Functional Properties of Yoghurt Fortified with Fruits Pulp

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Abstract: The world interested in food fortification with fruits (e.g. persimmon, mango and guava) that have nutritive and healthy benefits. Therefore, the present study is focused to study the antioxidants properties of yoghurt fortified with fruit pulps. Full fat set yoghurt fortified with different fruit pulps at ratios (3, 10 and 15%, w/w) were prepared and stored at 5±1°C for 14 days. Chemical, rheological, total viable lactic acid bacteria and sensory properties were measured when fresh and after 7 and 14 days of storage period. The results indicated that, there were significant differences between plain yoghurt and fruit yoghurt in the total solids (T.S%), free radical scavenging activity (RSA%), total phenolic compounds (TPC) and total flavonoid compounds (TFC), which increased with the increase of the fruit pulp ratios. While, pH value was decreased with the increase of the fruit pulps percentage added and with extended storage period. The yoghurt containing guava pulp had the highest total viable lactic acid bacteria count compared with plain yoghurt and other fruit yoghurt. Sensory evaluation results showed that there were significant (p<0.05) differences among the yoghurt treatments. The yoghurt containing 10% mango, 10% persimmon and 5% guava were recorded highest scores in full fat yoghurt compared with plain yoghurt and other ratios. The highest apparent viscosity was recorded in yoghurt containing persimmon, mango and guava pulps, respectively. The results of current study demonstrated that addition of fruits to the yoghurt significantly improved the rheological properties, body & texture and flavour compared with control treatment and support set yoghurt with more bioactive compounds.

Keywords: Functional fruit yoghurt, antioxidant scavenging activity, full fat, persimmon, mango and guava

INTRODUCTION

Yoghurt consumption has increased around the world due to its nutritional value, therapeutic effects and functional properties (Mckinley, 2005). Yoghurt is easily digested, rich source of carbohydrates, protein, fat, vitamins, calcium and phosphorous (Vahedi et al., 2008). It is common to fortify yoghurt with different fruits for enhancing flavour and improve its nutritional as well as sensory properties (Cakmakci et al., 2012). Mango, guava, persimmon, pear, cactus, strawberry, blueberry, orange, peach and date fruits or pulps are frequently used in yoghurt production (Arslan and Ozel, 2012; Abdelhaiem and Blassy, 2019). This fruits has important effects in the body defense system against free radical (Manisha et al., 2017). The total solids (pectin and sugars) from the fruits when mixed with yoghurt, causing an increase in its consistency and viscosity therefore, mouth feel is improved (Matter et al., 2016). Fruits may be added to yoghurt formula as pulp, juice, canned or syrup.

Persimmon fruit (Diospyros kaki L.) could be used in yoghurt making as a source of antioxidant and phenolic compounds. It contains high amount of phenolic compounds including polyphenols, carotenoids and also, a good source of fibers, vitamins (C and A), minerals (iron and calcium) and tannins (Arslan and Bayrakci, 2016; Curi et al., 2017).

Mango fruit (Mangifera indica L.) is one of the most important tropical fruits and a good source of antioxidants especially polyphenols and carotenoids (Nunes et al., 2007). It is an excellent source of vitamin A and flavonoids like alpha-carotene, beta-carotene and beta-cryptoxanthin (Raut et al., 2015; Vazquez-Olivo et al., 2019).

Guava (Psidium guajava) is known as a medical fruit with high nutritive value, it contains a great amount of vitamins (C, A, B_{12} and B_{6}). It is an important source of antioxidant due to contain carotenoids like beta-carotene and polyphenols, that can prevent the oxidation of lipids and its play important role in delaying the development of chronic disease such as cardiovascular disease, cancer, inflammatory bowel and Al-Zheimer's disease (Kavas and Kavas, 2016; Parvez et al., 2018).

The present study was focused to study the antioxidants properties of the yoghurts fortified with fruit pulps.

MATERIALS AND METHODS

Materials

Milk: Fresh buffalo’s milk was obtained from dairy plant, Dairy Department in the Faculty of Agriculture, Suez Canal University, Egypt. 

