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# Effect of ginger (*Zingiber officinalis*) addition on fermented bovine milk: Rheological properties, sensory attributes and antioxidant potential

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**Abstract –** The present study aims to investigate the addition effect of ginger powder (*Zingiber officinalis*) in bovine milk used for yogurt processing by determining the physico-chemical, the rheological and the sensory attributes after 24-hour storage. The total phenolic content and the antioxidant activity were evaluated during 21 days of cold storage at 4 °C for control and fortified yogurt samples with 1% ginger powder. The supplementation of bovine milk with ginger powder at concentration ranging from 0.5 to 2.5% (w/v), accelerated the rate of pH reduction, increased the total solids contents, reduced the syneresis rate, increased the apparent viscosity and improved the textural properties of yogurt samples. Fortified yogurt sample with 1% ginger powder showed higher values of total phenolics content, DPPH scavenging activity, reducing power and metal chelating assay during storage period compared to control samples. Furthermore, the antioxidant activity for 1% ginger yogurt increased significantly over storage period.

**Keywords:** Ginger powder, yogurt, antioxidant activity, total phenolics, syneresis

## 1. Introduction

Yogurt is a very popular dairy product obtained by the lactic acid fermentation of bovine milk through the action of the Streptococcus thermophilus and Lactobacillus delbrueckii ssp. bulgaricus. The manufacturing process of yogurt consisted in a lactic fermentation causing the destabilization of the milk protein system and thus leading to a gel formation. In dairy industry, three different physical states of yogurts could be manufactured, namely set yogurt (undisturbed gel in the pot), stirred yogurt (the acid gel formed during incubation in big fermentation tanks is disrupted by stirring) or drinking yogurt. The fermentation of set yogurts is achieved in the container. However, stirred yogurts are mostly fruit-flavored since aromas and fruits are usually added after fermentation so that to be thoroughly dispersed in the yogurt matrix (Chandan 2006).

The industrial manufacturing of yogurts was increased (Park et al. 2005) due to the health benefit of bovine milk components as well as lactic acid bacteria used (LAB) (Park et al. 2005). Several attempts to prepare yogurts from different food resources have been realized (Lal et al. 2006). Production of yogurt from bovine milk supplemented with ginger powder was aimed to combine the sensory properties of the ginger with the well-known yogurt flavor. The global properties of yogurt, mainly nutritional value, acidity level, aroma compounds production, sensory attributes, and rheological parameters are affected by the initial chemical composition of raw milk (Bonczar et al. 2002).

Ginger (Zingiber officinale) was extensively used as a spice for a variety of food and beverages. It is considered as an important medicine since its roots contain several biologically active compounds. These compounds are responsible for many medical applications (Hanou et al. 2016). Furthermore, ginger contains an important amount of starch (up to 40%, dry basis) with several potential applications. Starches have been recognized, for a long time, as an important source of energy. Moreover, it is considered as one of the most thickening agents used for yogurt manufacturing (Ibrahim 2015). Ginger is also reported to be a good source of protein (Latona et al. 2012). Thus, the supplementation of ginger could be a good source of growth factors for inoculated lactic acid bacteria as it may improve the texture of fermented bovine milk. This study aims to evaluate the addition effect of ginger powder in different concentrations to bovine milk used for yogurt processing by determining the chemical composition, rheological and sensory properties of yogurts after 24-hour storage. On the other hand, the antioxidant

potential of supplemented yogurt samples with 1% of ginger powder during 21 days was evaluated, in comparison with a yogurt sample without addition of ginger powder, taken as control.

## 2. Materials and methodes

### 2.1. Yogurt making process

Yogurt was prepared using raw bovine milk with 11% sugar (*w/v* milk) addition. Sugar was dissolved in the raw milk. Then, 0.5, 1, 1.5 and 2.5 % of ginger powder were added to raw milk and the mixture was stirred gently. The mixture was put in the refrigerator overnight with a manual stirring every 2 h. The mixture was then pasteurized in a water bath at 85 °C for 30 min and then cooled down to 45 °C. Milk was placed into a vat and was subsequently inoculated with 7.5 % ($10^6$ - $10^7$ cfu/mL) of the starter culture (PAL YOG 3-30 D, Laboratoires STANDA, F-14050 CAEN CEDEX), which is a combination of *Streptococcus thermophiles* and *Lactobacillus delbrueckii subsp. Bulgaricus*. Incubation was performed at 45 °C until the pH reached 4.5 (approximately 6 h). The fermentation was then interrupted by cooling the vat to 4 °C. Yogurt samples were kept at 4 °C for 24 h for further analyses.

### 2.2. Physicochemical analyses of yogurt samples

The pH values of yogurt samples (control and fortified) were measured using pH meter (Hanna Instruments, Portugal) connected to an electrode 406 M 6 (Mettler Toledo, France). Titratable acidity of yogurt samples was determined using the potentiometric method according to the IDF standard (IDF, 1991) and expressed as degree Dornic (°D). The milk fat of yogurts was determined (IDF 152 A, 1997) using Gerber method. Total solids contents of yogurts were determined by drying 5 g of yogurt samples at 103 °C for 7 h in a capsule containing sand (IDF 21 B, 1987). The ash contents of yogurts were determined in a muffle furnace by incineration at 550 °C according to NF V04-208 (1989). The total protein contents (conversion factor 6.25) of yogurt samples, were determined by Kjeldhal method. Compositional analyses of fortified yogurts were run 24 h after yogurt preparation.

