Improving Quality Properties of Frozen Yogurt by Fortification with Lemongrass (Cymbopogon citratus) as Prebiotic

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Abstract: The present study was carried out to evaluate lemongrass's antimicrobial activities and probiotic cultures' viability in frozen yogurt. The yogurt was prepared with two different commercial starters of probiotics [Lactobacillus acidophilus (LA-5), Bifidobacterium lactis (BB-12)], incorporation with Streptococcus thermophilus and two various concentrations of lemongrass powder or extract (0.5% and 1%). The data showed that lemongrass extract inhibited all microorganisms' growth at a concentration of 36 µl/mL for fungi species (Aspergillus niger, Aspergillus flavus and Penicillium spp.) and 48 µl/mL for bacteria species (Pseudomonas fluorescens, aeruginosa, fragi and Aeromonas hydrophila, caviae, sobria). Lemongrass powder or extract produced an alternative, stable color and stable quality of yogurt during frozen storage. Sensory evaluation of frozen yogurt with lemongrass powder 0.5% had acceptable quality characteristics with higher antioxidant effect (Thiobarbituric acid values 1.02 mg malonaldehyde/kg) after 30 days of frozen storage. The viability loss during frozen storage of commercial probiotic cultures Lactobacillus acidophilus (LA-5) and Bifidobacterium lactis (BB-12) decreased between 0.7, 1.15 and 0.76, 1.36 log CFU/g, respectively in all treatments. The population of these microorganisms remained above 10^5 CFU/g.

Keywords: Lemongrass; probiotic bacteria; frozen yogurt; fungi; antimicrobial activity; Cymbopogon citratus

INTRODUCTION

Nowadays, there is an exponential growth in herbal functional foods as consumers everywhere desire diets healthier. Lemongrass (Cymbopogon citratus) is a grass that belongs to Cymbopogon genus and Graminaceae family (Adene and Agbaje, 2007). Lemongrass has phytochemicals such as flavonoids, tannins, alkaloids and essential oils. The prefix lemon attributes to its lemon-like typical odor due to the presence of citral, and citral is a combination of two stereoisomeric monoterpenaldehydes (Majewska et al., 2019). The aqueous lemongrass extract is commonly used as an aromatic drink and the whole plant is well incorporated into many various traditional foods for its lemon flavor (Figueirinha et al., 2008).

The lemongrass usage was repeatedly found in ancient and recent folk remedies for treating coughs, elephantiasis, consumption, pneumonia, ophthalhmia, malaria and vascular disorders. Many researchers have investigated that lemongrass holds antioxidants, antidepressant, astringent, antiseptic, bactericidal, fungicidal, sedative and nervine properties, hypoglycemic and hypolipidemic effects. Further, several studies had proved the lemongrass antibacterial activity against a diverse range of microorganisms comprising both gram-positive and gram-negative bacteria, fungus and yeasts. Lemongrass leaves extract exhibited a tremendous antimicrobial effect against various antibiotics resistant microorganisms (Li et al., 2018; De Silva et al., 2017).

Frozen yogurt has characteristics of both yogurt and ice cream and could be used as a probiotics carrier. Culture viability is often facing high stress during frozen yogurt production (Magarinos et al., 2007). The main challenge of probiotic frozen yogurt processing is to ensure the maintenance of the surviving viability during the freezing process and frozen storage below 0°C (Favaro-Trindade et al., 2006), especially the lethal effects of ice crystals on probiotics. The benefits of probiotics are well known that they help improve the consumer's general health and prevent many types of diseases and enhance the immune system when consumed sufficiently. These beneficial effects on the consumer can only be achieved by consuming 100 grams daily, containing 10^9 CFU/mL or gram (Jayammane and Adams, 2006). Furthermore, probiotics can develop and improve different types of flavors and the nutritional quality of the product.

