Addition of inulin to probiotic yogurt: Viability of probiotic bacteria (*Bifidobacterium bifidum*) and sensory characteristics

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Abstract

The objective of this work was to study the effect of different concentrations of inulin (0.2, 0.4, and 0.6%) on the viability of probiotic bacteria (*Bifidobacterium bifidum*) and sensory characteristics of probiotic yogurt. The yogurt was manufactured with *Lactobacillus delbruckii* ssp. *bulgaricus* (Lb), *Streptococcus thermophilus* (St), and *Bifidobacterium bifidum* (Bb). Raw milk was received, heated to 90°C, and divided into 4 aliquots portions. All portions were inoculated with 5.11 log cfu of Lb and St combined and 5 log cfu of Bb per kg of milk. The first portion was utilized as control (T1) while 0.2, 0.4, and 0.6% of inulin were added to the second (T2), third (T3), and fourth (T4) portions, respectively. All treatments were incubated at 40°C until a pH of 4.6 was reached. Subsequently, the yogurt was cooled and stored at 4°C for 16 days. Titratable acidity, total bacterial count (TBC), Bb count, yeast count, mold count, and sensory evaluation were determined during the storage. The results showed that the addition of inulin and the storage period have significant effects (p < .05) on the titratable acidity of the yogurt. The storage of control was ended after 8 days at 4°C due to the growth of molds on the surface of the samples. The TBC decreased (p < .05) over time in control from 8.28 to 7.97 log cfu/g. It was also decreased (p < .05) with increasing the concentration of inulin. However, the addition of inulin increased (p < .05) the viability of Bb during the storage, as well as, acted as an antimicrobial against molds in T2, T3, and T4. Additionally, there were no significant differences (p > .05) in the sensory evaluation of all treatments. We conclude that inulin can be utilized in the manufacturing of probiotic yogurt as a prebiotic, which, in turn, enhances the growth of Bb and increase the shelf-life.

Keywords

*Bifidobacterium bifidum*, inulin, probiotic yogurt, sensory properties
Inulin is an oligosaccharide (fructan), soluble fiber in water, and can be extracted from several sources, including types of chicory, garlic, wheat, oat, and dahila bulgur (Koruri et al., 2014). It has one β-2-1-linked fructosyl unit with a terminal glucosyl unit (Paseephol et al., 2008). Inulin is considered a prebiotic and there is an interesting trend of using this ingredient to supplement fermented products, such as yogurt to improve gastrointestinal health, as well as, calcium absorption and boost the immune system. Additionally, it stimulates the growth of probiotic bacteria, such as Lactobacillus and Bifidobacterium in products during storage to reach the colon with a high viable number of those probiotics (Pereira et al., 2013).

Inulin has been utilized in many dairy products to improve the chemical, functional, and sensory characteristics, as well as the viability of probiotic bacteria in many dairy products, such as cheese (Buriti et al., 2007; Cardarelli et al., 2008; Hennelly et al., 2006; Salvatore et al., 2014; Zhang et al., 2021), yogurt (Canbulat & Ozcan, 2015; Li et al., 2019; Mazloumi et al., 2011; Sarwar et al., 2019; Shakerian et al., 2014), frozen yogurt (Isik et al., 2011; Rezaei et al., 2014), and ice cream (Akalin & Erişir, 2008; Akbary et al., 2016; Akin et al., 2007; Balthazar et al., 2018; Schaller-Povolny & Smith, 1999; Tiwari et al., 2015).

