics of the CYP reconstituted yogurt and YCMP mix reconstituted yogurt were analyzed daily for the first week and then weekly for a period of 8 wk. Sensory consumer testing of CYP reconstituted yogurt and YCMP mix reconstituted yogurt was conducted with 100 consumers. At 56 d, YCMP mix reconstituted yogurt had 5 log cfu/mL higher counts of *Streptococcus thermophilus* than the control (CYP reconstituted yogurt). Also, *Lactobacillus bulgaricus* counts of YCMP mix reconstituted yogurt were 6.55 log cfu/mL at 28 d and were 5.35 log cfu/mL at 56 d, whereas the CYP reconstituted yogurt from 28 d onwards had a count of <10 cfu/mL. The YCMP mix reconstituted yogurt also had significantly higher apparent viscosity and sensory scores for appearance, color, aroma, taste, thickness, overall liking, consumer acceptability, and purchase intent than CYP reconstituted yogurt. Overall, YCMP mix reconstituted yogurt had more desirable characteristics than CYP reconstituted yogurt.

Key words: yogurt, powder, reconstituted

INTRODUCTION

According to the Code of Federal Regulations (21 CFR 131.200), yogurt is the food produced by culturing

cream, milk, partially skim milk, or skim milk, used alone or in combination, with lactic acid-producing bacteria *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*. Yogurt has a titratable acidity (TA) of not less than 0.9%, expressed as lactic acid (21 CFR 131.200). The yogurt market has grown considerably since 2003. Yogurt sales and consumption have increased in the last 5 yr (IDFA 2009, 2010, 2011, 2012, 2013). Generally, the recommended total number of active yogurt culture bacteria at the time of consumption should be a minimum of 10^7 cfu/g (Chandan, 1999). To confer health benefits, probiotic bacteria should be viable at the time of consumption at a recommended concentration of 6 to 8 log cfu/g (Ross et al., 2005; Vasiljevic and Shah, 2008).

Many potential health and nutritional benefits from lactic acid bacteria exist. These include improved digestion of lactose and control of intestinal infections, some types of cancer, and serum cholesterol levels (Gilliland, 1990). Some *L. delbrueckii* ssp. *bulgaricus* strains have immunological effects (Ebina et al., 1995; Kitazawa et al., 1998; Kitazawa et al., 2003). Certain strains of *S. thermophilus* produce bacteriocins. Some studies have characterized several bacteriocins (e.g., thermophilin 110 and thermophilin 1277) produced by *S. thermophilus* that are active against *Pedococcus acidilactici*, *Clostridium butylicum*, *Clostridium sporogenes*, *Clostridium botulinum*, *Bacillus cereus*, and *Listeria monocytogenes* (Gilbreth and Somkuti, 2005; Kabuki et al., 2009). To improve the health benefits, the recent trend is to add *Lactobacillus acidophilus* to yogurt (Ashraf and Shah, 2011). *Lactobacillus acidophilus* may prevent diarrhea in children and adults, and it is especially effective in treating rotavirus in children (Lee et al., 2001; Allen et al., 2009). Other health benefits associated with *L. acidophilus* include anticarcinogenic properties, reduction in blood pressure and serum cholesterol concentration, and increased resistance to infectious diseases (Ashraf and Shah, 2011).

Generally, yogurt is dried by spray drying, microwave vacuum drying, or freeze-drying. Each drying method has its benefits and drawbacks. Survival of yogurt bacteria is affected by the outlet temperature in the spray drying process. According to Bielecka and Majkowska

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(2000), the best survival at an outlet temperature range of 70 to 75°C was 13.7 to 15.8% for *L. delbrueckii* ssp. *bulgaricus* and 51.6 to 54.7% for *S. thermophilus*. At temperatures below 60°C, wet powder was obtained, whereas at above 90°C, the powder was not acceptable due to browning (Kim and Bhowmik, 1990). In addition, it has been reported that most of the aroma compounds and rheological characteristics of yogurt are lost during the spray-drying process (Kumar and Mishra, 2004). The approximate survival of culture bacteria was 50% in microwave vacuum-dried yogurt below 45°C (Kim et al., 1997). Freeze-dried yogurt has the best flavor and is the more authentic product compared with those obtained using other conventional drying methods (Rybka and Kailasapathy, 1997). The survival of lactic acid bacteria in freeze-dried yogurt was only 50 to 60% (Radaeva et al., 1975). Freeze-drying is the most expensive form of drying and generally not commercially feasible for manufacturing large quantities of yogurt powder.