Starters cultures: Direct vat starter (DVS) culture containing Str. thermophilus and Lb.delbrueckii ssp. bulgaricus (YC-X11) was obtained from Chr. Hansen's Laboratories, Denmark. The culture was stored at -18±1°C until used before expired date.

Other materials: Commercial grade crystalline sugar (sucrose), fresh mango, persimmon and guava were obtained from the local market of Ismailia governorate, Egypt.

Methods

Preparation of fruit pulps

Fruits (persimmon, mango and guava) were washed, peeled, cut into pieces and seeds were removed. The fruit pieces were blended by mixer (Braun Power Max MX 2000 Blender, Germany) for 5 min to obtain fine paste pulp, heated at 85°C for 3 min, cooled to 5±1°C, homogenized at 6000 rpm for 5 min using Ultra Turrax homogenizer (Germany) and kept in polyethylene bags at 5°C until used.
Preparation of full fat fruit yoghurt

Adjusted buffalo’s milk (milk fat 3.7%, total solids 12.6% and titratable acidity, 0.17%) was used with adding 5% sugar. It was heated to 85°C for 10 min, cooled to 40°C and inoculated with 0.03% yoghurt culture (DVS). Milk was divided into four parts. The first part with no additives used as a control. Each part from previous parts were divided into three equal portions and then 5%, 10% and 15% of each fruit pulps were added. Then the inoculated milk yoghurt mixes were filled into 120 g plastic cups and incubated at 42°C until pH reaches to 4.7 pH value (2-3 h). After complete coagulation, all treatments were stored in the refrigerator at 5±1°C for 14 days and examined when fresh, and after 7 and 14 days of storage period. All treatments were carried out in triplicate.

Chemical analysis of yoghurt

Yoghurt samples were mixed and analyzed in three replicates for total solids according to the method described in AOAC (2000). The values of pH were measured using Jenway pH meter with Jenway spear electrode No: 3505 (Jenway limited, Gransmore green, Felsted, Dunmow, England). The free radical scavenging activity % of the methanolic extracts was determined by DPPH method described by Caleja et al. (2016). The absorbance of the mixture was measured at 515 nm by using spectrophotometer (model 20D uv, Milton Roy company, USA). The DPPH solution without extract was used as blank sample. The antioxidant activity was calculated as follows:

DPPH radical–scavenging activity (%) = 
\[
\frac{(A_{\text{sample}} - A_{\text{blank}})}{A_{\text{blank}}} \times 100
\]

Where, A is the absorbance at 515 nm.

Total phenolic compounds were determined in the methanolic extracts by Folin-Ciocalteu assay with slight modifications (Barros et al., 2011). The absorbance was measured at 765 nm by spectrophotometer (model 6505 uv/vis, JENWAY, UK). A calibration curve of gallic acid (0.00 – 0.10 mg mL⁻¹) was prepared and total phenolic compounds was determined from the linear regression equation (R² = 0.9986) of the calibration curve. The results were expressed as mg of gallic acid equivalents per 100 g of sample.

Total flavonoids content was determined by Barros et al. (2011). The absorbance was measured at 510 nm by spectrophotometer (model T80 uv/vis, PG instruments Ltd., USA). A calibration curve of quercetin was prepared and total flavonoids content was determined from the linear regression equation (R² = 0.9976) of the calibration curve. The results were expressed as mg quercetin 100 g⁻¹ of sample.