Inulin has been used as a fat replacer to enhance the properties of low-fat yogurt (Guven et al., 2005; Paseephol et al., 2008; Pimentel et al., 2013; Seydim et al., 2005). It has been found that the addition of 1% inulin improved the characteristics of low-fat yogurt made from skim milk, which was similar to yogurt made from whole milk; however, higher amounts of inulin can lead to more whey separation (Guven et al., 2005). A similar study found that the firmness and brightness of low-fat yogurt were improved with the addition of 2% inulin; yet, whey separation was also higher (Pimentel et al., 2013). Another study reported that incorporating inulin in low-fat yogurt exhibited better rheological behavior that was similar to full-fat yogurt, but it did not improve the firmness or apparent viscosity (Paseephol et al., 2008). Others found that the firmness of yogurt increased with the addition of 4% inulin as a probiotic in yogurt (Oliveira et al., 2011). Also, inulin was utilized successfully to improve the texture of yogurt (Sarwar et al., 2019). Another study found that the overrun and glass transition of yogurt improved with the addition of 4 and 6% inulin while hardness was decreased (Muzammil et al., 2017). Furthermore, the addition of inulin at a range of 3 to 15% improved the functional characteristics with low syneresis (Zbikowska et al., 2020). Additionally, the apparent viscosity of yogurt increased with adding inulin up to 2% to yogurt (Helal et al., 2018). Another study reported that yogurt texture can be enhanced using inulin (Yi et al., 2010). The functional characteristics (e. g., overrun and meltability) of frozen yogurt enhanced with the addition of 2% inulin (Rezaei et al., 2014). Moreover, inulin has improved the functional characteristics of frozen yogurt, such as viscosity and meltability of frozen yogurt (Isik et al., 2011).

It has been found that inulin is enhancing the growth and viability of probiotic bacteria, such as Saccharomyces boulardii, Lactobacillus rhamnosus, and Bifidobacterium animalis in full-fat yogurt (Canbulat & Ozcan, 2015; Sarwar et al., 2019; Shakerian et al., 2014); Lactobacillus acidophilus and Lactobacillus delbrueckii ssp. bulgaricus in low-fat yogurt (Mazloumi et al., 2011); Lactobacillus acidophilus and Bifidobacterium lactis, as well as, lactic acid bacteria in frozen yogurt (Isik et al., 2011; Rezaei et al., 2014). Additionally, inulin has been utilized to encapsulate probiotic bacteria, such as Lactobacillus acidophilus and Lactobacillus casei, which resulted in maintaining a higher number of those bacteria at a rate of 7.0 log cfu/g (Krasaekoot & Watcharapoka, 2014).

Some studies reported that inulin is improving the sensory characteristics of yogurt, while others found that it has no significant effects. It has been found that 1 or 2% of inulin did not result in significant differences in the sensory characteristics of low-fat yogurt (Mazloumi et al., 2011). Another study did not report any effect of inulin on the sensory properties of ice cream made with fermented milk supplemented with inulin (Akin et al., 2007). On the other hand, it has been found that the addition of inulin and fructans improved the sensory characteristics of low-fat stirred yogurt (Crispin-Isidro et al., 2015). Inulin was found to increase the synerysis of probiotics to produce more volatile fatty acids that improve the sensory characteristics of yogurt up to 28 days of storage (Sarwar et al., 2019).

The addition of inulin in milk before making yogurt has a positive effect on the functional and sensory characteristics, as well as, consumer health because it maintains a high viable number of probiotics. As a result, the objectives of this study were to manufacture a probiotic yogurt supplemented with inulin (0.2, 0.4, and 0.6%) and studying the functional properties of this yogurt during storage at 4°C for 16 days.

2 | MATERIAL AND METHODS

2.1 | Manufacture of probiotic yogurt supplemented with inulin

Fresh buffalo’s milk was obtained from the Animal Farm (Faculty of Agriculture, Assiut University, Assiut, Egypt), heated to 90°C for 5 min, and cooled to 40°C. The milk was then inoculated with 5.11 log cfu of Lactobacillus delbrueckii ssp. bulgaricus (Lb) and Streptococcus thermophilus (St) (Dairy Science Department, Faculty of Agriculture, Assiut University, Egypt) combined, and 5 log cfu of Bifidobacterium bifidum (Bb) per kg of milk (Cairo MIRCN, Faculty of Agriculture, Ain Shams University, Egypt). The milk was divided into 4 aliquots portions. The first portion was utilized as control (T1; with no inulin) while 0.2, 0.4, and 0.6% of inulin were added to the second (T2), third (T3), and fourth (T4) portions, respectively. All treatments were incubated at 40°C until a pH of 4.6 was reached and this process took approximately 4 hr. Subsequently, the yogurt was cooled and
stored at 4°C for 16 days. This experiment was repeated 3 times using 3 different batches of raw milk.