Yogurt powder can be used in a wide variety of food applications, including instant yogurt and replacement of fresh yogurt for beverage and dip. It can also be used in snacks, confections, bakery items and breakfast cereals, ice cream bars, and yogurt-coated nuts. Upon reconstitution, yogurt powder does not taste like yogurt; it is off-flavored. However, yogurt powder provides longer and more stable shelf life than that of regular yogurt. Moreover, the reduced weight and bulk water of this dehydrated product decreases packaging, handling, and transportation costs. This product is very convenient for consumers to use, as it can be stored at ambient temperature for a long shelf life. Internationally, consumers do not always have access to purchasing natural yogurt in supermarkets. A powdered version can also be shipped to natural calamity areas or for food aid to less-fortunate countries. Other than providing nutrition, a food product also providing convenience in storage and consumption would be an added advantage. For a reconstituted yogurt, consumers would just need to add the powder to water and stir to mix well. The yogurt and yogurt drink market has benefited greatly as consumers have paid greater attention to healthy eating. In the food industry, it is important to produce a high-quality food product with a low cost. Upon reconstitution, having a better quality product than is currently available is desirable and would be beneficial to both the food industry and consumers. Further study on the parameters of this kind of reconstituted yogurt is also valuable. Industry manufactures and sells milk powder but preparation of reconstituted milk is an application at the consumer/household end. This is also true for other industries,

such as the vegetable juice powder and fruit juice powder industries. This same concept is being applied here to yogurt cultured milk powder (YCMP) mix, which can be a future industry endeavor, and reconstituted yogurt can be the application at the consumer end for convenience in storage and consumption.

The purpose of this study was to determine whether reconstituted YCMP mix would have higher culture bacterial counts and better physicochemical and sensory characteristics than reconstituted commercial yogurt powder (CYP) currently available. The specific objectives of this study were to (1) enumerate *S. thermophilus*, *L. delbrueckii* ssp. *bulgaricus*, *Escherichia coli*/coliforms, and yeasts and molds of reconstituted CYP and reconstituted YCMP mix up to 8 wk; (2) elucidate the influence on the physicochemical characteristics (pH, TA, color, and apparent viscosity) of reconstituted CYP and YCMP mix up to 8 wk; and (3) study the sensory characteristics of CYP, YCMP mix, and YCMP mix with *L. acidophilus* (YCMPA) upon reconstitution and determine the consumer acceptability of the product.

MATERIALS AND METHODS

Reconstituted Yogurt Manufacture

Reconstituted yogurt formulations are shown in Table 1. The CYP was whey and nonfat milk mixed together, cultured, and spray dried to obtain the nonfat yogurt powder (DairiConcepts LP, Springfield, MO).

Commercial yogurt powder reconstituted yogurt was manufactured with nonfat yogurt powder (DairiConcepts LP), water, and blueberry puree (Sensient Tech-

Table 1. Reconstituted commercial yogurt powder (CYP) and reconstituted yogurt-cultured milk powder mix (YCMP) formulations

Ingredient	Formulation	
	CYP, g	YCMP mix, g
Commercial yogurt powder	948.4	0
Nonfat dry milk	0	810
Water	2,700	2,700
Blueberry puree ¹	720	720
Citric acid ²	0	23.4
Pectin ³	0	72
Yogurt starter culture ³	0	43

¹Sensient Technologies Corp. (Milwaukee, WI).

²Anhydrous, coarse granular 14 to 30 mesh (Sungai Budi Group, Jakarta Selatan, Indonesia).

³Low-methoxyl pectin (Gum Technology Inc., Tucson, AZ).

⁴A blend at a 1:1 ratio of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus* (FD-DVS YC-380; Chr. Hansen Inc., Milwaukee, WI).

nologies Corp., Milwaukee, WI). Water was preheated to 40°C and nonfat yogurt powder was added to the 40°C water and stirred, which was followed by addition of blueberry puree and subsequent stirring to make CYP reconstituted yogurt, which was then cooled to 4°C until further analysis.