Hence the present study was carried out to investigate the potential application of lemongrass powder or extract as a food preservative for its antibacterial activity against some selected spoiling and pathogenic microorganisms and as a source of protection (prebiotic) for probiotic bacteria as well. The herbal ice cream was formulated with probiotics and lemongrass powder or extract based on the acceptable optimal levels and was evaluated according to sensory attributes as response variables.

MATERIALS AND METHODS

Microbial strains and media

Aspergillus niger (Asp. niger), Aspergillus flavus (Asp. flavus) and Penicillium spp. were obtained from mycotoxin laboratory, National Research Center, Doki, Cairo, Egypt. Pseudomonas spp. (Ps. fluorescens, aeruginosa, fragi) and Aeromonas spp. (Aero. hydrophila, caviae, sobria) were obtained from the Department of Food Hygiene, Animal Health Research Institute, Cairo, Egypt.

Freeze-dried starters of Lactobacillus acidophilus (LA-
5) (L. acidophilus), Bifidobacterium lactis (BB-12) (B. lactis) and Streptococcus thermophilus (FD-DVS ABT-2– Probio-Tec) (Str. thermophilus) were obtained from Chr. Hansen’s Lab, Copenhagen, Denmark. The cultures were stored at -18°C until used before their expiry date. MRS NNLP agar and MRS agar were obtained from Merck (Darmstadt, Germany). Lemongrass leaves (Cymbopogon citratus) were purchased from a local market in Ismailia, Egypt. Leaves were washed with tap water and dried using a connective dryer (WT-blender, Type F115, Germany) at 40°C for 3 days. Dried leaves were finely ground using a blender (Warning Commercial, HGB2WTS3, Torrington, Connecticut, USA).

Preparation of lemongrass powder and extract:

300 mL of boiling water were added to 50 g of lemongrass powder in a conical flask (500 mL) and stirred by a magnetic bar on a hot plate for 10 mins at 90°C. The extract was then filtered and concentrated using rotary evaporator to semi-solid form. The concentrate was stored at 4°C until being analyzed.

Minimum inhibitory concentration (MIC)

Preparation of extract

0.1 g of extract was dissolved in 100 mL distilled water (w/v) to make 100 mg/100 mL (1000 µg/mL). 5 mL of the above solution were diluted with 50 mL distilled water (v/v) from which desired concentration such as 6, 12, 18, 24, 30, 36, 42 and 48 µg/mL.

Dilution susceptibility test

The dilution susceptibility test method was used to determine the minimum inhibitory concentration of leaves extract according to methods described by Brothers and Wyatt (2000) as follows: one mL of 24hr activated cultures were serially diluted and one mL from each dilution (in duplicates) was transferred into petri dishes. Different concentrations of the extract from 0 to 48 µg/mL were thoroughly mixed with 10 mL sterilized medium (sabouraud dextrose agar for fungi and nutrient agar for bacteria), then poured into the aforementioned petri dishes. The dishes were incubated at 30°C and 37°C for fungi and bacteria, respectively, for 48hr. Viable colonies were counted, and inhibition percent was calculated and referred to as the viable count at 0.0% of the extract.

Antimicrobial Assay of leaves extract:

The crook borer diffusion method was used to measure the antimicrobial activity according to the method described by (Piddock, 1990) by removing a slug from solidified agar media (sabouraud dextrose agar for fungi) with a sterile crook borer (1 cm diameter) after inoculation with bacteria or fungi. Leaves extract was added at a concentration of 26 µl in duplicates. Inoculated plates were incubated at 37°C for bacteria and 28°C for fungi, and then inhibition zones (mm) of the microbial growth were measured.

Preparation of Frozen Yogurt

Frozen yogurt has been prepared, as described by Marshall and Arbuckle (1996). Control of frozen yogurt and four mix formulations were used in this study with different lemongrass levels to represent the effect of lemongrass on frozen yogurt quality and the viability of probiotics. The control of frozen yogurt (T1) was standardized (4% fat, 11% SNF, 15% sugar and 0.25% CMC), while other four-lemongrass frozen yogurt treatments were prepared with adding 0.5%, 1% and 0.5%, 1% lemongrass powder and extract, respectively.