### 2.3. Color of yogurt samples

Color of the yogurt samples was measured using a colorimeter (Lab Scan II, Hunter Associate Laboratory Inc., Reston, VA, USA). The yogurt samples were placed inside a glass refract cup on the light pore size of 44.45 mm. Data were recorded as CIE L* / values indicating lightness (L*), Chroma (C) value of $(a^{*2} + b^{*2})^{1/2}$ and Hue angle (h°) value of $\tan^{-1}$ (b*/a*) to represent the saturation and shade of the color, respectively.

### 2.4. Syneresis and viscosity of yogurt samples

Yogurt syneresis rate was determined by the centrifugation method of Celik et al. (2006). 20 grams of yogurt were weighed and centrifuged at 16800 × g for 20 min at 4 °C (Megafuge 16 R centrifuge, Thermo Fischer Scientific, Waltham, MA, USA). Syneresis rate was expressed as the volume of separated whey per 100 g of yogurt. Viscosity of the yogurt samples was measured by a rotational viscometer (DV-III, Brookfield, MA, USA) using a spindle No. 6 at 200 rpm. Viscosity of the different yogurt samples was recorded as milliPascal·second (mPa·s).

### 2.5. Texture measurement

Texture properties of yogurt samples were determined using Textural Profile Analysis (TPA) test by a Texture Analyser (LLOYD instruments, England) (Mallek et al. 2012). All measurements were performed in a controlled room at 25 °C. A cylindrical probe (25 mm) was used to compress the yogurt sample by 50% of its original height (30 mm) at a displacement speed of 60 mm/min. All the Texture operations were controlled by the software supplied by Texture Technologies Corp connected to the instrument. Texture profile parameters: Hardness (N), springiness, and cohesiveness were measured.

### 2.6. Sensory evaluation

After 24 h of storage at 4 °C, yoghurt samples were evaluated for consumer sensory acceptance by a 100-member panel recruited among staff and students of the Laboratoire Analyses, Valorisation et Sécurité des Aliments as well as National School of Engineering of Sfax (Tunis, State of Tunisia) who stated that they were yoghurt lovers and users. Yogurt samples were served in a homogeneous way to the panelists. Each of the five yoghurt samples studied in this paper was coded with three-digit random

numbers, and randomly presented to the panel. Panel members were asked to rate the likeness on appearance, flavour (odor and taste), mouthfeel, after taste and overall impression of the samples by using a 6 – point hedonic scale, with 0 = dislike extremely and 5 = like extremely.

### 2.7. Antioxidant capacity of ginger and yogurts

#### 2.7.1. Extraction procedure

Yogurt extracts were prepared according to Shori and Baba (2013). 10 g of each yogurt sample was weighed into plastic centrifuge tubes and diluted with deionized distilled water (2.5 mL). pH of yogurt samples was determined. The yogurts were acidified to pH 4.0 by adding HCl solution (0.1 M). Then, the acidified yogurts were incubated for 10 min in a water bath (45 °C) and centrifuged (5000 × g, 10 min, 4 °C). The pH of the resulting supernatant was then adjusted to 7.0 using NaOH solution (0.1 M) followed by another step of centrifugation (5000 ×g, 10 min, 4 °C). The obtained clear supernatant was harvested and stored at (-20 °C) to be used for further analysis within 1-2 weeks of preparation.

#### 2.7.2. Total phenolic content assay

Total phenolics content (TPC) was assayed using the Folin–Ciocalteu reagent, following Dewanto et al. (2002) method. An aliquot of 0.125 mL of each yogurt extract sample was added to 0.5 mL of deionized water and 0.125 mL of the Folin–Ciocalteu reagent. The mixture was shaken and stood for 6 min, before adding 1.25 mL of 7% sodium carbonate ($Na_2CO_3$) solution. Then, the solution was adjusted with deionized water to a final volume of 3 mL and mixed thoroughly. After incubation for 90 min, the absorbance versus prepared blank was read at 760 nm. Total phenolic contents were expressed as mg gallic acid equivalents (GAE) per gram of dry weight (mg GAE/g DW) through the calibration curve with gallic acid. The calibration curve range was 0–400 µg/mL ($R^2$ = 0.99).

#### 2.7.3. DPPH radical scavenging capacity of yogurt

The DPPH radical-scavenging capacity of yogurt samples was determined according to Bersuder et al. (1998) method. A volume of 500 µL of each sample at different concentrations was added to 375 µL of ethanol (99%) and 125 µL of DPPH solution (0.02% in ethanol) as free radical source. The mixtures were shaken to be then incubated for 60 min at room temperature in darkness. The radical-scavenging capacity was measured using spectrophotometer (UV mini 1240, UV/VIS spectrophotometer, SHIMDZU, Kyoto, Japan) by controlling the decrease in absorbance at 517 nm. In its radical form, DPPH has an absorption band at 517 nm which disappears upon reduction by an antiradical compound. Lower absorbance of the reaction mixture showed higher DPPH free radical-scavenging activity. DPPH radical-scavenging capacity was calculated as follows:

$$\boldsymbol{DPPH\ radical-scavenging\ activity} = \frac{\boldsymbol{A_{control} - A_{sample}}}{\boldsymbol{A_{control}}} \times \mathbf{100}$$