Yogurt cultured milk powder mix reconstituted yogurt was manufactured with instant, low-heat, nonfat dry milk; freeze-dried yogurt starter culture (a blend at a 1:1 ratio of *L. delbrueckii* ssp. *bulgaricus* and *S. thermophilus*; FD-DVS YC-380; Chr. Hansen Inc., Milwaukee, WI); pectin (low-methoxyl pectin; Gum Technology Inc., Tucson, AZ); citric acid (anhydrous, coarse granular 14–30 mesh; Sungai Budi Group, Jakarta Selatan, Indonesia); water; and blueberry puree (Sensient Technologies Corp.). After preheating the water to 40°C, all dry ingredients were added to the 40°C water and stirred, which was followed by blueberry puree addition and subsequent stirring to make YCMP mix reconstituted yogurt, which was then cooled to 4°C until further analysis.

Total solids content in both CYP reconstituted yogurt and YCMP mix reconstituted yogurt were kept constant at 26% (wt/wt). Product manufacture was replicated 3 times.

Yogurt cultured milk powder mix with *L. acidophilus* reconstituted yogurt, for the sensory evaluation study, was manufactured by adding 1% (wt/wt) freeze-dried *L. acidophilus* (LYO 100 DCU-S, HOWARU; Chr. Hansen Inc.) to the YCMP mix. All dry ingredients were added to the 40°C water and stirred, which was followed by blueberry puree addition and subsequent stirring to make YCMPA mix reconstituted yogurt, which was then cooled to 4°C.

Experimental Design

This study consisted of CYP reconstituted yogurt as the control and YCMP mix reconstituted yogurt as the treatment. For the first and second objectives, microbial and physicochemical characteristics of the reconstituted yogurts were analyzed daily for the first week and then weekly for a period of 8 wk (1, 2, 3, 4, 5, 6, 7, 14, 21, 28, 35, 42, 49, and 56 d) after reconstitution. Three replications of each treatment were conducted. For the third objective, consumer tests of sensory characteristics of reconstituted yogurts from YCMP mix, YCMPA mix, and CYP were conducted with 100 panelists. The experimental design for sensory evaluation was a randomized block design with panelists as blocks. The experimental design for microbial counts, pH, TA, and apparent viscosity was a randomized block design with repeated measures in time with replications as blocks.

Preparation of Media

Peptone water (0.1%) was prepared by dissolving 1 g of peptone medium (Bacto Peptone, Difco; Becton, Dickinson and Co., Sparks, MD) in 1 L of distilled water, and then autoclaving in 99-mL portions at 121°C for 15 min. *Streptococcus thermophilus* agar and lactobacilli de Man, Rogosa, and Sharpe (MRS) agar with pH adjusted to 5.2 were prepared according to Dave and Shah (1996).

Growth of *S. thermophilus* and *L. delbrueckii* ssp. *bulgaricus*

Growth of *S. thermophilus* and *L. delbrueckii* ssp. *bulgaricus* was determined by pour plating. One gram of yogurt samples was serially diluted with 99 mL of sterilized 0.1% peptone water (Difco Laboratories Inc., Detroit, MI). One milliliter of diluted samples was pipetted into Petri dishes and then pour plated. Lactobacilli MRS agar adjusted to pH 5.2 was prepared for *L. delbrueckii* ssp. *bulgaricus* and *S. thermophilus* agar for *S. thermophilus*. For *S. thermophilus*, pour plates were incubated aerobically at 37°C for 24 h and for *L. delbrueckii* ssp. *bulgaricus*, pour plates were incubated anaerobically at 43°C for 72 h before counting colonies (Dave and Shah, 1996; Tharmaraj and Shah, 2003).

Escherichia coli/Coliform and Yeast and Mold Counts

Escherichia coli/coliform and yeast and mold counts were performed after reconstitution of CYP and YCMP by using *E. coli*/coliform Petrifilm (3M, St. Paul, MN) containing violet red bile agar for *E. coli*/coliform, and yeast and mold Petrifilm (3M) for yeasts and molds. The procedure was performed by weighing 11 g of CYP and YCMP samples and diluting into 99 mL of sterilized 0.1% peptone water (Difco Laboratories Inc.) separately. Dilutions of 10^{-1} and 10^{-2} were prepared and 1 mL of the dilutions was plated in duplicate on previously labeled Petrifilm and incubated at 32°C for 24 h for *E. coli*/coliform and 25°C for 120 h for yeasts and molds. The colonies were counted after the incubation.

pH

The pH was measured after reconstitution of CYP and YCMP mix by using an Oysters Series pH meter (Extech Instruments Corp., Waltham, MA). The pH meter was calibrated using commercial pH 4.00 and 7.00 buffers (Fisher Scientific, Fair Lawn, NJ) and the

temperature setting of the pH meter was adjusted to the temperature of sample ($8 \pm 2^\circ\text{C}$) before reading.

