Functional Low Fat Fruit Yoghurt

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Abstract: Low fat set yoghurt (0.7%) fortified with different fruit pulps (persimmon, mango and guava) and ratios (5, 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 at 7 and 14 days of storage period. There were significant (p≤0.05) differences between plain yoghurt (control) and functional low fat yoghurt in the total solids (T.S %), antioxidant scavenging activity (ASA%), total phenolic compounds (TPC) and total flavonoid compounds (TFC), they were increased with the increase of the fruit pulp ratios added. While, the pH value and fat% were decreased with the increase of the fruit pulps percentage. The results showed that pH value decreased with extended storage period. Highest values of ASA, TFC and TPC were belonged to yoghurt fortified with guava, mango and persimmon, respectively at 15 % ratio and at 7 days then decreased. The yoghurt containing guava pulp had the highest total viable lactic acid bacteria count compared with plain yoghurt and other fruits yoghurt. The highest (p≤0.05) apparent viscosity was recorded in yoghurt fortified mango, guava and persimmon pulps, respectively. Yoghurt treatments containing 10% mango, 10% persimmon and 5% guava recorded highest sensory scores in low fat yoghurt compared with plain yoghurt and other ratios. The results of current study demonstrated that addition of fruits to the yoghurt significantly improved the rheological properties, body & texture and flavour and support production of low fat yoghurt with more bioactive compounds.

Keywords: Antioxidant scavenging activity, persimmon, mango and guava.

INTRODUCTION

The history of yoghurt backed to 6000 BC. Yoghurt has been discovered by the way as fermented milk products. Yoghurt is a fermented milk product by the action of lactic acid bacteria through fermentation of lactose to lactic acid. Yoghurt is one of the most popular fermented milk. The popularity of yoghurt may be due to various health and therapeutic value. As it considered a good source of protein, calcium, phosphorus, magnesium, zinc, riboflavin, thiamin, vitamin B12 and other constituents of high biological values (Vahedi et al., 2008).

De Vrese et al. (2015) and Hassan (2017) reported that yoghurt has a beneficial effect on health by decreasing cholesterol absorption, lowering blood pressure, it causes a slight reduction in stomach pH, which reduces the risk of pathogen transit. It is considered as a healthy food due to its high digestibility and bioavailability of nutrients and also can be recommended to the people suffering from lactose intolerance, gastrointestinal disorder such as inflammatory bowel disease and irritable bowel disease and aids in immune system and loss of weight.

Recently, there is increased consumer demand for low fat products for healthy and nutritional benefits. It is claimed that low fat yoghurt consumption can lead to lower risk of coronary heart disease, bone fracture and colon cancer. It is common to fortified yoghurt with different fruits for enhancing flavour and enrichment yoghurt with antioxidants compounds (Senadeera et al., 2018).

Decrease fat content in yoghurt always cause weak body, poor texture, low viscosity and syneresis (whey separation) that affect appearance, texture and mouth-feel, it also leads to the reduction in smoothness and creaminess mouth feels due to removal of milk fat and low total milk solids. To avoid this problem and improve the texture and functional properties of low fat yoghurt the level of non-fat milk solids content must be increased by addition of skim milk powder or by additive of some fruits (Mehanna et al., 2013; Srisuvor et al., 2013; Nguyen et al., 2017). Routray and Mishra (2011) reported that fortification of yoghurt with fruits preparations, fruit flavour, fruit puree, fruit pulp enhance taste, colour and texture of the products.

Fruits which contain antioxidants compounds play a significant role in health aspects. It has an important effect in the body defense system against free radicals. Antioxidants stabilize free radical by donate its own electron and minimize harmful effect of free radicals (Manisha et al., 2017).

Jiménez-Sánchez et al. (2015) and Curi et al. (2017) stated that persimmon (Diospyros kaki L.) is a fruit native to Asia and classified as a low-acid fruit, traditionally grown in subtropical climates. Persimmon has a good commercial acceptance because of its appearance, aroma and attractive flavour and can be eaten fresh or in processed form. In addition to the organoleptic characteristics, persimmon is a fruit that has beneficial health properties, as it contains high amounts of phenolic compounds including polyphenols, carotenoids and high content of antioxidant. Also, it is a good source of fiber, vitamins and minerals and it contains many bioactive compounds, especially ascorbic acid, condensed tannins and carotenoids.