2.2 | Chemical and microbiological analyses

Titratable acidity was determined by calculating the lactic acid content in the yogurt (Akın et al., 2007; Sadler & Murphy, 2010). Total bacterial count (TBC), *Bifidobacterium bifidum* (Bb) count, yeast, and mold counts were determined as described by Hamdy and others (Hamdy et al., 2020). The chemical and microbiological analyses were performed at 0, 4, 8, 12, and 16 days.

2.3 | Sensory evaluation

Sensory evaluation of probiotic yogurt was also determined as described by Hamdy and others with some modifications (Hamdy et al., 2020). Samples were evaluated for color and appearance (15 points), flavor (45 points), acidity (10 points), body and texture (30 points) to have 100 points as a total. The sensory characteristics were determined at 0 and 16 days.

2.4 | Statistical analysis

Data were statistically analyzed using R software (R x64-3.3.3, 9,205 NW 101st St, Miami, Florida, United States) by ANOVA using a GLM for each variable to study the effect of inulin and time or their interaction on the characteristics of probiotic yogurt. Mean separation was done using the least significant difference (LSD) comparison test when significant differences were detected at \( p < .05 \).

3 | RESULTS AND DISCUSSION

3.1 | Titratable acidity (% lactic acid)

The effect of inulin on titratable acidity (%) of probiotic yogurt during 16 days of storage at 4°C is shown in Figure 1. Also, Table 1 is presented mean squares and \( p \)-values that resulted from ANOVA. The addition of inulin increased the acidity of probiotic yogurt significantly (\( p < .05 \)), and this increase was noticeable up to 12 days of storage. Additionally, storage time as well as the interaction of inulin and storage time significantly affected (\( p < .05 \)) the acidity of probiotic yogurt (Table 1). The acidity was 0.78% in control (without inulin) at 0 day, and this value elevated (\( p < .05 \)) to 0.9% after 8 d of storage. The control samples were excluded from the experiment after 8 d of storage since they were molded, which means less shelf-life as compared to inulin treatments. During 16 days of storage, acidity of probiotic yogurt increased (\( p < .05 \)) from 0.76% to 1%, 0.85 to 1%, and 0.89 to 1% when 0.2, 0.4, and 0.6% of inulin were added. After 16 days of storage, acidity was similar in all treatments.

3.2 | Total bacterial count (TBC)

The TBC of probiotic yogurt made with inulin is shown in Figure 2. Table 1 is also exemplified the mean squares and \( p \)-values of TBC. The addition of inulin (0.2, 0.4, and 0.6%), storage time, and their interaction showed a significant effect (\( p < .05 \)) on the TBC of probiotic yogurt. The shelf-life of control or non-inulin yogurt samples was finished at 8 days since the molds were noticeable on the surface of yogurt. As a result, the last reading of TBC in control samples was recorded at 8 days. However, the TBC was decreased in all yogurt samples during storage at 4°C. The TBC in yogurt with no added inulin decreased from approximately 8.3 to 8 log cfu/g after 8 days. The TBC was lower at 0 day in yogurt with inulin as compared to control. The TBC at 0 d was found by 7.58, 6.95, and 6.89 log cfu/g when 0.2, 0.4, and 0.6% inulin added to the probiotic yogurt, respectively, and these values decreased to 7.15, 4.37, and 3.25 log cfu/g, respectively, after 16 days of storage.

Increasing the inulin content resulted in low TBC in probiotic yogurt, which refers to that inulin could have a preservative impact.
on growing other microorganisms, such as, St, Lb, yeast, and molds. Also, we theorized that the high lactic acid content (high acidity) in probiotic yogurt with inulin made the products non suitable for the growth of those microorganisms (act as a preservative), which reduced the TBC. It has been reported that the lactic acid resulted from the fermentation of lactose in milk acted as a preservative for the product (Delavari et al., 2014; Hekmat & Reid, 2006). Another reason is that incorporation of Bb starter cultures adversely affects the Lb counts, which is contributed to decreasing the TBC during storage (Baig & Prasad, 1996).