TA

The TA was measured after reconstitution of CYP and YCMP mix without any blueberry puree by weighing 9 g of yogurt, adding 5 drops of phenolphthalein as an indicator solution, and titrating with 0.1 *N* NaOH to a faint pink end point.

Apparent Viscosity

The apparent viscosity was measured after reconstitution of CYP and YCMP mix using a viscometer (Brookfield model DV-II and Helipath Stand; Brookfield Engineering Laboratories Inc., Stoughton, MA). According to measurement recommendations, to obtain a torque between 10 and 90%, 2 different spindles were used. For CYP, an RV1 spindle was used at a speed of 50 rpm and for YCMP an RV4 spindle was used at a speed of 5 rpm. The RV spindle was inserted in the center of the sample at a constant depth of 2 cm from the top level of the sample. The Helipath was set in downward motion to cut circular layers at increasing depths of the sample. Dimensions of containers that held samples were as follows: top diameter = 7.5 cm, bottom diameter = 6 cm, and height = 9 cm. The apparent viscosity was determined at $8 \pm 2^\circ\text{C}$ and was continuous over the 33 s that were required to collect 100 data points acquired by the computer using Wingather 32 software (Brookfield Engineering Laboratories Inc.).

Sensory Evaluation

The sensory evaluation was exempted from continued oversight by the Louisiana State University Institutional Review Board through exemption number HE13-12. The sensory evaluation was conducted with 100 random participants including students and faculty at Louisiana State University. Three treatments: CYP, YCMP mix, and YCMPA mix, upon reconstitution, were packed into three 60-g plastic cups and provided to participants in random order, using identical cups coded with 3-digit random numbers.

Participants were instructed not to talk to others during the evaluation and instructed to clean their palate between each sample with the purified water and unsalted saline crackers. The participants were given a sample of approximately 30 g per treatment per replication and were asked to evaluate it. The evaluation form consisted of a 9-point rating scale, ranging from 1 = dislike extremely to 9 = like extremely, to evaluate

appearance, color, aroma, taste, thickness, powderiness, overall liking, and yes/no questions for acceptability and purchase intent of the products.

Statistical Analysis

The results for microbial and physicochemical characteristics were analyzed using PROC GLM of SAS (9.3; SAS Institute Inc., Cary, NC). Differences of least squares means were used to determine significant differences at $P < 0.05$ for main effects (treatment and day) and interaction effect (treatment $\times$ day). Significant differences ($P < 0.05$) among the main effects were analyzed using the Tukey adjustment. The results for sensory evaluation were subjected to PROC ANOVA of SAS. Data are presented as mean $\pm$ standard deviation of the mean.

RESULTS AND DISCUSSION

Streptococcus thermophilus

The counts of *S. thermophilus* in CYP and YCMP mix reconstituted yogurts during 8 wk of storage are shown in Figure 1. The treatment $\times$ day interaction effect was not significant ($P = 0.077$), whereas the treatment effect ($P < 0.0001$) and day effect ($P < 0.0001$) were significant.

Logarithmic mean counts of *S. thermophilus* in YCMP mix reconstituted yogurt were more than 3 times higher than logarithmic mean counts of *S. thermophilus* in CYP reconstituted yogurt (Figure 1). Because the CYP was manufactured by the spray-drying process, this significant difference may be explained by low survival rates during spray drying of the cultures and low stability during storage (Peighambardoust et al., 2011). The increase in the lag phase before the onset of growth means that spray-dried starter cultures cannot be used for inoculation in dairy fermentations directly (Boza et al., 2004).

During the storage period of 8 wk, the counts of *S. thermophilus* observed at d 1, 2, and 5 were significantly ($P < 0.05$) higher than the counts observed at d 28, 35, 42, 49, and 56. Michael et al. (2010) also reported that the counts of *S. thermophilus* declined from 9 to 8 log cfu/mL in yogurt during a storage period of 50 d.