Li et al. (2014) and Abbasi et al. (2017) reported that mangoes are one of the most important tropical fruits, it is a good source of antioxidant, bioactive phytochemicals especially (flavonoid, tocopherol, polyphenols and carotenoids) and dietary fiber and had strong free radical scavenging activity. The composition bioactivity of mango pulp was analyzed to establish characterization and cellular antioxidant and
antiproliferative activities towards HepG2 human liver cancer cells line. Mango could be processed into flavoured drinks, probiotic beverages, dried products and canned foods.

Guava is rich in flavonoids, it plays important role to exhibit antimicrobial, antipyretic and anti-diabetic properties in addition to contain of proteins, carbohydrates, many minerals as (calcium, phosphorous, magnesium and iron) and dietary fibers which can reduce the sugar levels in the body and had anti-inflammatory properties. Guava pulp had a great amount of antioxidant such as ascorbic acid, polyphenols and many enzymes (Moussa and El-Gendy, 2019; Pham et al., 2019).

The present study was focused to study the antioxidant properties of the low fat yoghurts fortified with fruit pulps.

MATERIALS AND METHODS

Materials
Milk: Fresh buffalo’s milk was obtained from Dairy Unit, Dairy Department in the Faculty of Agriculture, Suez Canal University, Egypt. Fresh Buffalo's low fat milk was standardized (fat 0.7%) by the fat separator (local separator, Egypt).

Starter cultures: Direct vat starter (DVS) culture containing Streptococcus thermophilus and Lactobacillus 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) was obtained from the local market. Fresh persimmon, mango and guava were obtained from the local market at Ismailia governorate, Egypt.

Methods
Preparation of fruit pulps and extraction
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 and heated at 85°C for 3 min then cooled to 5±1°C and homogenized at 6000 rpm for 5 min using Ultra Turrax homogenizer (Germany) and kept in polyethylene bags at 5°C until used.

Preparation of low fat fruit yoghurt
Standardized milk (milk fat 0.7%, total solids 9.59%) and titratable acidity, 0.16%) was used. It was heated to 85°C for 10 min and cooled to 40°C then inoculated with 0.03 % yoghurt culture. Milk was divided into four parts. The first part (no additives) used as a control. Each part from other parts was divided into three equal portions and then 5, 10 and 15% of each fruit pulps were added. 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 at 7 and 14 days of storage period. All treatments were carried out in triplicate.

Chemical analysis
Yoghurt samples were mixed and analyzed in three replicates for total solids % and fat % according to the method described in AOAC (2000). Aroma compounds (acetaldehyde and diacetyl) were determined as described by Lees and Jago (1969). The values of pH were measured using Jenway pH meter with Jenway spear electrode No: 3505 (Jenway limited, Gransmore green, Felsted, Dunmow, England) by dipping the electrode in the milk or yoghurt samples. The antioxidant scavenging activity % of the methanolic extracts was determined by DPPH method described by Lee et al. (2003) and modified by Ravichandran et al. (2013) and 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:

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

Where, A is the absorbance at 515 nm.

Determination of total phenolic compounds
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 (\(R^2= 0.9986\)) of the calibration curve. The results were expressed as mg of gallic acid equivalents per 100 g of sample.

Determination of total flavonoid compounds
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 (\(R^2= 0.9976\)) of the calibration curve. The results were expressed as mg 100 g\(^{-1}\) of sample.

Rheological analysis
Apparent viscosity (mPa.s) was measured using a Brookfield rotational viscometer model RV 111 (Brookfield Engineering Laboratories Inc., MA, USA).

Lactic acid bacteria count
Eillker agar medium (Eillker et al., 1956) was used for the enumeration of total viable lactic acid bacteria after incubation (Memmert, Germany) at 37°C for 2 days under aerobic condition.