Table (1): Chemical composition of fruit pulps after preparation

| Components              | Persimmon | Mango | Guava |
|-------------------------|-----------|-------|-------|
| T.S (%)                 | 25        | 20    | 14    |
| pH value                | 5.2       | 4.53  | 3.7   |
| Radical scavenging activity (%) | 28.98   | 29.54 | 82.40 |
| Total phenolic compounds (mg100g⁻¹) | 22.88   | 42.33 | 87.7  |
| Total flavonoid compounds (mg100g⁻¹) | 2.68     | 9.12  | 10.67 |
Chemical analysis of fortified yoghurt with fruit pulps

Total solids %

Total solids content of plain yoghurt recorded the lowest percentage (14.13%) compared with other fruit yoghurts (Table 2). Increasing the addition of fruit pulps to yoghurt induced to a parallel significantly (p<0.05) increase in T.S% of the resultant yoghurt. This increment due to the highest T.S in fruit pulps than that of milk (Ronak et al., 2016). The T.S% of fruit pulp yoghurt treatments were increased significantly (p<0.05) along the storage period. Similar results were reported by Arslan and Bayrakci (2016).

pH value

The pH values of all fruit pulp yoghurt treatments were lower than that of control, addition of fruit pulps decreased significantly (p<0.05) the pH values of yoghurt as result of low pH of fruits (Table 3). Tanwar et al. (2014) and Souza et al. (2018) reported similar results. The lowest pH value was recorded in yoghurt contain 15% of guava pulp. These results are in agreement with Ziena and Abd-Elhamid (2009). They reported that the decrement in the pH values of functional yoghurt reflected the high activity of starter.

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7  | 14  |      |
| C          | 14.13±0.14 | 14.45±0.12 | 14.60±0.06 | 14.38 a |
| P5         | 14.97±0.15 | 15.17±0.25 | 15.46±0.39 | 15.19 c |
| P10        | 16.44±0.39 | 17.38±0.11 | 17.56±0.13 | 17.12 b |
| P15        | 17.34±0.11 | 17.60±0.05 | 17.80±0.10 | 17.58 a |
| M5         | 15.53±0.16 | 15.74±0.17 | 15.80±0.01 | 15.69 e |
| M10        | 16.60±0.02 | 16.79±0.02 | 17.85±0.05 | 17.07 b |
| M15        | 17.32±0.09 | 17.44±0.03 | 17.54±0.02 | 17.43 a |
| G5         | 14.95±0.06 | 15.17±0.07 | 15.23±0.06 | 15.11 f |
| G10        | 15.81±0.07 | 15.91±0.06 | 16.16±0.19 | 15.69 e |
| G15        | 16.43±0.08 | 16.52±0.08 | 16.87±0.60 | 16.60 c |
| Mean       | 15.80 c | 16.04 b | 16.30 a |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. *Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c...) are significantly different (p<0.05).
Table (3): Effect of adding persimmon, mango and guava pulps on pH value of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7 | 14 |
| C          | 4.69 ± 0.14 | 4.43 ± 0.10 | 4.24 ± 0.36 | 4.74 a |
| P5         | 4.57 ± 0.06 | 4.54 ± 0.02 | 4.34 ± 0.23 | 4.48 de |
| P10        | 4.71± 0.15 | 4.66± 0.14 | 4.61± 0.02 | 4.65 abc |
| P15        | 4.26± 0.34 | 4.69± 0.08 | 4.61± 0.06 | 4.52 de |
| M5         | 4.76± 0.01 | 4.73± 0.01 | 4.61± 0.01 | 4.70 ab |
| M10        | 4.63± 0.02 | 4.61± 0.01 | 4.51± 0.01 | 4.58 bcd |
| M15        | 4.55± 0.01 | 4.42± 0.01 | 4.35± 0.02 | 4.44 ef |
| G5         | 4.67± 0.03 | 4.60± 0.01 | 4.42± 0.03 | 4.56 cde |
| G10        | 4.45± 0.02 | 4.33± 0.01 | 4.21± 0.01 | 4.32 f |
| G15        | 4.37±0.03  | 4.04± 0.05 | 3.98± 0.03 | 4.13 g |
| Mean       | 4.58 a | 4.52 a | 4.41 b |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. *Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c…) are significantly different (p<0.05).