Lactobacillus delbrueckii ssp. *bulgaricus*

The counts of *L. delbrueckii* ssp. *bulgaricus* in CYP and YCMP reconstituted yogurts during the 8 wk of storage are shown in Figure 2. The treatment $\times$ day interaction effect was significant ($P = 0.0060$).

Figure 1. Logarithmic mean counts $\pm$ SD of *Streptococcus thermophilus* for reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix during 56 d of storage at $4 \pm 1^\circ\text{C}$.

The YCMP mix reconstituted yogurt *L. delbrueckii* ssp. *bulgaricus* counts were significantly higher than the CYP reconstituted yogurt over 8 wk of storage (Figure 2). In the spray-drying process, the number of *L. delbrueckii* ssp. *bulgaricus* decreased with increased outlet or inlet air temperature and atomizing air pressure (Kim and Bhowmik, 1990). Bielecka and Majkowska (2000) reported that the best survival was 13.7 to 15.8% for *L. delbrueckii* ssp. *bulgaricus* and 51.6 to 54.7% for *S. thermophilus* at an outlet temperature range of 70 to 75°C . Therefore, it is likely that the commercial yogurt powder contained a low concentration of *L. delbrueckii* ssp. *bulgaricus* and *S. thermophilus*.

During the 8-wk storage period, the counts of *L. delbrueckii* ssp. *bulgaricus* in CYP reconstituted yogurt observed during the first 2 wk (d 1, 2, 3, 4, 5, 6, 7, and 14) were significantly higher than the counts observed during wk 3. The viable counts in CYP reconstituted yogurt decreased to <10 cfu/mL from d 28 onwards (Figure 2). The counts of *L. delbrueckii* ssp. *bulgaricus* in YCMP mix reconstituted yogurt observed during the first 2 wk (d 1, 2, 3, 4, 5, 6, 7, and 14) were significantly higher than the counts observed during the last 6 wk (d 21, 28, 35, 42, 49, and 56). Furthermore, the counts observed at d 21, 28, and 35 were significantly ($P < 0.05$)

higher than counts observed at d 42, 49, and 56 (Figure 2). The higher counts of *L. delbrueckii* ssp. *bulgaricus* in CYP reconstituted yogurt were obtained in the first 3 wk in the range of 1.86 to 0.67 log cfu/mL. Similarly, the higher counts of *L. delbrueckii* ssp. *bulgaricus* in YCMP mix reconstituted yogurt were obtained in the first 2 wk in the range of 7.52 to 7.14 log cfu/mL. The viable counts decreased to the lowest at 56 d (Figure 2). Michael et al. (2010) also reported that the growth of *L. delbrueckii* ssp. *bulgaricus* declined from 8 to 3 log cfu/mL in yogurt during a storage period of 50 d.

Escherichia coli/Coliforms, Yeasts, and Molds

No *E. coli*/coliform bacteria were observed in either CYP reconstituted yogurt or YCMP reconstituted yogurt during the 8-wk storage period. Also, there were no detectable *E. coli*/coliform counts within the ingredients of CYP reconstituted yogurt and YCMP reconstituted yogurt. Therefore, it appears that no food safety issues would exist related to *E. coli*/coliforms in these reconstituted yogurt products. Growth of yeast and mold in CYP and YCMP reconstituted yogurts

Figure 2. Logarithmic mean counts $\pm$ SD of *Lactobacillus delbrueckii* ssp. *bulgaricus* for reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix during 56 d of storage at $4 \pm 1^\circ\text{C}$.

Figure 3. Logarithmic mean counts $\pm$ SD of yeast and mold for reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix during 56 d of storage at $4 \pm 1^\circ\text{C}$.

during the 8-wk storage is shown in Figure 3. The treatment $\times$ day interaction effect ($P = 0.99$) and treatment effect ($P = 0.48$) were not significant, whereas the day effect was significant ($P < 0.0001$). Commercial yogurt powder reconstituted yogurt had detectable yeast and mold counts 1 wk earlier than YCMP reconstituted yogurt, but no detectable counts were obtained in the first 2 wk after the reconstitution (Figure 3). Although one would not be expected to keep the reconstituted yogurt for more than 1 wk, this study was extended to determine what would happen if reconstituted products were stored that long. Both the CYP and YCMP reconstituted yogurts were safe in the first week of refrigerated storage.