### 3.3 Bifidobacterium bifidum (Bb) count

The Bb count in probiotic yogurt is presented in Figure 3. The mean squares and P-values of Bb count are also exemplified in Table 1. The addition of inulin, storage time, as well as their interaction has a significant effect (p < .05) on the Bb count of the probiotic count. Additionally, there was a replicate effect on the Bb count and this can be due to the slight difference in the count of Bb starter cultures during making the yogurt. The trend of Bb in control or T1 (no inulin added) was opposite to other treatments. The Bb in control decreased from 5.48 to 3.99 log cfu/g after 8 days of storage (end of storage for control due to growth of molds). However, this count increased from 5.53 to 6.92 log cfu/g in T2 (0.2% inulin), 6.45 to 7.49 log cfu/g in T3 (0.4% inulin), and 7.37 to 8.83 log cfu/g in T4 (0.6% inulin) after 16 days of storage at 4°C.

Increasing the inulin content in the probiotic yogurt enhanced the growth of Bb during the storage, which referred to that inulin is a suitable nutrient for Bb. Many studies reported similar findings. It has been reported that the viability of probiotic bacteria, such as Lactobacillus acidophilus and Lactobacillus delbrueckii ssp. Bulgaricus, increased with the addition of inulin in low-fat yogurt (Mazloumi et al., 2011). Li and others have also reported that there a slight increase in starter cultures utilized to make low-fat yogurt in the existence of 0.5% inulin (Li et al., 2019). Another study found that inulin maintained > 6.0 log cfu/g viable counts of Saccharomyces boulardii in yogurt (Sarwar et al., 2019). Adding 2% of inulin to probiotic yogurt led to increase the viability of Lactobacillus rhamnosus to 6.7 log cfu/g (Canbulat & Ozcan, 2015). Moreover, using inulin by 1% in yogurt enhanced the growth of Bifidobacterium animalis in probiotic yogurt with low proteolysis levels (Shakerian et al., 2014). Moreover, the viable counts of Lactobacillus acidophilus and Bifidobacterium lactis were increased when 2% of inulin added to frozen yogurt (Rezaei et al., 2014). It has also found that addition of inulin to frozen yogurt maintained a higher number of lactic acid bacteria that ranged from 8.1 to 8.5 during 3 months of shelf-life (Isik et al., 2011). Furthermore,

| Factor                      | df | Acidity (%)  | TBC          | Bb            |
|-----------------------------|----|--------------|--------------|---------------|
| Treatment<sup>a</sup>       | 3  | 0.028(2.2e-16)*** | 30.04(2.2e-16)*** | 24.69(2.2e-16)*** |
| Time<sup>b</sup>            | 4  | 0.047(2.2e-16)*** | 6.72(2.2e-16)*** | 2.13(2.2e-16)*** |
| Replication                 | 2  | 0.00002(0.6195) | 0.013(0.41) | 0.08(4.02e-06)*** |
| Treatment × Time            | 10 | 0.0016(7.054e-15)*** | 1.18(2.2e-16)*** | 0.67(2.2e-16)*** |
| Error                       | 34 | 0.000046      | 0.014        | 0.004         |

<sup>a</sup>Treatment = 0, 0.2, 0.4, and 0.6% inulin  
<sup>b</sup>Time = 0, 4, 8, 12, and 16 days  
*Statistically significant at p < .05

### TABLE 1  Mean squares and P-values (in parentheses) of acidity (%), total bacterial count (TBC), and Bifidobacterium bifidum (Bb) count of probiotic yogurt made with 0.0, 0.2, 0.4, and 0.6% inulin
Inulin has been utilized to produce fermented yogurt that was eventually used in making ice cream formulations to improve the viability of probiotic bacteria. It has been found that the addition of inulin in fermented yogurt maintained high viability of probiotics in ice cream as compared to control (Akin et al., 2007). Inulin has also been utilized in fermented soy milk and resulted in > 9.0 log cfu/ml (Mishra & Mishra, 2018). Additionally, inulin has been utilized to encapsulate probiotic bacteria, such as *Lactobacillus acidophilus* and *Lactobacillus casei*, which resulted in maintaining a higher number of these bacteria (7.0 log cfu/g) (Krasaekoopt & Watcharapoka, 2014).