Each frozen yogurt treatment was prepared in three replicates and analyzed for chemical, bacteriological and organoleptic characteristics at zero time and after 7, 15 and 30 days of frozen storage at +18±1°C. The frozen yogurt was prepared as following; skimmed milk powder was reconstituted in warm water to 11% total solids for yogurt production. The prepared yogurt pasteurized at 85°C for 10 min, cooled to 45°C, and then inoculated with 2% of freeze-dried DVS starter (L. acidophilus (LA-5), B. lactis (BB-12) and Str. thermophilus) (10⁷–10⁸ CFU/mL). The inoculated yogurt incubated at 45°C for 4 hrs (to final pH 4.8).

Viability of probiotics

The viability of probiotics was determined before freezing [zero time] (neglected results), post-freezing, 7, 15 and after 30 days of storage period by serial dilutions in sterilized peptone water by pour plate method. Lb. acidophilus (LA-5) was enumerated by using MRS agar while B. lactis (BB-12) was determined by MRS NNLP agar. All these plates were incubated at 37°C anaerobically for 72 hrs.

Chemical analysis

The chemical composition of samples for ash, crude fiber, fat, moisture and protein contents were determined according to the method of AOAC (2012). Carbohydrates were determined by difference (Table, 1).

| Proximal analysis | Moisture content | Crude protein | Total ash | fat | fiber | Carbohydrate |
|------------------|------------------|---------------|-----------|-----|-------|--------------|
| Wet weight       | 66.09 ±0.121     | 3.50 ±0.008   | 2.80 ±0.314| 3.37 ±0.32 | 8.34 ±0.516 | 15.90 ±0.021 |
| Dry weight       | —                | 10.32 ±0.143  | 8.26 ±0.002| 9.94 ±0.171 | 24.59 ±0.221 | 46.88 ±0.085  |

- Total phenolic compounds (TPC) of lemongrass leaves 46.08%
- Antioxidant activity (DPPH) of lemongrass leaves (81.70%)
**Thiobarbituric acid value (TBA)**

Lipid oxidation was measured by the 2-thiobarbituric acid distillation method of Pearson (1981); 10 g yogurt sample was macerated with 50 mL water for 2 mins and washed into a distillation flask with 47.5 mL water. After that, 2.5 mL of 4 M HCl were added to bring the pH to 1.5, followed by any antifoaming preparation and a few glass beads. The flask was heated utilizing an electric mantle so that 50 mL distillate is collected in 10 mins from the time boiling commences. 5 mL of the distillate was pipetted into a glass-stoppered tube, and then 5 mL TBA reagent (0.2883 g/100 mL of 90% glacial acetic acid) were added, stoppered, shook and heated in boiling water for 35 mins. A blank was prepared similarly using 5 mL water with 5 mL reagent. The tubes were cooled in water for 10 mins and the absorbance (D) versus blank was measured at 538 nm using a spectrophotometer (T80 UV/VIS, PG Instruments Ltd, UK). TBA No. [as mg malondialdehyde (MDA)/kg sample] = 7.8 D

**Sensory evaluation**

Sensory properties of frozen yogurt control and all treatments were evaluated in the same day of processing (day, 1) and after 7, 15 and 30 days of storage at -18±1°C according to the method of Salama (2004). Flavor (45 points), body and color (10 points) and total score (100 points) were evaluated by 15 panelists of the experienced staff members of Food Technology and Dairy Departments, Faculty of Agriculture, Suez Canal University, Egypt.