Organoleptic evaluation
Organoleptic properties for the control and other treatments of fruit yoghurt were evaluated at fresh (1 day) and after 7 and 14 days of storage at 5±1 °C by staff members (10) of the Dairy Department, Faculty of
Agriculture, Suez Canal University, Egypt as described by IDF (1997). Yoghurt samples were organoleptically scored for flavour (50 points), body & texture (40 points) and appearance (10 points).

**Statistical analysis**

All measurements were done in triplicate and analysis of variance with two factors (treatments and storage time) and conducted by the procedure of General Linear Model (GLM) by using CoStat program (2005) under windows software version 6.311 and least significant difference (LSD) test were employed to determine significant difference at (p<0.05).

**RESULTS AND DISCUSSION**

**Chemical composition of fruit pulps:**

Chemical composition of persimmon, mango and guava pulps used for fruit yoghurt manufacturing are shown in Table 1. Data showed that guava pulp had higher antioxidant scavenging activity %, total phenolic and total flavonoid compounds compared with persimmon and mango pulps and had lower T.S and pH value. While, persimmon pulp had a higher T.S compared with other fruits. These results are in agreement with Yaqub et al. (2016), Hashemi et al. (2017) and Parvez et al. (2018).

| Components                                | Persimmon | Mango | Guava |
|-------------------------------------------|-----------|-------|-------|
| T.S (%)                                   | 25        | 20    | 14    |
| pH value                                  | 5.2       | 4.53  | 3.7   |
| Antioxidant scavenging activity (%)       | 28.98     | 29.54 | 82.40 |
| Total phenolic compounds (mg100 g⁻¹)      | 22.88     | 42.33 | 87.7  |
| Total flavonoid compounds (mg100 g⁻¹)     | 2.68      | 9.12  | 10.67 |

**Chemical analysis of low fat fruit yoghurt**

**Total solids %**

Total solids content of plain yoghurt was recorded the lowest percentage compared with other fruit yoghurt when fresh and during storage period (Table 2). Increase addition of fruit pulps resulted an increased in T.S% of the resultant yoghurt. The increment in T.S% was proportional with the increase of added fruit pulps ratios, this due to the highest T.S % in fruit pulps than that of milk (Ronak et al., 2016). The effect of adding fruit pulps on T.S% was significantly (p<0.05). The T.S% of fruit pulp yoghurt treatments were increased significantly (p<0.05) along the storage period (Arslan and Bayrakci, 2016).

Table (2): Effect of adding persimmon, mango and guava pulps on the total solid % of yoghurt during storage period

| Treatments | Storage period (days) | Mean  |
|------------|-----------------------|-------|
|            | Fresh | 7    | 14    |       |
| C          | 11.46 ± 0.27          | 11.83 ± 0.03 | 11.89± 0.01 | 11.72 ^j |
| P5         | 12.77 ± 0.22          | 13.14 ± 0.23 | 13.24 ± 0.23 | 13.05 ^g |
| P10        | 13.93 ± 0.06          | 14.16 ± 0.06 | 14.43 ± 0.13 | 14.17 ^d |
| P15        | 14.60 ± 0.06          | 14.86 ± 0.06 | 14.94 ± 0.07 | 14.80 ^b |
| M5         | 12.66 ± 0.02          | 12.75 ± 0.02 | 12.95 ± 0.02 | 12.78 ^h |
| M10        | 13.87 ± 0.02          | 13.87 ± 0.02 | 14.09 ± 0.06 | 13.97 ^e |
| M15        | 14.93± 0.02           | 14.92 ± 0.06 | 15.11± 0.09 | 14.98 ^a |
| G5         | 12.09±0.13            | 12.19± 0.08  | 12.27±0.06  | 12.18 ^i |
| G10        | 13.16 ± 0.06          | 13.30 ± 0.09 | 13.33± 0.07 | 13.26 ^f |
| G15        | 14.24 ± 0.05          | 14.33 ± 0.03 | 14.39± 0.01 | 14.32 ^c |