### 3.4 Yeast and mold count

The yeast count of probiotic yogurt is graphed in Figure 4. The yeast counts were not detected in control up to 8 days of storage, while it was detected in yogurt supplemented with inulin after 16 days of storage. The molds were detected in control after 8 days while yogurt supplemented with inulin did not exhibit any molds. The yeast count was 3.75 log cfu/g in control after 8 d. However, the count of yeast was 6.17, 3.3, and 2.39 log cfu/g after adding of 0.2, 0.4, and 0.6% inulin, respectively, after 16 days of storage at 4°C. It looks like the inulin has decreased the growth of yeast, which increases the shelf-life or storage time of probiotic yogurt. Also, this preservative effect can be due to the high lactic acid content in those treatments (Delavari et al., 2014; Hekmat & Reid, 2006).

### 3.5 Sensory evaluation

The sensory evaluation of probiotic yogurt is presented in Table 2. The inulin does not affect (*p > .05) the organoleptic characteristics of that yogurt, although there was a slight increase in the scores of flavor, texture, and appearance at 0 day as compared to control. The control was not judged at 16 d due to the short shelf-life for that treatment that ended after 8 days. The overall scores tend to decrease after 16 d of storage and this might be due to the high acetaldehyde content produced from Bb starter cultures, which was not favorable to the panelists.

Other studies have reported similar results that inulin does not affect the sensory properties of probiotic yogurt. A study found that the addition of 1 or 2% of inulin did not result in significant differences in the sensory characteristics of low-fat yogurt (Mazloumi et al., 2011). Akin and others also reported that inulin does not affect the sensory of ice cream made with fermented milk supplemented with inulin (Akin et al., 2007). However, others found that inulin can be utilized to improve the sensory characteristics of low-fat yogurt. It has been reported that the addition of inulin and fructans improved the sensory properties of low-fat stirred yogurt as compared to full-fat yogurt due to forming gel on the casein micelles (Crispín-Isidro et al., 2015). Using inulin has also been found to result in a smooth texture and good sensory characteristics (Seydim et al., 2005). Inulin increased the syneresis of probiotic to produce more volatile fatty acids that improve the sensory characteristics of yogurt up to 28 days of storage (Sarwar et al., 2019). The acceptability of low-fat yogurt was increased when inulin was added (Pimentel et al., 2013), which was similar to full-fat yogurt. Frozen yogurt was acceptable when 2% of inulin was added (Rezaei et al., 2014). The addition of inulin to yogurt improved the formation of acetaldehyde formation (Helal et al., 2018). Inulin in general improved the acceptance and flavor of yogurt (Canbulat & Ozcan, 2015). Furthermore, yogurt made from soy milk with inulin exhibited good sensory characteristics (Rinaldoni et al., 2012).

![FIGURE 4 Yeast count (log cfu/g) in probiotic yogurt made with 0.0, 0.2, 0.4, and 0.6% inulin](image)

### Table 2 Sensory evaluation of probiotic yogurt made with 0.0, 0.2, 0.4, and 0.6% inulin

| Inulin (%) | Time (d) | Flavor (45) | Texture (30) | Appearance (15) | Acidity (10) | Overall score (100) |
|------------|----------|-------------|--------------|----------------|--------------|---------------------|
| 0.00       | 0        | 42.67       | 26.67        | 12.00          | 10.00        | 91.33               |
| 0.20       |          | 42.67       | 28.00        | 12.00          | 8.00         | 90.67               |
| 0.40       |          | 43.00       | 28.00        | 14.00          | 8.00         | 93.00               |
| 0.60       |          | 42.67       | 28.00        | 13.00          | 8.00         | 91.67               |
| 0.00       | 16       | ND          | ND           | ND             | ND           | ND                  |
| 0.20       |          | 41.33       | 28.00        | 13.00          | 8.00         | 90.33               |
| 0.40       |          | 42.00       | 28.00        | 13.00          | 8.00         | 91.00               |
| 0.60       |          | 40.33       | 27.70        | 12.00          | 8.00         | 88.00               |