Where A_control is the absorbance of the control reaction (containing all reagents except the sample), and A_sample is the absorbance of the sample (with the DPPH solution)

#### 2.7.4. Reducing power assay

The capacity of yogurt samples to reduce iron (III) was determined according to Yildirim et al. (2001). An aliquot of 1 ml of each protein sample at different concentrations was mixed with 2.5 mL of 0.2 M phosphate buffer (pH 6.6) and 2.5 mL of 1% (*w/v*) potassium ferricyanide solution. The mixtures were incubated at 50 °C for 30 min. After incubation, 2.5 mL of 10% (*w/v*) TCA was added. The mixtures were then centrifuged for 10 min at 10,285 g. Finally, 2.5 mL of the supernatant solution from each sample mixture were mixed with 2.5 mL of distilled water and 0.5 mL of 0.1% (*w/v*) ferric chloride. After 10 min, the absorbance of the resulting solutions was measured using spectrophotometer (UV mini 1240, UV/VIS spectrophotometer, SHIMDZU) at 700 nm. Higher absorbance of the reaction mixture leads to higher reducing power. The control was also conducted using distilled water instead of the sample.

#### 2.7.5. Metal chelating activity

The chelating activities of the yogurt sample towards ferrous ion (Fe2+) were determined according to Decker and Welch methods (1990). A volume of 0.1 ml of each sample at various concentrations was

mixed with 0.1 ml of 2 mM FeCl2, 4H2O and 0.2 mL of 5 mM 3-(2-pyridyl)-5,6-bis(4-phenyl-sulphonic acid)-1,2,4-triazine (ferrozine). Similarly, the blank was conducted using distilled water instead of the sample. The metal ion chelating activity was calculated using the following equation:

$$\textbf{\textit{Chelating activity}}\ (\%) = \mathbf{1} - \frac{\boldsymbol{A_{562\ sample}}}{\boldsymbol{A_{562\ blank}}}$$

### 2.8. Statistical analyses

Analysis of variance was carried out using SPSS software statistics 19. Significant differences ($p < 0.05$) among all treatments were detected using Duncan's multiple range tests. Values expressed are means ± standard deviation (n = 3) of triplicate measurements.

## 3. Results and discussion

### 3.1. Physicochemical analyses of yogurt samples

The mean values of chemical components of the various yogurt samples prepared with different ginger powder concentrations is shown in Table 1. A comparison with a yogurt sample made without ginger powder addition, taken as control, was achieved. Supplementation of raw bovine milk with ginger powder decreased significantly pH from 4.62 for control sample to 4.44 for yogurt fortified with 2.5% of ginger powder ($p < 0.05$). Moreover, ginger powder addition to bovine milk increased significantly ($p < 0.05$) the total solids, protein and fat contents in yogurt samples. The increase of these components in supplemented bovine milk is due to the ginger powder. It was observed that protein content increased significantly ($p < 0.05$) in yogurt with the concentration of ginger powder from 2.91 to 3.62% (Table 1). Ash content showed no statistically significant difference compared to control yogurt except for the sample supplemented with 2.5 % of ginger powder ($p < 0.05$).

### 3.2. Color analysis of yogurt samples

Color measurement shows slight differences of color between different kinds of fortified yogurts. The addition of ginger powder to bovine milk increased significantly h° from 70.87 for control yogurt sample to 88.79 for fortified yogurt sample with 2.5% of ginger powder (Table 1). The variation of h° indicated that yogurt color tends towards yellow. With the increase of ginger powder concentration addition, L* values decreased, from 91.58 for the control sample to 82.32 for yogurt fortified with 2.5% of ginger powder, while a* and b* values increased, demonstrating that yogurts supplemented with ginger powder addition were darker, red and yellower than control yogurt. These colors might be due to the ginger powder color (brown). Otherwise, a significant increase in C* values ($p < 0.05$), from 16.51 for the control sample to 21.23 for the yogurt added with 2.5% of ginger powder was observed (Table 1). The obtained results are in disagreement with those previously reported by Kumar and Mishra (2007) for soy and mango milk yogurt.

### 3.3. Syneresis and viscosity of yogurt samples

Syneresis evaluation results of different yogurt samples are presented in Figure 1. Control yogurt was criticized for whey separation and showed a significantly higher syneresis rate ($p < 0.05$) compared to fortified yogurts with ginger powder. Syneresis rate of all yogurt samples decreased as the protein proportion contained in yogurt samples was important. The lowest syneresis was observed with yogurt supplemented with 2.5% of ginger powder (35.61%) followed by the other concentrations in decreasing order. This result could be attributed to increasing total solids content of bovine milk due to ginger powder addition as well as starch containing in ginger in high concentration (Matumoto-Pintro et al. 2011). The obtained result suggests that proteins contribute to the increase in water holding capacity of the yogurt gel. Ginger powder used in this study served as a stabilizer in yogurts to reduce whey separation and improve texture.