Mean: 13.37 ^c  13.54 ^b  13.66 ^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 with the same row with different superscript (a, b, c…) are significantly different (p<0.05).
pH value
The pH values of all fruit pulp yoghurt treatments were lower than the control, addition of fruit pulps decreased the pH values of yoghurt as result of low pH of fruits (Table 3). The effect of addition different fruit pulps ratio was not clear significantly (p<0.05). The pH of all fruit yoghurt treatments decreased along storage period. The lowest pH value was recorded in yoghurt contain 15% of guava pulp while, the highest pH value was recorded in control. These results are in agreement with Ziena and Abd-Elhamid (2009) reported that the decrement in the pH values of functional yoghurt reflected the high activity of starter. This phenomena was due to the growth of lactic acid bacteria and produced lactic acid due to the special synergism between Streptococcus spp. and Lactobacillus spp. These results were in agreement with Tanwar et al. (2014); Amal et al. (2016) and Souza et al. (2018).

Table (3): Effect of adding persimmon, mango and guava pulps on pH value of yoghurt during storage period

| Treatments | Fresh  | Storage period (days) | Mean |
|------------|--------|-----------------------|------|
|            | 4.75 ± 0.01 | 4.65 ± 0.02 | 4.50 ± 0.01 | 4.63 * |
| P5         | 4.15 ± 0.30 | 4.51 ± 0.09 | 4.57 ± 0.13 | 4.46 bcd |
| P10        | 4.21 ± 0.29 | 4.54 ± 0.10 | 4.57 ± 0.13 | 4.43 bcd |
| P15        | 4.20 ± 0.26 | 4.47 ± 0.04 | 4.53 ± 0.05 | 4.40 bcd |
| M5         | 4.73 ± 0.02 | 4.61 ± 0.01 | 4.34 ± 0.02 | 4.56 db |
| M10        | 4.51 ± 0.05 | 4.38 ± 0.03 | 4.23 ± 0.02 | 4.37 cd |
| M15        | 4.42 ± 0.01 | 4.27 ± 0.03 | 4.17 ± 0.06 | 4.29 de |
| G5         | 4.63 ± 0.02 | 4.60 ± 0.01 | 4.22 ± 0.03 | 4.47 bc |
| G10        | 4.33 ± 0.02 | 4.20 ± 0.01 | 3.98 ± 0.03 | 4.17 c |
| G15        | 4.12 ± 0.03 | 3.93 ± 0.03 | 3.82 ± 0.03 | 3.95 f |

Mean 4.40 * 4.40 * 4.29 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 with the same row with different superscript (a, b, c…) are significantly different (p<0.05).

Antioxidant scavenging activity %
Fruit pulps contain various antioxidant compounds which act against oxidizing agents (Jin et al., 2018). Adding fruit pulp to the yoghurt increased the ASA % of the yoghurt (Table 4), the increase proportional linear were related to the increase in fruit pulps in all treatments and the effect were significantly (p<0.05). The highest value of ASA% was reached in yoghurt containing 15% of guava pulp. These results are in agreement with Kholy (2018). Kholy (2018) reported that ASA % tend to decrease along the storage period, as a result of possible oxidation. Scibisz et al. (2012) attributed the decrease in ASA % to the interaction of antioxidant compounds with casein or whey protein causing formation of soluble complex which responsible for decreasing ASA %.

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 (El-Batawy et al., 2014). The effect of fruit pulps addition was significantly (p<0.05) on the TPC of all fruit yoghurt treatments compared with control (Table 5). It is clear that addition of guava pulp recorded the highest value in TPC content of functional yoghurt in all ratios, due to high contents of TPC in guava pulp compared with control and other treatments. 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. 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 (4): Effect of adding persimmon, mango and guava pulps on antioxidant scavenging activity % of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7     | 14   |      |
| C          | 7.93 ± 0.02 | 7.56 ± 0.30 | 7.24 ± 0.12 | 7.57 |
| P5         | 13.03 ± 1.01 | 11.29±1.05 | 11.85 ± 0.30 | 12.05 |
| P10        | 16.52± 1.10 | 15.88±2.05 | 14.98±0.86 | 15.79 |
| P15        | 17.99±2.14 | 17.93±1.88 | 15.79±1.29 | 17.23 |
| M5         | 8.49±0.02 | 8.19±0.02 | 8.12±0.03 | 8.26 |
| M10        | 10.62±0.04 | 10.51±0.08 | 10.41±0.03 | 10.51 |
| M15        | 12.46±0.03 | 11.96±0.03 | 11.87±0.02 | 12.09 |
| G5         | 11.24±0.25 | 11.20±0.10 | 10.39±0.10 | 10.94 |
| G10        | 15.24±0.50 | 15.08±0.05 | 14.21±0.09 | 14.84 |
| G15        | 17.88±0.04 | 17.85±0.03 | 17.14±0.05 | 17.72 |
| Mean       | 12.88 | 12.87 | 12.20 |