Abbreviations: ND, not determined.
4 | CONCLUSION

The addition of inulin as a prebiotic to probiotic yogurt improved the functional characteristics and the viability of *Bifidobacterium*, as well as increasing the shelf-life of yogurt. Inulin has a potential health benefit, such as improving the absorption of calcium and enhancing gastrointestinal health. Inulin can have a promising application to supplement other dairy products, such as soft cheese, ice cream, and drinks.

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REFERENCES

Akalin, A. S., & Erişir, D. (2008). Effects of inulin and oligofructose on the rheological characteristics and probiotic culture survival in low-fat probiotic ice cream. *Journal of Food Science, 73*, M184–M188. https://doi.org/10.1111/j.1750-3841.2008.00728.x

Akbari, M., Eskandari, M. H., Niakosari, M., & Bedeltavana, A. (2016). The effect of inulin on the physicochemical properties and sensory attributes of low-fat ice cream. *International Dairy Journal, 57*, 52–55. https://doi.org/10.1016/j.idairyj.2016.02.040

Akın, M. B., Akın, M. S., & Kırmacı, Z. (2007). Effects of inulin and sugar levels on the viability of yogurt and probiotic bacteria and the physical and sensory characteristics in probiotic ice-cream. *Food Chemistry, 104*, 93–99. https://doi.org/10.1016/j.foodchem.2006.11.030

Baig, M. I., & Prasad, V. (1996). Effect of incorporation of cottage cheese whey solids and *Bifidobacterium* bifidum in freshly made yogurt. *Journal of Dairy Research, 63*, 467–473. https://doi.org/10.1017/S0022029900031976

Balthazar, C. F., Conte Júnior, C. A., Moraes, J., Costa, M. P., Raices, R. S. L., Franco, R. M., Cruz, A. G., & Silva, A. C. O. (2016). Physicochemical evaluation of sheep milk yogurts containing different levels of inulin. *Journal of Dairy Science, 99*, 4160–4168. https://doi.org/10.3168/jds.2015-10072

Balthazar, C. F., Silva, H. L. A., Esmerino, E. A., Rocha, R. S., Moraes, J., Carmon, M. A. V., Azevedo, L., Camps, I., K.D Abud, Y., Sant’Anna, C., Franco, R. M., Freitas, M. Q., Silva, M. C., Raices, R. S. L., Escher, G. B., Granato, D., Senaka Ranadheera, C., Nazarro, F., & Cruz, A. G. (2018). The addition of inulin and Lactobacillus casei 01 in sheep milk ice cream. *Food Chemistry, 246*, 464–472. https://doi.org/10.1016/j.foodchem.2017.12.002

Buriti, F. C. A., Cardarelli, H. R., Filisetti, T. M. C. C., & Saad, S. M. I. (2007). Synbiotic potential of fresh cream cheese supplemented with inulin and Lactobacillus paracasei in co-culture with *Streptococcus thermophilus*. *Food Chemistry, 104*, 1605–1610. https://doi.org/10.1016/j.foodchem.2007.03.001

Canbulat, Z., & Ozcan, T. (2015). Effects of short-chain and long-chain inulin on the quality of probiotic yogurt containing Lactobacillus rhamnosus. *Journal of Food Processing and Preservation, 39*, 1251–1260. https://doi.org/10.1016/j.jfpp.2012.12.003

Cardarelli, H. R., Buriti, F. C. A., Castro, I. A., & Saad, S. M. I. (2008). Inulin and oligofructose improve sensory quality and increase the probiotic viable count in potentially synbiotic petit-suisse cheese. *LWT - Food Science and Technology, 41*, 1037–1046. https://doi.org/10.1016/j.lwt.2007.07.001