Table (4): Effect of adding persimmon, mango and guava pulps on radical scavenging activity % of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7 | 14 |
| C          | 10.25± 0.12 | 9.57± 0.03 | 8.89± 0.16 | 9.57 g |
| P5         | 12.27±1.16 | 13.60± 0.50 | 11.30± 0.51 | 12.38 i |
| P10        | 16.54± 1.65 | 18.29± 1.89 | 15.85± 1.05 | 16.89 d |
| P15        | 18.86± 1.98 | 20.95± 1.85 | 17.60± 2.15 | 18.46 c |
| M5         | 11.86± 0.03 | 10.89±0.10 | 10.58± 0.09 | 11.19 b |
| M10        | 13.50± 0.05 | 13.30± 0.12 | 12.61± 0.02 | 13.13 g |
| M15        | 15.67± 0.10 | 15.30± 0.02 | 14.97± 0.05 | 15.31 c |
| G5         | 14.22± 0.14 | 14.13± 0.11 | 13.90± 0.05 | 14.08 f |
| G10        | 22.87± 0.07 | 21.71± 0.21 | 18.15± 0.05 | 18.47 b |
| G15        | 22.87±0.07  | 21.71± 0.21 | 20.14± 0.05 | 21.57 a |
| Mean       | 15.15 a | 15.28 a | 14.11 b |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. *Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c…) are significantly different (p<0.05).
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Total phenolic compounds

Fruit pulps are a good source of antioxidants, especially, polyphenols, carotenoids, dietary fiber and vitamin C (Abbasi et al., 2017). Fortifying yoghurt with fruit pulps increased the TPC, the increment was in parallel with the increase of added fruit pulps ratios. Similar results were reported by El-Batawy et al. (2014). Addition of fruit pulps affect significantly (p<0.05) the TPC value of all fruit yoghurt treatments compared with control (Table 5). It is clear that addition of guava pulp recorded the highest value (p<0.05) in TPC content of fruit yoghurt at all ratios, due to the high contents of TPC in guava pulp. These results are in agreement with Ismail et al. (2017). Throughout the storage period, the TPC decreased gradually for all fruit yoghurt treatments. The storage period significantly (p<0.05) affected the TPC of all fruit yoghurt treatments. The decreased in TPC could be attributed to decomposition of some TPC contents. Also, the decrease in TPC may be due to the hydrolysis of polyphenols by LAB to aromatic acids such as phenyl acetic, phenyl propionic and benzoic acids. Phenolic compounds could be divided to subgroups as phenolic acids, flavonoids and tannins (Sagdic et al., 2012). These results were in agreement with El-Kholy (2018).

Table (5): Effect of adding persimmon, mango and guava pulps on total phenolic compounds (mg GAE 100 g⁻¹) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh                 | 7    | 14   |      |
| C          | 0.99±0.01             | 0.98±0.01 | 0.94±0.01 | 0.96<sup>b</sup> |
| P5         | 1.10±0.02             | 1.14±0.03 | 1.04±0.03 | 1.09<sup>6b</sup> |
| P10        | 1.26±0.04             | 1.32±0.06 | 1.22±0.03 | 1.26<sup>6c</sup> |
| P15        | 1.75±0.09             | 1.84±0.06 | 1.74±0.01 | 1.77<sup>d</sup> |
| M5         | 1.08±0.05             | 1.01±0.01 | 0.98±0.01 | 1.02<sup>6h</sup> |
| M10        | 1.21±0.02             | 1.19±0.01 | 1.03±0.01 | 1.14<sup>6g</sup> |
| M15        | 1.37±0.02             | 1.33±0.01 | 1.21±0.02 | 1.30<sup>c</sup> |
| G5         | 4.72±0.05             | 4.55±0.03 | 4.35±0.05 | 4.53<sup>c</sup> |
| G10        | 8.28±0.16             | 7.91±0.10 | 7.11±0.10 | 7.76<sup>b</sup> |
| G15        | 10.45±0.14            | 9.94±0.04 | 9.31±0.05 | 9.9<sup>a</sup> |
| Mean       | 3.01<sup>a</sup>      | 2.93<sup>a</sup> | 2.71<sup>b</sup> |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c…) are significantly different (p<0.05).