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 with the same row with different superscript (a, b, c…) are significantly different (p<0.05).

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

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7     | 14   |      |
| C          | 0.77±0.02 | 0.75±0.02 | 0.70±0.01 | 0.74 |
| P5         | 1.02±0.07 | 0.95±0.06 | 0.90±0.09 | 0.95 |
| P10        | 1.11±0.05 | 1.06±0.08 | 1.03±0.05 | 1.06 |
| P15        | 1.21±0.05 | 1.17±0.02 | 1.14±0.01 | 1.17 |
| M5         | 0.83±0.02 | 0.82±0.02 | 0.77±0.01 | 0.80 |
| M10        | 0.91±0.02 | 0.89±0.02 | 0.85±0.02 | 0.88 |
| M15        | 0.97±0.02 | 0.94±0.01 | 0.92±0.02 | 0.94 |
| G5         | 3.60±0.19 | 3.34±0.16 | 3.01±0.16 | 3.31 |
| G10        | 5.84±0.07 | 5.69±0.12 | 5.09±0.16 | 5.54 |
| G15        | 8.22±0.21 | 7.89±0.14 | 7.51±0.34 | 7.87 |
| Mean       | 2.43 | 2.36 | 2.19 |

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 with the same row with different superscript (a, b, c…) are significantly different (p<0.05).
Total flavonoid compounds

It could be noticed that yoghurt fortified with persimmon, mango and guava pulps had a higher TFC than control treatment as shown in Table 6. Fortification of yoghurt with guava pulp increased the TFC, the increment was in parallel with the increase of added pulp ratios (Moussa and El-Gendy, 2019). It was clear that the G15, G10 and G5 then P15 treatments were recorded higher TFC contents than control respectively. Ismail et al. (2017) stated that peel and pulp of guava fruit presented high levels of flavonoid compounds. The effect of addition of fruit pulps on TFC of yoghurt was significantly (p<0.05). Along the storage period, the TFC decreased for all fruit yoghurt treatments. The storage period significantly (p<0.05) affected the TFC content of all fruit yoghurt treatments. These results were in agreement with the study of Jin et al. (2018).

Table (6): Effect of adding persimmon, mango and guava pulps on total flavonoid compounds (mg 100 g⁻¹) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|----------------------|------|
|            | Fresh | 7 | 14 | |
| C          | 0.80±0.01 | 0.79±0.01 | 0.73±0.01 | 0.77 f |
| P5         | 0.88±0.00 | 0.85±0.00 | 0.79±0.00 | 0.84 f |
| P10        | 1.08±0.00 | 0.99±0.00 | 0.92±0.00 | 0.99 e |
| P15        | 1.32±0.00 | 1.22±0.00 | 1.20±0.00 | 1.24 d |
| M5         | 0.84±0.01 | 0.83±0.01 | 0.81±0.01 | 0.82 f |
| M10        | 0.86±0.01 | 0.85±0.00 | 0.85±0.00 | 0.85 f |
| M15        | 0.91±0.01 | 0.91±0.01 | 0.89±0.01 | 0.90 y |
| G5         | 3.09±0.07 | 2.84±0.10 | 2.53±0.11 | 2.82 c |
| G10        | 5.37±0.17 | 4.96±0.13 | 4.77±0.11 | 5.03 b |
| G15        | 8.03±0.10 | 7.81±0.09 | 7.25±0.05 | 7.69 a |
| Mean       | 2.29 a | 2.22 b | 2.07 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 with the same row with different superscript (a, b, c…) are significantly different (p<0.05).