The apparent viscosity values tended to increase with the supplementation level of ginger powder (Figure 1). This increase reflects the incorporation level of ginger powder where the fortification of 2.5% of ginger powder had the most marked effect on the viscosity values (1520 mPa·s) compared to that of 1%, which is around 890 mPa·s. The viscosity of the control yogurt had the lowest value which is 600 mPa·s. The addition of ginger powder considerably improved the viscosity of the yogurt samples compared to the control yogurt. The significant increase in viscosity values of different yogurt samples fortified with ginger powder could be attributed to the increase in total solids content ($p < 0.05$). This result might also be related to increased protein-protein interactions from the added ginger powder

(Hanou et al. 2016). Furthermore, ginger is known to contain an important amount of starch (up to 40%, dry basis) with various potential applications. Starches have the ability to thicken gel and hold water in yogurt manufacture (Ibrahim 2015). Therefore, the ginger powder addition to yogurt could significantly increase its water holding capacity compared to control sample. Similar results were previously reported by Lobato-Calleros et al. (2014).

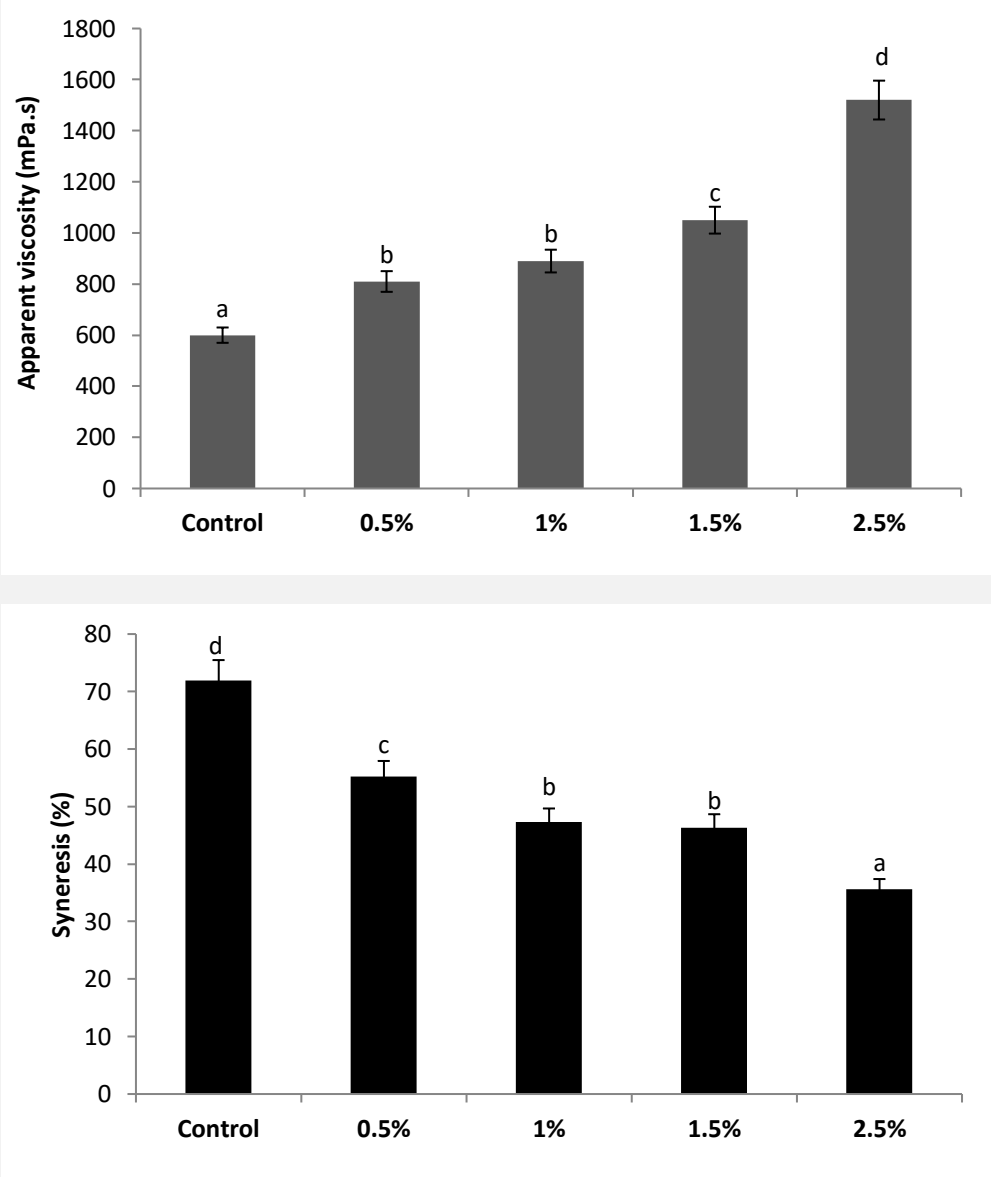


**Figure 1.** Apparent viscosity and syneresis parameters of control and supplemented yogurt samples with different concentrations of ginger powder