Apparent Viscosity

The apparent viscosity of CYP and YCMP mix reconstituted yogurts during the 8 wk of storage is shown in Figure 4. The treatment $\times$ day interaction effect ($P = 0.29$) and day effect ($P = 0.31$) were not significant, whereas the treatment effect was significant ($P < 0.0001$).

The mean apparent viscosity of YCMP mix reconstituted yogurt was significantly ($P < 0.05$) higher than the mean apparent viscosity of CYP reconstituted yogurt. It is not likely that the CYP reconstituted yogurt contained stabilizers such as pectin, as the CYP reconstituted yogurt was unstable, forming 2 distinct layers of settled solids and serum on top after 3 d of reconstitution, and these layers progressed with time. In contrast, YCMP mix reconstituted yogurt was uniform

during the entire 56 d of refrigerated storage, showing no whey separation. Flavored yogurt drinks are made with pectin to improve and stabilize the viscosity (Tamime and Robinson, 1985). Basak and Ramaswamy (1994) reported that pectin and strawberry concentrate had a considerable effect on the flow behavior with yield stress of stirred yogurt.

pH

The pH of CYP reconstituted yogurt and YCMP mix reconstituted yogurts during the 8 wk of storage is shown in Figure 5. The treatment $\times$ day interaction effect was not significant ($P = 0.64$), whereas the treatment effect ($P < 0.0001$) and day effect ($P = 0.0033$) were significant.

The mean pH value of YCMP mix reconstituted yogurt was significantly ($P < 0.05$) higher than the mean pH value of CYP reconstituted yogurt. The pH value observed at d 5 was significantly ($P < 0.05$) higher than the pH observed at d 42, 49, and 56. Gueimonde et al. (2003) reported a decrease in pH over storage when they studied the quality of plain yogurt stored at 4°C for 44 d. A decrease in pH during yogurt shelf life

Figure 4. Mean apparent viscosity $\pm$ SD of reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix during 56 d of storage at $4 \pm 1^\circ\text{C}$.

Figure 5. Mean pH $\pm$ SD of reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix during 56 d of storage at $4 \pm 1^\circ\text{C}$.

is expected as a result of the activity of yogurt starter cultures (Damin et al., 2009).

TA

The TA of CYP and YCMP mix reconstituted yogurts during the 8 wk of storage is shown in Figure 6. The treatment $\times$ day interaction effect was not significant ($P = 0.56$), whereas the treatment effect ($P = 0.0008$) and day effect ($P < 0.0001$) were significant.

The mean of TA of CYP reconstituted yogurt was significantly ($P < 0.05$) higher than YCMP mix reconstituted yogurt. The TA observed during the first 3 wk were significantly ($P < 0.05$) lower than the TA observed during the last 3 wk. The TA increased from 1.23 to 1.29 during 8 wk of refrigerated storage. The TA increase during the storage period follows the decrease in pH. The decrease in pH during the reconstituted yogurt shelf life resulting from the activity of starter cultures would explain the increase in TA during its shelf life.

Figure 6. Mean titratable acidity $\pm$ SD of reconstituted yogurts from commercial yogurt powder (CYP) and yogurt cultured milk powder (YCMP) mix stored for 56 d at $4^\circ\text{C} \pm 1^\circ\text{C}$.

Sensory Evaluation

The sensory evaluation of CYP reconstituted yogurt, YCMP mix reconstituted yogurt, and YCMPA mix reconstituted yogurt was conducted with 100 random people. Probabilities for fixed effect of sensory attributes were appearance ($P < 0.0001$), color ($P = 0.0009$), aroma ($P = 0.0025$), taste ($P < 0.0001$), thickness ($P < 0.0001$), powderiness ($P < 0.0001$), and overall liking ($P < 0.0001$), indicating a significant difference among treatments.

In terms of all attributes (appearance, color, aroma, taste, thickness, powderiness, and overall liking), CYP reconstituted yogurt obtained significantly lower scores compared with the other 2 reconstituted yogurts (Table 2). Compared with YCMP mix reconstituted yogurt, YCMPA mix reconstituted yogurt had significantly higher scores for appearance, taste, powderiness, and overall liking. No significant differences existed in color, aroma, and thickness between YCMP mix reconstituted yogurt and YCMPA mix reconstituted yogurt (Table 2).