Total flavonoid compounds

Flavonoid is a bioactive phytochemicals found in fruit, vegetables. Fruits are rich sources of antioxidant activity and can help our body to stay healthy. It could be notice that yoghurt fortified with persimmon, mango and guava pulps have higher TFC than control as shown in Table (6). Fortification of yoghurt with guava pulp increased significantly (p<0.05) the TFC, the increment was in parallel with the increase of added pulp ratios. These results are in agreement with Moussa and El-Gend (2019). It was clear that the G15 and G10 treatments were recorded the highest TFC contents than control and other treatments. Ismail et al. (2017) stated that peel and pulp of guava fruit presented high levels of flavonoid compounds. Along the storage period, the TFC decreased significantly (p<0.05) for all fruit yoghurt treatments. These results were in agreement with the study of Jin et al. (2018).

Apparent Viscosity

Viscosity is defined as the resistance of flow. The viscosities of liquid and semi-solid foods have a large impact on their quality characteristics (Karaman et al., 2014). The apparent viscosity of fruit yoghurt increased with the increase of fruit pulp addition compared with control. The higher apparent viscosity was recorded to mango yoghurt treatments than other treatments as shown in Table (7). It may be due to the absorption of water by water soluble fibers in mango (Mahmood et al., 2008). A significant (p<0.05) differences could be noticed between control and other fruit pulp treatments. Throughout the storage period the apparent viscosity increased significantly (p<0.05) up to day 7<sup>th</sup>, then a gradually decreased at day 14<sup>th</sup> for all fruit yoghurt treatments. These results were in agreement with Kavas and Kavas (2016).
Table (6): Effect of adding persimmon, mango and guava pulps on total flavonoid compounds (mg quercetin 100 g⁻¹) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7     | 14  |      |
| C          | 0.87±0.00 | 0.85±0.01 | 0.81±0.01 | 0.84 f |
| P5         | 0.90±0.00 | 0.98±0.01 | 0.92±0.02 | 0.93 f |
| P10        | 1.15±0.00 | 1.23±0.02 | 1.11±0.01 | 1.16 f |
| P15        | 1.46±0.01 | 1.50±0.01 | 1.31±0.02 | 1.42 d |
| M5         | 0.90±0.01 | 0.90±0.00 | 0.88±0.01 | 0.89 f |
| M10        | 0.94±0.01 | 0.94±0.01 | 0.92±0.02 | 0.93 f |
| M15        | 1.15±0.01 | 1.15±0.01 | 1.10±0.01 | 1.13 c |
| G5         | 3.61±0.06 | 3.35±0.04 | 3.02±0.03 | 3.32 c |
| G10        | 6.11±0.12 | 5.84±0.07 | 5.46±0.08 | 5.80 b |
| G15        | 8.58±0.25 | 8.18±0.32 | 7.87±0.32 | 8.20 a |

Mean: 2.41 a 2.34 a 2.20 b

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. aValues are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c...) are significantly different (p<0.05).

Table (7): Effect of adding fruit pulps on apparent viscosity (mPa.s) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7     | 14  |      |
| C          | 8452.00± 90.00 | 8245.00± 52.00 | 2872.25± 61.27 | 566.41 f |
| P5         | 9974.00±123.00 | 8463.00±69.00 | 216.5±12.30 | 6295.66 ef |
| P10        | 12473.00±1046.00 | 11623.00±1123.00 | 450.36±8.96 | 8182.12 cde |
| P15        | 12354.00±559.00 | 8325.00±69.00 | 394.57±12.17 | 7024.52 def |
| M5         | 10352.00±84.89 | 11699.00±20.07 | 9176.3±48.29 | 10409.11 b |
| M10        | 10674.33±45.57 | 11932.33±22.50 | 9381.67±10.41 | 10662.77 b |
| M15        | 12190.00±10.00 | 14569.67±46.26 | 11627.00±24.64 | 12795.55 a |
| G5         | 9504.67±31.90 | 10273.33±37.86 | 8787.33±29.57 | 9521.77 bc |
| G10        | 9893.33±12.66 | 11063.67±31.79 | 9849.67±46.37 | 9818.88 bc |
| G15        | 10994.00±12.77 | 11303.00±45.57 | 8459.00±34.39 | 10521.77 bc |

Mean: 10523.63 a 10574.69 a 6005.01 b

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. aValues are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c...) are significantly different (p<0.05).