**Instrumental color measurement**

Objective measurement of color (CIE L*, a* and b*) was performed at the surface of yogurt samples using a color reader CR-10 (Konica Minolta sensing, Inc., Osaka, Japan). In this coordinate system, the L* value is a measurement of lightness, ranging from 0 (black) to 100 (white), a* value ranges from -100 (greenness) to +100 (redness) and b* value ranges from -100 (blueness) to +100 (yellowness). The redness index (a*/b*) was determined as described by Chen et al. (1997).

**Statistical analysis**

All measurement was done in triplicate and data were reported as means ± standard deviation (SD). The analysis of variance and significant differences were tested by one-way ANOVA using SPSS software (version 16.0 for windows, SPSS Inc., Chicago). It was considered that p≤0.05 was statistically significant.

**RESULTS AND DISCUSSIONS**

**Antimicrobial activities of lemongrass extract**

Antimicrobial activities of lemongrass extract were evaluated in this study. The data showed that lemongrass extract inhibited the growth of all microorganisms at concentrations (36 µl) for fungi species and bacteria species. The data exhibited that bacteria species were more resistant to lemongrass extract than fungi species. In general, the reduction of viable bacteria cells gradually increased according to the increase of the extract concentration, which was added to the growth agar media.

The tabulated results indicated that *Ps. aeruginosa* and *fragi* were sensitive to lemongrass extract than *ps. fluorescens*, which were utterly inhibited in the presence of 42 µg/mL of extract, while *Ps. fluorescens* was still viable when the same concentration was added to the growth agar media. From the data, it can also be noticed that *Aero. hydrophila* was more resistant to lemongrass extract than *Aero. caviae* and *sobria*. On the other hand, the results revealed that MIC for *Asp. niger* and *Asp. flavus* of lemongrass extract was (36 µl/mL), while MIC for *Penicillium* sp. was (30 µl/mL) of lemongrass extract (Table 2). The inhibition effect of lemongrass may be due to its bactericidal components such as phenols, flavonoids and essential oil. According to Singh et al. (2011), phenolic compounds and tannins have been found to inhibit pathogenic microorganisms. Ewansiha et al. (2012) mentioned that lemongrass showed antimicrobial activity against *Staph. aureus*, *Salmonella typhi* and *E. coli*. All molds, yeasts, *Lactobacillus* and most of the *Bacillus* sp. were sensitive to lemongrass oil.

Antimicrobial tests using the diffusion method showed that lemongrass extract inhibited the growth of *Pseudomonas* and *Aeromonas* sp. The data revealed that *Aero. hydrophila* was more resistant to lemongrass extract than *sobria* and *caviae*, which had inhibition zone 27±0.3, 29±0.1 and 31±0.4 mm, respectively (Fig 1). On the contrary, *Ps. fragi* and *aeruginosa* were sensitive to lemongrass extract than *Ps. fluorescens* by inhibition zone 32±0.3, 31±0.1 and 28±0.6mm, respectively (Fig 2). On the other hand, *Asp. niger* and *flavus* showed inhibition zone 33±0.4 mm while *Penicillium* sp. were sensitive to lemongrass extract than *Asp. sp. as well, *Penicillium* sp. had inhibition zone 35±0.1mm (Fig 3).

**Viability of probiotics in frozen yogurt**

Our results showed a slight decrease in the viable counts of *Lb. acidophilus* and *B. lactis* in all treatments during the frozen storage period (30 days). The initial viable cell counts of *Lb. acidophilus* and *B. lactis* for all treatments were between 7.97 ±0.02 - 7.60 ±0.07 and 6.91 ±0.01 - 6.25 ±0.04 log CFU/g, respectively (Table 3). From the data, it can be observed that counts of Lactobacilli decreased between 0.7 and 1.15 log CFU/g, depending on probiotic frozen yogurt treatments. Nonetheless, after 30 days of freezing storage, the population of these microorganisms remained above 105 CFU/g, which were utterly protected from freezing damage. From the data, the results showed decreases between 0.76 and 1.36 log CFU/g in all treatments.
Table (2): Minimum inhibitory concentrations (MIC) of lemongrass extract on some *Aeromonas* spp., *Pseudomonas* spp. and fungi spp.