### 3.4. Texture profile analysis

Texture profiles of the different yogurts were obtained after 24 h of storage at 4 °C and the results are summarized in Table 1. Hardness is an important parameter which is used to determine yogurt texture. Control yogurt had significantly the lowest hardness value (0.58 N). This could be attributed to a lower protein rearrangement in the control yogurt sample (Prasanna et al. 2013). The addition of ginger powder changed significantly the gel hardness. A significantly higher hardness values were obtained for all fortified yogurts. The increased hardness of supplemented yogurts might be attributed to decreased water in the gel system due to the decreased syneresis rate. Likewise, the increase in hardness could also

be attributed to the enzymatic activity of enzymes derived from 2.5 % of ginger powder higher than that of enzymes derived from the control yogurt. This obtained result confirmed that found in this study regarding apparent viscosity and syneresis values (Fig. 1). The addition of ginger powder contributed to the significant increase of adhesiveness for yogurt supplemented with 2.5 % of ginger powder in comparison with the control sample ($p < 0.05$) while no significant difference in cohesiveness and springiness between all samples was noticed. The textural attributes of yogurt samples were observed to be significantly ($p < 0.05$) increased with increasing ginger powder concentrations, except for cohesiveness and springiness attributes. This is because of the higher protein level in yogurts supplemented with ginger powder compared to control yogurt sample. Espírito Santo et al. (2012) showed that fruit peel powder promoted higher texture parameters values in skim yogurts co-fermented by B.lactis strains compared to their respective controls.

**Table 1.** Physico-chemical, color and textural parameters of different yogurt samples

| | Control | Different Ginger powder concentrations | | | |
|---|---|---|---|---|---|
| | | 0.5% | 1% | 1.5% | 2.5% |
| **Physico-chemical parameters** | | | | | |
| **pH** | 4.62 ± 0.04$^{c}$ | 4.58 ± 0.11$^{c}$ | 4.57 ± 0.04$^{b,c}$ | 4.49 ± 0.00$^{a,b}$ | 4.44 ± 0.04$^{a}$ |
| **TA (°D)** | 73.67 ± 2.69$^{b,c}$ | 72..50 ± 2.78$^{b}$ | 71.33 ± 1.64$^{b}$ | 74.33 ± 2.52$^{a}$ | 82.00 ± 3.00$^{c}$ |
| **TS (%)** | 23.28 ± 0.27$^{a}$ | 23.83 ± 0.15$^{a}$ | 24.24 ± 0.31$^{b}$ | 26.48 ± 0.77$^{c}$ | 28.46 ± 0.32$^{d}$ |
| **Protein (%)** | 2.71 ± 0.05$^{a}$ | 2.91 ± 1.12$^{a}$ | 3.28 ± 0.02$^{b}$ | 3.45 ± 0.09$^{c}$ | 3.62 ± 0.26$^{d}$ |
| **Fat (%)** | 3.82 ± 0.15$^{a}$ | 5.38 ± 0.05$^{b}$ | 6.80 ± 0.21$^{c}$ | 8.17 ± 0.36$^{d}$ | 9.91 ± 0.19$^{d}$ |
| **Ashes (%)** | 0.711 ± 0.12$^{b}$ | 0.704 ± 0.08$^{b}$ | 0.695 ± 0.33$^{b}$ | 0.685 ± 0.15$^{b}$ | 0.636 ± 0.04$^{a}$ |
| **Color parameters** | | | | | |
| **L *** | 91.58 ± 0.95$^{b}$ | 86.74 ± 1.21$^{a}$ | 85.31 ± 0.57$^{a}$ | 84.97 ± 0.56$^{a}$ | 82.32 ± 7.04$^{a}$ |
| **C*** | 16.51 ± 0.38$^{a}$ | 20.16 ± 0.05$^{b}$ | 20.39 ± 0.28$^{b,c}$ | 20.83 ± 0.06$^{b,c}$ | 21.23 ± 1.47$^{c}$ |
| **a*** | -5.41 ± 0.35$^{a}$ | -3.27 ± 0.01$^{b}$ | -1.84 ± 0.04$^{c}$ | -1.40 ± 0.11$^{d}$ | -0.45 ± 0.01$^{e}$ |
| **b*** | 15.60 ± 0.53$^{a}$ | 19.89 ± 0.06$^{b}$ | 20.31 ± 0.28$^{b}$ | 20.78 ± 0.06$^{b}$ | 21.23 ± 1.48$^{c}$ |
| **h°** | 70.87 ± 0.51$^{a}$ | 80.66 ± 0.09$^{b}$ | 84.82 ± 0.05$^{c}$ | 86.15 ± 0.03$^{d}$ | 88.79 ± 0.02$^{e}$ |
| | 48.91 ± 1.01$^{d}$ | 47.11 ± 0.97$^{c,d}$ | 46.12 ± 0.24$^{a,b}$ | 46.12 ± 0.47$^{b,c}$ | 44.48 ± 6.09$^{a}$ |
| **Textural parameters** | | | | | |
| **Hardness (N)** | 0.52 ± 0.04$^{a}$ | 0.59 ± 0.03$^{b}$ | 0.56 ± 0.02$^{b}$ | 0.56 ± 0.00$^{b}$ | 0.84 ± 0.02$^{c}$ |
| **Cohesiveness** | 0.38 ± 0.06$^{a}$ | 0.34 ± 0.06$^{a}$ | 0.34 ± 0.06$^{a}$ | 0.36 ± 0.07$^{a}$ | 0.43 ± 0.03$^{a}$ |
| **Adhesiveness (N)** | 0.22 ± 0.03$^{a}$ | 0.23 ± 0.02$^{a}$ | 0.19 ± 0.04$^{a}$ | 0.18 ± 0.01$^{a}$ | 0.36 ± 0.03$^{b}$ |
| **Springiness (mm)** | 25.87 ± 5.00$^{a}$ | 23.5 ± 5.62$^{a}$ | 22.96 ± 3.84$^{a}$ | 25.39 ± 3.85$^{a}$ | 26.8 ± 1.59$^{a}$ |

Averages ± Standard deviation (SD) of three replicates.
$^{a-e}$Values within the same row with different superscripts differed significantly by Duncan's multiple-range test($p<0.05$).