Total viable LAB count

Addition of persimmon and mango pulps led to decrease of the total viable LAB count of yoghurt in all treatments, while, addition of guava pulp led to an increase in the total viable LAB count of yoghurt (Table 8). It was noticed that G10 (10% guava pulp) had the highest (p<0.05) total viable LAB count than control and other treatments.

The total viable count of LAB for most fruit yoghurt treatments except P15 were increased up to 7 days and then decreased up to end of storage period. The effect of storage period was significantly (p<0.05) for all fruit yoghurt treatments. Jin et al. (2018) reported that fruits and vegetables contain bioactive compounds can be used as substrates for the growth of probiotic bacteria.

Organoleptic characteristics

The overall acceptability of yoghurt fortified with M10, G5 and P10 were recorded the highest (p<0.05) total acceptability score compared with other treatments. Addition of fruit pulps significantly at (p<0.05) affected the total score values of all fruit yoghurt treatments (Table 9). Also, the storage period significantly (p<0.05) affected the overall acceptability. The score values of overall acceptability gradually decreased along the storage period. However, the yoghurt treatments containing 10 % mango, 5% guava and 10 % persimmon pulp were quite good and gained the highest (p<0.05) scores even after 14 days of storage period.
### Table (8): Effect of adding persimmon, mango and guava pulps on the total viable LAB count (log cfu g⁻¹) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|----------------------|------|
|            | Fresh | 7      | 14 | |
| C          | 8.79 ± 0.11 | 9.16 ± 0.19 | 8.28 ± 0.15 | 8.74^b |
| P5         | 8.12 ± 0.08 | 8.83 ± 0.06 | 7.45 ± 0.65 | 8.13^d |
| P10        | 8.38 ± 0.15 | 8.89 ± 0.05 | 7.24 ± 0.18 | 8.17^d |
| P15        | 7.95 ± 0.05 | 7.70 ± 0.11 | 7.09 ± 0.13 | 7.58^c |
| M5         | 8.53 ± 0.22 | 8.88 ± 0.09 | 8.03 ± 0.06 | 8.48^c |
| M10        | 8.55 ± 0.22 | 8.89 ± 0.09 | 8.47 ± 0.25 | 8.63^bc |
| M15        | 7.95 ± 0.05 | 8.13 ± 0.09 | 7.14 ± 0.05 | 7.74^c |
| G5         | 8.77 ± 0.02 | 9.18 ± 0.02 | 8.29 ± 0.05 | 8.74^b |
| G10        | 9.31 ± 0.02 | 9.41 ± 0.01 | 8.50 ± 0.05 | 9.07^a |
| G15        | 8.25 ± 0.05 | 8.47 ± 0.02 | 7.67 ± 0.32 | 8.13^d |

Mean | 8.50^b | 8.75^a | 7.79^c |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. *Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c…) are significantly different (p<0.05).