| Microorganisms          | Lemongrass concentration (µl) |
|-------------------------|-------------------------------|
|                         | 0    | 6    | 12   | 18   | 24   | 30   | 36   | 42   | 48   |
| **(Inhibition %)**      |      |      |      |      |      |      |      |      |      |
| *Aeromonas hydrophila*  | 0.0  | 3.61 | 10.81| 20.27| 40.82| 68.95| 79.62| 92.14| 100.0|
| *Aeromonas caviae*      | 0.0  | 8.13 | 16.83| 31.16| 56.88| 81.13| 93.18| 100.0|--
| *Aeromonas sobria*      | 0.0  | 6.21 | 12.91| 28.99| 53.44| 76.22| 91.16| 100.0|--
| *Pseudomonas fluorescens* | 0.0  | 5.21 | 18.10| 22.33| 44.81| 66.11| 81.25| 90.0 | 100.0|
| *Pseudomonas aeruginosa*| 0.0  | 8.12 | 24.08| 28.86| 51.62| 84.18| 95.73| 100.0|--
| *Pseudomonas fragi*     | 0.0  | 6.12 | 18.31| 28.79| 50.29| 79.82| 93.68| 100.0|--
| *Aspergillus niger*     | 0.0  | 5.29 | 20.83| 50.17| 78.81| 83.1 | 100.0|--
| *Aspergillus flavus*    | 0.0  | 6.28 | 23.78| 52.19| 81.11| 91.5 | 100.0|--
| *Penicillium* spp.      | 0.0  | 7.39 | 28.01| 60832| 88.80| 100.0|--    |

**Figure (1):** Inhibition zones produced against *Aeromonas* spp. by using lemongrass extract.

**Figure (2):** Inhibition zones produced against *Pseudomonas* spp. by using lemongrass extract.

**Figure (3):** Inhibition zones produced against *Asp. niger*, *Asp. flavus* and *Penicillium* spp. by using lemongrass extract.
Table (3): The viability of probiotic bacteria in frozen yogurt fortified with lemongrass (mean ±S.D)

| Days of storage at -18°C | T0 | T1 | T2 | T3 | T4 |
|-------------------------|----|----|----|----|----|
|                         | Lb. acidophilus | B. lactis | Lb. acidophilus | B. lactis | Lb. acidophilus | B. lactis | Lb. acidophilus | B. lactis | Lb. acidophilus | B. lactis |
| 0                       | 7.83 ± 0.01 | 6.56 ± 0.12 | 7.97 ± 0.02 | 6.91 ± 0.01 | 7.95 ± 0.04 | 6.90 ± 0.01 | 7.63 ± 0.03 | 6.38 ± 0.06 | 7.60 ± 0.07 | 6.25 ± 0.04 |
| 7                       | 7.72 ± 0.09 | 6.56 ± 0.03 | 7.83 ± 0.04 | 6.69 ± 0.04 | 7.80 ± 0.07 | 6.66 ± 0.03 | 7.43 ± 0.10 | 6.10 ± 0.08 | 7.41 ± 0.18 | 6.20 ± 0.05 |
| 15                      | 7.33 ± 0.07 | 5.96 ± 0.02 | 7.43 ± 0.04 | 6.49 ± 0.03 | 7.42 ± 0.10 | 6.47 ± 0.02 | 7.31 ± 0.04 | 5.83 ± 0.03 | 7.02 ± 0.05 | 5.82 ± 0.04 |
| 30                      | 6.86 ± 0.03 | 5.50 ± 0.09 | 6.96 ± 0.03 | 5.55 ± 0.07 | 6.90 ± 0.03 | 5.65 ± 0.05 | 6.48 ± 0.04 | 5.51 ± 0.07 | 6.55 ± 0.13 | 5.49 ± 0.10 |

T0: Control  
T1: yogurt with 0.5% lemongrass powder  
T2: yogurt with 1.0% lemongrass powder  
T3: yogurt with 0.5% lemongrass extract  
T4: yogurt with 1.0% lemongrass extract

The expected decreasing of viable count due to the adverse effects of freezing condition for the viability of bacteria. A loss of half to one log cycle in viable counts caused by the freezing process (Davidson et al., 2000). Furthermore, this reduction of bacterial counts could be due to acid's ability to enhance the negative effect on bacterial growth.