### 3.5. Sensory evaluation

The effect of ginger powder addition on sensory attributes of 24-hour yogurts is presented in Table 2. Flavour scores of different kind of yogurts supplemented with ginger powder was observed to be significant compared to control yogurt. The highest flavour score of 3.42 was obtained for control yogurt followed by yogurt supplemented with 1% of ginger powder (3.19), while the lowest score was obtained for yogurt made with 0.5% of ginger powder. Off-flavours were detected in the control yogurt as well as in the yogurt supplemented with 1% of ginger powder but those samples were rated superior and most

preferred by the panelists. Also samples produced with 0.5% of ginger powder addition were characterized by slightly perceptible off-flavours, however, these yogurt samples have been evaluated positively by the panelists. Mouthfeel score was highest in yogurts supplemented with 1% of ginger powder. Ginger powder was used for its stabilizing effect but also for its thickening property due to its higher starch content, which gives a better mouthfeel of yogurt.

Appearance score ranged from 3.13-3.53 and was significantly ($p < 0.05$) higher in yogurts supplemented with 1% of ginger powder compared to control. This result is due to the presence of separated whey on the surface of the control yogurt. Overall acceptability score reflected the scores obtained by all sensory parameters and it was significantly ($p < 0.05$) higher for control sample followed by yogurt added with 1% of ginger powder. According to the results of the sensory evaluation, it was clear that, supplementation of 1% ginger powder was observed to be optimum between all ginger powder concentrations added to bovine milk for yogurt processing. Moreover, the supplemented ginger powder's main role in this study was to provide a distinctive flavor, a body and to act as flavor enhancer for better assessment by the consumers. However, the excess in ginger powder addition (1.5 and 2.5%) seems to have a negative impact on the overall assessment of yogurt, since the samples with lower concentrations of ginger (0.5 and 1%) are most appreciated by panelists among all other concentrations (Table 2). As a conclusion, the addition of 1% ginger powder in yogurt was most appreciated by panelists.

**Table 2.** Sensory attribute ratings of the 24-hour-yogurts (scores from 100 naïve panelists).

| | **Control** | **Different ginger powder concentrations** | | | |
|---|---|---|---|---|---|
| | | **0.5%** | **1%** | **1.5%** | **2.5%** |
| **Appearance** | $3.40 \pm 1.15^{b}$ | $3.43 \pm 0.89^{b}$ | $3.53 \pm 0.89^{c}$ | $3.13 \pm 1.13^{a}$ | $3.23 \pm 1.10^{a}$ |
| **Flavour** | $3.42 \pm 1.22^{c}$ | $2.62 \pm 0.19^{a}$ | $3.19 \pm 1.02^{b}$ | $2.87 \pm 1.15^{a}$ | $2.92 \pm 0.96^{a}$ |
| **Mouthfeel** | $3.66 \pm 0.99^{b}$ | $3.30 \pm 1.21^{a}$ | $3.80 \pm 1.17^{c}$ | $3.37 \pm 1.16^{a}$ | $3.37 \pm 1.27^{a}$ |
| **Off-flavour** | $3.65 \pm 1.17^{c}$ | $2.86 \pm 1.27^{b}$ | $3.06 \pm 1.11^{b}$ | $2.50 \pm 1.31^{a}$ | $2.50 \pm 1.31^{a}$ |
| **Odour** | $3.63 \pm 0.97^{b}$ | $3.07 \pm 1.11^{a}$ | $3.47 \pm 0.94^{b}$ | $2.70 \pm 1.18^{a}$ | $3.07 \pm 1.20^{a}$ |
| **Overall impression** | $3.87 \pm 0.88^{c}$ | $3.27 \pm 0.91^{a}$ | $3.37 \pm 1.16^{b}$ | $2.77 \pm 0.97^{a}$ | $2.97 \pm 1.07^{a}$ |

Averages ± Standard deviation (SD) of three replicates.

$^{a\text{-}b\text{-}c}$Values within the same row with different superscripts differed significantly by Duncan's multiple-range test($p<0.05$).

### 3.6. Total phenolic content and antioxidant potential of yogurt samples during refrigerated storage

Total phenolic content (TPC) and antioxidant potential of control yogurt and yogurt enriched with 1% ginger powder are shown in Table 3. The observed TPC for the control yogurt decreased significantly ($p < 0.05$) during the storage period. The obtained result contrasts with those observed by Muniandy et al. (2016). Supplemented yogurts with 1% ginger powder showed significant differences in TPC profile at each storage time ($p < 0.05$). Compared to control sample, yogurt enriched with 1% ginger powder showed a significant increase in TPC during cold storage (Table 3). This result is in agreement with those reported by Muniandy et al. (2016) for green tea yogurts. However, it contrasts with the results reported by Tseng and Zhao (2013) for grape pomace yogurts. The addition of 1% ginger powder increased the total phenolic compound concentrations by 46.35, 59.38, 64.49 and 66.01% during 1, 7, 14 and 21 storage days regarding control sample, respectively (Table 3). The observed decrease in TPC could be due to proteolysis of milk proteins which may release amino acids with phenolic side chains, mainly tyrosine. Furthermore, microbial metabolism of phenolic compounds in 1% ginger powder yogurt as well as production of new phenolic acids during acidification may result in an increase of phenolic groups (Blum 1998).