Crispín-Isidro, G., Lobato-Calleros, C., Espinosa-Andrews, H., Alvarez-Ramirez, J., & Vernon-Carter, E. J. (2015). Effect of inulin and agave fructans addition on the rheological, microstructural and sensory properties of reduced-fat stirred yogurt. *LWT - Food Science and Technology, 62*, 438–444. https://doi.org/10.1016/j.lwt.2014.06.042

Delavari, M., Pourrahmad, R., & Sokutifar, R. (2014). Production of low fat synbiotic yogurt containing Lactobacillus plantarum and inulin. *Advances in Environmental Biology, 8*, 17–24.

Guven, M., Yasar, K., Karaca, O. B., & Hayaloglu, A. A. (2005). The effect of inulin as a fat replacer on the quality of set-type low-fat yogurt manufacture. *International Journal of Dairy Technology, 58*, 180–184. https://doi.org/10.1111/j.1471-0307.2005.00210.x

Handy, A. M., Ahmed, M. E., Mehta, D., Elfaruk, M. S., Hammam, A. R. A., & El-Derwy, Y. M. A. (2020). Enhancement of low-fat Feta cheese characteristics using probiotic bacteria. *Food Sciences and Nutrition, 8*(fsn3), 1889. https://doi.org/10.1002/fsn3.1889

Hekmat, S., & Reid, G. (2006). Sensory properties of probiotic yogurt is comparable to standard yogurt. *Nutrition Research, 26*, 163–166. https://doi.org/10.1016/j.nutres.2006.04.004

Helal, A., Rashid, N., Dyab, M., Otaibi, M., & Alnemr, T. (2018). Enhanced functional, sensory, microbial and texture properties of low-fat set yogurt supplemented with high-density inulin. *Journal of Food Process and Beverages, 6*, 1–11.

Hennelly, P. J., Dunne, P. G., O’Sullivan, M., & O’Riordan, E. D. (2006). Textural, rheological and microstructural properties of imitation cheese containing inulin. *Journal of Food Engineering, 75*, 388–395. https://doi.org/10.1016/j.jfoodeng.2005.04.023

Isik, U., Boyacıoğlu, D., Capanoglu, E., & Nilüfer Erdil, D. (2011). Frozen yogurt with added inulin and isomalt. *Journal of Dairy Science, 94*, 1647–1656. https://doi.org/10.3168/jds.2010-3280

Koruri, S. S., Banerjee, D., Chowdhury, R., & Bhattacharya, P. (2014). Studies on prebiotic food additive (inulin) in indian dietary fibre sources-garlic (*Allium sativum*), wheat (*Triticum spp*), oat (*Avena sativa*) and dalia (*Bulgur*). *International Journal of Pharmacy and Pharmaceutical Sciences, 6*, 278–282.

Krasaekoop, W., & Watcharapoka, S. (2014). Effect of addition of inulin and galactooligosaccharide on the survival of microencapsulated probiotics in alginate beads coated with chitosan in simulated digestive system, yogurt and fruit juice. *LWT - Food Science and Technology, 57*, 761–766. https://doi.org/10.1016/j.lwt.2014.01.037

Li, R., Ding, Q., & Zhao, X.-H. (2019). Impact of milk fortification on the microbiological and physicochemical properties of set-type skimmed yogurt using three commercial soluble prebiotics. *Foods, 8*, 181. https://doi.org/10.3390/foods8060181

Mazloumi, S. M., Shekarforoush, S. E., Ebrahimnejad, H., & Sajedianfard, J. (2011). Effect of adding inulin on microbial and physico-chemical properties of low fat probiotic yogurt. *Iranian Journal Veterinary Research, 12*, 93–98.