Treatments 1 and 2 had the lowest decrease of Lactobacilli and Bifidobacteria counts, followed by the control sample. This reduction could be due to lemongrass addition as a powder form that provides conditions that may protect or enhance bacterial growth.

Natural additives were used to control fungal spoilage for clean-label products. In this study, lemongrass was used to control yeast and mold spoilage of frozen yogurt. The average value of molds and yeasts count of different treatments of yogurt was not more than $10^3$ CFU/g compared to the control sample. (The data is not tabulated). Means that all yogurt treatments were outstanding in hygiene. According to Nyamath and Karthikeyan (2018), lemongrass had antimicrobial activity against gram-positive and gram-negative bacteria, yeasts and molds.

Antioxidant effect of lemongrass powder and extract in frozen yogurt

TBA test involves the reaction between MDA resulted from lipid oxidation and TBA reagent and formation of pink color. The oxidation of polyunsaturated fatty acids in yogurt leads to the formation of a TBA pink color with maximum absorption at 532 nm (Semeniuc et al., 2016). Lemongrass had a significant effect ($P \leq 0.05$) on TBA values in yogurt samples compared with the control sample. During storage, TBA showed a significant increase from 0.9 mg MDA/Kg yogurt at zero time to 1.63 mg after 30 days of frozen storage at -18°C ±1 for the control sample and from 0.8 mg to 1.02, 1.00, 1.08 and 1.04 mg MDA/Kg yogurt after 30 days of frozen storage for T1, T2, T3 and T4, respectively (Table 4).

This decrease in TBA values in treatments might be due to the presence of bioactive compounds in lemongrass, which have antioxidant effect; the data also revealed a significant difference in the TBA values of different treatments. It can be assumed that the addition of lemongrass (powder or extract) to yogurt caused a reduction of oxidation and aldehydes formation compared to control. There were also significant differences in additive material type (powder or extract) or in lemongrass addition concentrations. The high lemongrass ratio tended to have slightly lower TBA absorbance scores than the low ratio. According to Hartatie et al. (2019), lipid oxidation in broiler meat was reduced by using lemongrass as a natural antioxidant. Lemongrass is used as a medicinal tea with antimicrobial and antioxidant properties (Kieling et al., 2019). Lemongrass contains essential oil and phenolic compounds known to have antioxidant activity (Anggraeni et al., 2018).
Table (4): Effect of lemongrass on thiobarbituric acid value (mg MDA/kg) of frozen yogurt during storage at -18°C±1 (Mean ±SD)

| Treatments | Storage time (days) |
|------------|---------------------|
|            | 0                   | 5       | 15      | 20      | 30      |
| **T₀**     | 0.91 ±0.002         | 1.01 ±0.002 | 1.21 ±0.071 | 1.39 ±0.719 | 1.63 ±0.191 |
| **T₁**     | 0.82 ±0.121         | 0.85 ±0.225  | 0.91 ±0.003  | 0.98 ±0.211  | 1.02 ±0.138 |
| **T₂**     | 0.80 ±0.331         | 0.81 ±0.142  | 0.88 ±0.008  | 0.90 ±0.254  | 1.00 ±0.145 |
| **T₃**     | 0.82 ±0.421         | 0.89 ±0.115  | 0.93 ±0.113  | 0.99 ±0.617  | 1.08 ±0.111 |
| **T₄**     | 0.81 ±0.008         | 0.82 ±0.161  | 0.89 ±0.004  | 0.92 ±0.476  | 1.01 ±0.002 |

Means within the same column marked with different letters are significantly different (P < 0.05).