The antioxidant potential of yogurt samples enriched with ginger powder was investigated in this study by three different methods. The variations in the DPPH radical scavenging activity, reducing power ability and metal chelating activity of control and fortified yogurt samples extracts during 21 days of storage at 4 °C are presented in Table 3. The present study indicated that 1% ginger powder yogurts showed significantly higher free radical scavenging potential and metal chelating activity compared to control samples during all storage period (Table 3). On the other hand, supplemented yogurts showed significantly lower reducing power capacity in comparison with control samples during storage (Table 3). During storage period, the DPPH radical scavenging values of control yogurt samples significantly increased ($p < 0.05$). This result could be due to bacterial metabolic activity which caused a breakdown of the macromolecules containing in the yogurt, that could react with the DPPH reagent. Supplemented yogurt samples showed storage trends for DPPH radical scavenging values similar to those obtained for TPC. Indeed, the presence of 1% ginger powder appeared to increase significantly ($p < 0.05$) DPPH radical scavenging activity in yogurt (80-95%) during 21 storage days at 4 °C. However, reducing power and metal chelating values showed small increase ($p < 0.05$) upon supplementation of yogurts (Table 3). All ginger yogurt samples presented significantly higher ($p < 0.05$) reducing power and metal chelating activities than respective control during 21 days of cold storage at 4 °C (Table 3). The obtained high DPPH radical scavenging activity in the present study (Table 3) could be associated with high bioactive peptides, released in 1% ginger yogurt, with antioxidant properties. This finding was in agreement with Shori and Baba (2013) for yogurt enriched with neem, garlic and cinnamon extracts.

**Table 3.** Total phenolic content (TPC) and antioxidant potential of yogurt during 21 days of storage at 4 °C.

| Parameter | Yogurt samples | Storage period (days) | | | |
|---|---|---|---|---|---|
| | | 1 | 7 | 14 | 21 |
| TPC (GAE µg/mL) | Control | $88.73 \pm 0.40^{cA}$ | $78.56 \pm 1.97^{bA}$ | $76.89 \pm 0.19^{aA}$ | $76.09 \pm 0.57^{aA}$ |
| | 1% GP | $165.39 \pm 0.94^{aB}$ | $193.39 \pm 1.32^{bB}$ | $216.50 \pm 1.01^{cB}$ | $223.84 \pm 1.32^{dB}$ |
| DPPH radical-scavenging activity (%) | Control | $63.33 \pm 2.82^{cA}$ | $61.60 \pm 1.39^{bA}$ | $55.50 \pm 4.60^{aA}$ | $55.69 \pm 2.05^{aA}$ |
| | 1% GP | $80.23 \pm 1.55^{aB}$ | $93.14 \pm 4.56^{bB}$ | $94.85 \pm 3.49^{cB}$ | $95.56 \pm 0.98^{dB}$ |
| Reducing power assay (DO=700 nm) | Control | $0.27 \pm 0.04^{bA}$ | $0.22 \pm 0.00^{aA}$ | $0.24 \pm 0.02^{aA}$ | $0.21 \pm 0.00^{aA}$ |
| | 1% GP | $0.54 \pm 0.01^{bB}$ | $0.50 \pm 0.00^{aB}$ | $0.53 \pm 0.01^{bB}$ | $0.54 \pm 0.00^{bB}$ |
| Metal chelating activity (%) | Control | $67.44 \pm 2.22^{cA}$ | $63.97 \pm 1.15^{aA}$ | $66.36 \pm 1.10^{bA}$ | $65.67 \pm 1.17^{bA}$ |
| | 1% GP | $95.88 \pm 0.06^{aB}$ | $96.72 \pm 1.04^{bB}$ | $96.69 \pm 0.62^{bB}$ | $96.75 \pm 2.11^{bB}$ |

Abbreviation: 1% GP = Yogurt enriched with 1 % of ginger powder, TPC = Total phenolic content, GAE = Gallic Acid Equivalent.
Means followed by different lowercase letters in same row within each sample were significantly different at $p < 0.05$; means forerun by different capital letters in same column within each storage time were significantly different at $p < 0.05$.

## 4. Conclusion

The addition of ginger powder in bovine milk at concentrations ranging from 0.5 to 2.5% (*w/v*) reduced significantly the pH of different yogurt samples. On another hand, its addition increased the textural properties of the fortified yogurt samples. The supplementation of 1% ginger powder was observed to be optimum between all ginger powder concentrations added to bovine milk for yogurt processing. The obtained results showed that ginger powder was effectively used to produce polyphenol fortified yogurt with higher antioxidant properties compared to control sample. Ginger powder ethanolic extract has high content of polyphenols and antioxidant activity. This result positively affected the phenolic content in yogurt during 21 days of refrigerated storage.