### Table (9): Organoleptic characteristics (overall acceptability) of fruit yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|----------------------|------|
|            | Fresh | 7      | 14 | |
| C          | 80.33 ± 2.08 | 80.00 ± 1.00 | 81.67 ± 1.15 | 80.66^g |
| P5         | 85.33 ± 1.15 | 85.33 ± 1.00 | 85.33 ± 1.15 | 85.22^de |
| P10        | 92.33 ± 2.08 | 90.67 ± 0.58 | 91.00 ± 1.00 | 91.33^b |
| P15        | 85.00 ± 4.00 | 82.67 ± 0.58 | 82.67 ± 0.58 | 83.44^f |
| M5         | 89.67 ± 0.58 | 90.00 ± 1.00 | 88.76 ± 0.58 | 89.44^c |
| M10        | 95.00 ± 1.73 | 95.33 ± 0.58 | 95.00 ± 0.00 | 95.11^a |
| M15        | 84.67 ± 2.08 | 84.33 ± 0.58 | 84.33 ± 1.53 | 84.55^df |
| G5         | 92.33 ± 1.53 | 92.33 ± 2.08 | 90.67 ± 2.08 | 91.77^b |
| G10        | 89.00 ± 0.00 | 87.67 ± 1.15 | 83.33 ± 1.53 | 86.66^d |
| G15        | 73.33 ± 1.53 | 71.00 ± 1.00 | 69.33 ± 3.21 | 71.22^b |

Mean | 86.03^b | 85.39^ab | 84.87^b |

C: control; P5: persimmon, 5%; P10: persimmon, 10%; P15: persimmon, 15%; M5: mango, 5%; M10: mango, 10%; M15: mango, 15%; G5: guava, 5%; G10: guava, 10% and G15: guava, 15%. *Values are means ± standard deviations of triplicate determinations. Means in the same row with different superscript (a, b, c…) are significantly different (p<0.05).

### CONCLUSION

Persimmon, mango and guava pulps can be used successfully in making functional fruit yoghurt to give highest overall acceptability comparable with plain yoghurt especially flavour and texture & body. The addition of 10% mango, 10% persimmon and 5% guava pulps give us the best treatments compared with other ratios. So, we can recommend enhancing flavour and radical scavenging activity of yoghurt by using these fruits for production of functional healthy yoghurt.

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الخصائص الوظيفية للزيادي المدعم بلب الفواكه

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الزيادي أحد الألبان المتخمرة الناتجة من تخرير سكر اللاكتوز الموجود بالثنايا ببكتريا حمض اللاكتيك. هناك اتجاه لتدعيم الزيادي ببعض الإضافات مثل الكاكاو والمانجو والجاودت التي تعطي قيمة غذائية وفوائد صحية للزيادي. وتشمل هذه الدراسة تأثير هذه الإضافات على خصائص الزيادي، بالإضافة إلى محتوى الأحماض الأمينية. تم دراسة تأثير إضافة لب الفواكه الساقية لزيادي كامل الدسم بنسبة مختلفة (5 و 10 و 15%) والتخزين على درجة حرارة 1±1°C لمدة 41 يومًا. ودراسة تأثير ذلك على الخصائص الكيميائية والروزولوجية والمستويات الكلية والكائنات المدمجة للمنتج عند اليوم الأول والثاني والرابع عشر. وتصبح وجود فروق معنوية بين الزيادي المدعم بالفاكهة وغير المدعم في المواد الصلبة الكلية والأحماض الأمينية والمواد الفينولية والفلافونيدين الكلية، والتي زادت بإضافة إضافات نسبة لب الفاكهة، بينما كانت قيم pH تقل بزيادة إضافة وطول فترة التخزين. وسجلت المواد المصبحة للأحماض الفينوليات والفلافونيدات أعلى في الزيادي المدعم بنسبة 15% من كلا من الفواكه ثم الكاكاكي على التوالي وكان ذلك في اليوم السادس ثم تقلت بعد ذلك بالتوجهين. كما أوضحت النتائج أن الزيادي المدعم بالحوافه سجل أعلى عدد لكلكترا حمض الأحماض الدهنية مقارنة بالكَنَتْرول والمعالجات الأخرى. وقد سجلت المعالجات التي تحتوي على 10% مانجو 10% كاكاكي، و 15% حافة أعلى على تقييم الحمي للزيادي كامل الدسم مقارنة بالكَنَتْرول والمعالجات الأخرى. كما أدى إضافة الفواكه للزيادي إلى تحسن الخصائص البيولوجية والحمى كلاً كلاً والكائنات من بكتريا الدماة بالإضافة إلى تدشيم الزيادي بالعديد من المركبات الحيوية.