T₀: Control
T₁: yogurt with 0.5% lemongrass powder
T₂: yogurt with 1.0% lemongrass powder
T₃: yogurt with 0.5% lemongrass extract
T₄: yogurt with 1.0% lemongrass extract

Effect of lemongrass powder and extract on sensory characteristics of frozen yogurt

Sensory evaluation showed that frozen yogurt fortified with lemongrass powder 0.5% had a good body, texture, flavor and quality characteristics with higher antioxidant effect (TBA values 1.02 mg MDA/kg) compared with frozen yogurt fortified with lemongrass powder 1% and lemongrass extract 0.5-1%.

Although T₁ had the highest sensory mean scores, all lemongrass frozen yogurt treatments showed higher flavor scores with accepted mild acid taste than the control sample (Table 6). Frozen yogurt was commercially evaluated to be the lowest-acid product. Moreover, lemongrass can also add a pleasant light, lemony flavor to foods (Abdelazez et al., 2017).
Effect of lemongrass as prebiotic on quality properties of frozen yogurt

| Treatments | Zero    | 7       | 15      | 30      |
|------------|---------|---------|---------|---------|
| Control    | 72.0±1.000 | 71.6±0.570 | 70.0±1.000 | 69.7±1.520 |
| T1         | 95.6±1.150 | 95.0±0.001 | 93.0±1.732 | 92.3±1.520 |
| T2         | 95.0±1.130 | 93.3±1.520 | 92.0±1.000 | 89.7±0.570 |
| T3         | 89.3±0.577 | 86.7±0.570 | 85.3±3.210 | 84.3±0.570 |
| T4         | 82.7±1.527 | 81.3±0.570 | 80.0±0.001 | 78.3±1.150 |

Means with the same column with different superscript (a, b, c...) are not significantly different (p<0.05)
T0: Control  
T1: yogurt with 0.5% lemongrass powder  
T2: yogurt with 1.0% lemongrass powder  
T3: yogurt with 0.5% lemongrass extract  
T4: yogurt with 1.0% lemongrass extract

CONCLUSION

Many studies have focused on probiotics and prebiotics and their health effects. Probiotics and lemongrass as dietary fiber (prebiotics) are well known for their beneficial health effects and source of functional foods. In conclusion, the addition of the powder or extract of lemongrass to frozen yogurt improved the viability of probiotic and quality characteristics of frozen yogurt.

Authors’ contributions

Eldeeb, G.S.S. was involved in chemical and microbial analysis, manuscript writing, correcting and editing. Mosilhey, S.M. was involved in the preparing for the implementation, calculating and manuscript writing. Abouelnaga, M. was involved in processing, data tabulating and manuscript writing. All authors read and approved the final manuscript.

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Effect of lemongrass as prebiotic on quality properties of frozen yogurt

تحسين خواص الجودة للزبادي المجمد بواسطة تدعيه بحشيشة الليمون كداعم حيوي

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تهدف هذه الدراسة إلى دراسة تأثير إضافة حشيشة الليمون كمضاد لميكروبات وكمنز ودعم لمجر بكتيريا البروبيويك في منتج الزبادي المجمد. تم تصنيع الزبادي بسلاسل [Lactobacillus acidophilus (LA-5) + Streptococcus thermophiles] بالإضافة إلى Bifidobacterium lactis (BB-12)]. مستخلص حشيشة الليمون عند تركيز 36 µL/mL على تثبيط نشاط فطريات (Aspergillus niger, Aspergillus flavus) وعدد تركيز 48 µL/mL فاستخدم بكتيريا Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, aeruginosa fragi و Pseudomonas fluorescens, 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