## 5. References

**Bersuder P, Hole M, Smith G (1998)** Antioxidants from a heated histidine glucose model system. I: Investigation of the antioxidant role of histidine and isolation of antioxidants by high performance liquid chromatography. J Am Oil Chem Soc 75: 181–187

**Blum U (1998)** Effects of microbial utilization of phenolic acids and their phenolic acid breakdown products on allelpathic interactions. J Chem Ecol 24: 685–708

**Bonczar G, Wszolek M, Siuta A (2002)** The effects of certain factors on the properties of yoghurt made from ewe's milk. Food Chem 79: 85-91

**Celik S, Bakirci I, Şat I G (2006)** Physicochemical and organoleptic properties of yogurt with cornelian cherry paste. Int J Food Prop 9: 401-408

**Chandan R C (2006)** Manufacturing Yogurt and Fermented Milks. (2nd ed.). Blackwell Publishing. UK. pp. 364

**Decker E A, Welch B (1990)** Role of ferritin as a lipid oxidation catalyst in muscle food. J Agric Food Chem 38: 674–677

**Dewanto V, Wu X, Adom K, Liu R H (2002)** Thermal processing enhances the nutritional value of tomatoes by increasing total antioxidant activity. J Agric Food Chem 50: 3010–3014

**Espirito Santo A P, Perego P, Converti A, Oliveira M N (2012)** Influence of milk type and addition of passion fruit peel powder on fermentation kinetics, texture profile and bacterial viability in probiotic yoghurts. LWT-Food Sci Technol 47: 393-399

**Hanou S, Boukhemis M, Benatallah L, Djeghri B, Zidoune M N (2016)** Effect of Ginger Powder Addition on Fermentation Kinetics, Rheological Properties and Bacterial Viability of Dromedary Yogurt. Adv J Food Sci Technol 10: 667-673

**Ibrahim A H (2015)** The effects of various stabilizers on physiochemical properties of camel milk yoghurt. Am J Sci 11: 15-24

**IDF (1991)** Yogurt. Determination of titratable acidity. Potentiometric method

**IDF (1987)** Lait. Crème et lait concentré non sucré. Détermination de la matière sèche, International Standard FIL-IDF 21B

**IDF (1997)** Lait et produits laitiers. Détermination de la teneur en matière grasse — Lignes directrices générales pour l'utilisation des méthodes butyrométriques, International Standard FIL-IDF 152A

**Kumar P, Mishra, H N (2007)** Effect of mango pulp and soymilk fortification on the texture profile of set yoghurt made from buffalo milk. J Texture Stud 34: 249-269

**Lal S N D, O'Connor C J, Eyres L (2006)** Application of emulsifiers stabilizers in dairy products of high rheology. Adv Colloid Interface Sci 123: 433-437

**Latona B F, Oyeleke G O, Olayiwola O A (2012)** Chemical analysis of ginger root. IOSR J Appl Chem 1: 47-49

**Lobato-Calleros C, Ramirez-Santiago C, Vernon-Carter E J, Alvarez-Ramirez J (2014)** Impact of native and chemically modified starches addition as fat replacers in the viscoelasticity of reduced-fat stirred yogurt. J Food Eng 131: 110-115

**Mallek Z, Fendri I, Khannous L, Ben Hassena A, Traore A I, Ayadi M A, Gdoura R (2012)** Effect of zeolite (clinoptilolite) as feed additive in Tunisian broilers on the total flora. meat texture and the production of omega 3 polyunsaturated fatty acid. Lipids Health Dis 11: 35

**Matmumoto-Pintro P T, Rabiey L, Robitaille G, Britten M (2011)** Use of modified whey protein in yoghurt formulations. Int Dairy J 21: 21-26

**Muniandy P, Shori A B, Baba A S (2016)** Influence of green, white and black tea addition on the antioxidant activity of probiotic yogurt during refrigerated storage. Food Packaging Shelf Life 8: 1–8

**NF (1989)** Lait - Détermination des cendres - Méthode de référence. NF V04-208, Ed. AFNOR, Paris : Association Française de Normalisation

**Park D J, Oh S, Ku K H, Mok C, Kim, S H, Imm J Y (2005)** Characteristics of yogurt-like products prepared from the combination of skim milk and soymilk containing saccharified-rice solution. Int J Food Sci Nutr 56: 23-34

**Prasanna P HP, Grandison A S, Charalampopoulos D (2013)** Microbiological, chemical and rheological properties of low fat set yoghurt produced with exopolysaccharide (EPS) producing Bifidobacterium strains. Food Res Int 51: 15-22

**Shori A B, Baba A S (2013)** Antioxidant activity and inhibition of key enzymes linked to type-2diabetes and hypertension by Azadirachta indica-yogurt. J Saudi Chem Soc 17: 295–301

**Tseng A, Zhao Y (2013)** Wine grape pomace as antioxidant dietary fibre for enhancing nutritional value and improving storability of yogurt and salad dressing. Food Chem 138: 356-365

**Velioglu Y S, Mazza G, Gao L, Oomah B D (1998)** Antioxidative activity and total phenolics in selected fruits, vegetables and grain products. J Agric Food Chem 46: 4113–4117

**Yildirim A, Mavi A, Kara A A (2001)** Determination of antioxidant and antimicrobial activities of *Rumex crispus L* extracts. J Agric Food Chem 49: 4083–4089