Mishra, S., & Mishra, H. (2018). Comparative study of the synbiotic effect of inulin and fructooligosaccharide with probiotics with regard to the various properties of fermented soymilk. *Food Science and Technology International, 24*, 564–575. https://doi.org/10.1177/1178201318776529

Muzammil, H. S., Rasco, B., & Sablani, S. (2017). Effect of inulin and glycercol supplementation on physicochemical properties of probiotic frozen yogurt. *Food & Nutrition Research, 61*, 1290314. https://doi.org/10.1080/16546628.2017.1290314

Oliveira, R. P. D. S., Perego, P., Oliveira, M. N. D., & Converti, A. (2011). Effect of inulin as prebiotic and synbiotic interactions between probiotics to improve fermented milk firmness. *Journal of Food Engineering, 107*, 36–40. https://doi.org/10.1016/j.jfoodeng.2011.06.005

Paseephol, T., Small, D. M., & Sherkat, F. (2008). Rheology and texture of set yogurt as affected by inulin addition. *Journal of Texture Studies, 39*, 617–634. https://doi.org/10.1111/j.1745-4603.2008.00161.x

Pereira, E., Barros, L., & Ferreira, I. (2013). Relevance of the mention of antioxidant properties in yogurt labels: In vitro evaluation
and chromatographic analysis. *Antioxidants*, 2, 62–76. https://doi.org/10.3390/antiox2020062

Pimentel, T. C., Cruz, A. G., & Prudencio, S. H. (2013). Short communication: Influence of long-chain inulin and Lactobacillus paracasei subspecies paracasei on the sensory profile and acceptance of a traditional yogurt. *Journal of Dairy Science*, 96, 6233–6241. https://doi.org/10.3168/jds.2013-6694

Rezaei, R., Khomeiri, M., Aalami, M., & Kashaninejad, M. (2014). Effect of inulin on the physicochemical properties, flow behavior and probiotic survival of frozen yogurt. *Journal of Food Science and Technology*, 51, 2809–2814. https://doi.org/10.1007/s13197-012-0751-7

Rinaldoni, A. N., Campderrós, M. E., & Pérez Padilla, A. (2012). Physico-chemical and sensory properties of yogurt from ultrafilatred soy milk concentrate added with inulin. *LWT - Food Science and Technology*, 45, 142–147. https://doi.org/10.1016/j.lwt.2011.09.009

Sadler, G. D., & Murphy, P. A. (2010). In S. S. Nielsen (Ed.), *pH and Titratable Acidity*. Springer.

Salvatore, E., Pes, M., Mazzarello, V., & Pirisi, A. (2014). Replacement of fat with long-chain inulin in a fresh cheese made from caprine milk. *International Dairy Journal*, 34, 1–5. https://doi.org/10.1016/j.idairyj.2013.07.007

Shakerian, M., Hadi Razavi, S., Khodaiyan, F., Ziai, S. A., Saed Yarmand, M., & Moayedi, A. (2014). Effect of different levels of fat and inulin on the microbial growth and metabolites in probiotic yogurt containing nonviable bacteria. *International Journal of Food Science & Technology*, 49, 261–268. https://doi.org/10.1111/jifs.12315

Tiwari, A., Sharma, H. K., Kumar, N., & Kaur, M. (2015). The effect of inulin as a fat replacer on the quality of low-fat ice cream. *International Journal of Dairy Technology*, 68, 374–380. https://doi.org/10.1111/1471-0307.12176

Yi, H., Zhang, L., Hua, C., Sun, K., & Zhang, L. (2010). Extraction and enzymatic hydrolysis of inulin from Jerusalem artichoke and their effects on textural and sensorial characteristics of yogurt. *Food and Bioprocess Technology*, 3, 315–319. https://doi.org/10.1007/s11947-009-0247-2

Żbikowska, A., Szymańska, I., & Kowalska, M. (2020). Impact of inulin addition on properties of natural yogurt. *Applied Sciences*, 10, 4317. https://doi.org/10.3390/app10124317

Zhang, X., Hao, X., Wang, H., Li, X., Liu, L., Yang, W., Zhao, M., Wang, L., & Massounga Bora, A. F. (2021). The effects of Lactobacillus plantarum combined with inulin on the physicochemical properties and sensory acceptance of low-fat Cheddar cheese during ripening. *International Dairy Journal*, 115, 104947. https://doi.org/10.1016/j.idairyj.2020.104947

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