Table 2. Means $\pm$ SD for sensory attributes for commercial yogurt powder (CYP), yogurt cultured milk powder (YCMP) mix, and YCMP mix with *Lactobacillus acidophilus* (YCMPA) reconstituted yogurts¹

Treatment	Appearance	Color	Aroma	Taste	Thickness	Powderiness	Overall liking
CYP	4.20 $\pm$ 1.78 ^a	5.93 $\pm$ 1.50 ^a	5.55 $\pm$ 1.97 ^a	3.49 $\pm$ 2.11 ^a	3.10 $\pm$ 1.74 ^a	3.45 $\pm$ 1.82 ^a	3.25 $\pm$ 1.72 ^a
YCMP	5.35 $\pm$ 2.07 ^b	6.40 $\pm$ 1.46 ^b	6.12 $\pm$ 1.51 ^b	4.56 $\pm$ 1.99 ^b	5.08 $\pm$ 2.07 ^b	4.08 $\pm$ 1.93 ^b	4.46 $\pm$ 2.04 ^b
YCMPA	5.93 $\pm$ 1.75 ^c	6.34 $\pm$ 1.65 ^b	6.18 $\pm$ 1.85 ^b	5.23 $\pm$ 2.08 ^c	5.10 $\pm$ 1.96 ^b	4.59 $\pm$ 1.96 ^c	4.95 $\pm$ 2.00 ^c

^{a-c}Means within a column with no common superscript differ ($P < 0.05$).

¹Evaluation was done on a 9-point rating scale, ranging from 1 = dislike extremely to 9 = like extremely.

According to Routray and Mishra (2011), aroma and taste are the most important sensory characteristics of yogurt. Citric acid is added in the manufacture of commercially available flavored yogurts. Using citric acid in the YCMP mix formulation might have positively influenced the taste of YCMP mix reconstituted yogurt and YCMPA mix reconstituted yogurts over CYP reconstituted yogurt.

The frequency of selecting acceptable was 54% for the YCMP mix reconstituted yogurt and 59% for YCMPA mix reconstituted yogurt, more than twice the frequency of 22% for the CYP reconstituted yogurt. Purchase intent frequencies of CYP, YCMP, and YCMPA reconstituted yogurts before knowing they contained bacteria that provide health benefits were 7, 24, and 24% respectively. The purchase intent of YCMP mix and YCMPA mix reconstituted yogurts was more than 3 times that of the CYP yogurt. Purchase intent frequency increased from 24 to 42% for YCMP mix reconstituted yogurt and from 24 to 46% for YCMPA mix reconstituted yogurts after knowing these reconstituted yogurts contained bacteria that provide health benefits.

CONCLUSIONS

This study compared the characteristics of YCMP mix reconstituted yogurt with those of CYP reconstituted yogurt. Results of this study showed that YCMP mix reconstituted yogurt had 5 log cfu/mL higher counts of *S. thermophilus* compared with the control (CYP reconstituted yogurt) at 56 d. Also, the *L. delbrueckii* ssp. *bulgaricus* count of YCMP mix reconstituted yogurt at 28 d was 6.55 log cfu/mL and at 56 d was 5.35 log cfu/mL, whereas the CYP reconstituted yogurt at 28 d onwards had no detectable counts. Commercial yogurt powder reconstituted yogurt did not meet the recommended yogurt culture bacteria concentration of 6 to 8 log cfu/g, which was met by YCMP mix reconstituted yogurt. No coliforms were observed at 56 d for both CYP and YCMP mix reconstituted yogurts. The apparent viscosity of YCMP mix reconstituted yogurt was significantly higher than CYP reconstituted yogurt. Yogurt cultured milk powder mix reconstituted yogurt had significantly higher pH but significantly lower TA than CYP reconstituted yogurt. Yogurt cultured milk powder mix reconstituted yogurt had significantly higher appearance, color, aroma, taste, thickness, powderiness, and overall liking scores compared with CYP reconstituted yogurt. Consumer acceptability of YCMP mix reconstituted yogurt (54%) was more than twice that of CYP reconstituted yogurt (22%). Yogurt cultured milk powder mix reconstituted yogurt had markedly higher culture bacterial counts and better

physicochemical and sensory characteristics compared with reconstituted commercial yogurt powder.

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