Apparent Viscosity (A.V)

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 A.V of fruit pulp yoghurt increased with increase addition of fruit pulp compared with control. The higher A.V was recorded at M15, M10 and G15, respectively, than control and other treatments (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 P5 & M15 fruit pulp treatments. Apparent viscosity increased until 7th day in mango and guava yoghurt, then gradually decreased at 14th day for all fruit yoghurt treatments. The effect of storage period was significantly (p<0.05) for all fruit yoghurt treatments. These results are in agreement with Kavas and Kavas (2016).

Total viable LAB count

Addition of persimmon and mango pulps led to decrease 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 10% yoghurt fortified with guava pulp had highest total viable LAB count than other treatments and control.

The total viable count of LAB for all fruit yoghurt treatments 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 contains bioactive compounds can be used as substrates for the growth of probiotic bacteria.
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          | 7355.33± 83.01 | 8093.33± 33.65 | 5816.00± 106.71 | 7088.22<sup>bc</sup> |
| P5         | 8112.00±208.00 | 7945.00±99.00 | 397.00± 26.00 | 5484.66<sup>d</sup> |
| P10        | 11012.00±926.00 | 8844.00±240.00 | 380.00± 14.00 | 6745.33<sup>cd</sup> |
| P15        | 10564.00± 929.00 | 8456.00±120.00 | 299.00± 4.00 | 6439.66<sup>ed</sup> |
| M5         | 7968.33± 20.21 | 8381.67± 33.29 | 6589.00± 31.51 | 7646.33<sup>abc</sup> |
| M10        | 8786.00± 21.00 | 9895.67±16.62 | 6868.67±31.07 | 8516.77<sup>ab</sup> |
| M15        | 9564.33± 22.15 | 10956.67± 35.12 | 6439.66±31.07 | 8714.66<sup>ab</sup> |
| G5         | 7662.33±27.97 | 8112.00±208.00 | 6589.00±31.51 | 7272.88<sup>abc</sup> |
| G10        | 8390.33±20.01 | 9003.67±16.62 | 6868.67±31.07 | 7890.22<sup>abc</sup> |
| G15        | 9189.67±168.79 | 9981.33± 19.14 | 5646.67±37.86 | 8272.55<sup>ab</sup> |

Mean | 8860.43<sup>a</sup> | 8974.03<sup>a</sup> | 4386.73<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 with the same row with different superscript (a, b, c...) are significantly different (p<0.05).

Organoleptic characteristics

The overall acceptability of yoghurt fortified with mango (M10, M15 and M5) and persimmon (P15 and P10) were recorded the highest total acceptability score compared with control and other treatments. Addition of fruit pulps significantly (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 decreases along the storage period. However, yoghurt treatments containing mango (10, 15 and 5 %) and persimmon (10 and 15%) pulps were quite good and gained the higher scores values 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<sup>-1</sup>) of yoghurt during storage period

| Treatments | Storage period (days) | Mean |
|------------|-----------------------|------|
|            | Fresh | 7 | 14 |      |
| C          | 9.37± 0.23 | 9.45 ± 0.20 | 8.78 ± 0.11 | 9.20<sup>b</sup> |
| P5         | 8.11 ± 0.10 | 8.85 ± 0.06 | 7.31 ± 0.16 | 8.08<sup>f</sup> |
| P10        | 8.92± 0.06 | 8.64 ± 0.14 | 8.66± 0.13 | 8.74<sup>ed</sup> |
| P15        | 8.21± 0.09 | 8.59± 0.27 | 8.21± 0.09 | 8.33<sup>e</sup> |
| M5         | 8.62± 0.29 | 8.95 ± 0.02 | 8.30 ± 0.22 | 8.62<sup>d</sup> |
| M10        | 8.93± 0.05 | 9.00 ± 0.11 | 8.71 ± 0.08 | 8.88<sup>c</sup> |
| M15        | 8.71± 0.08 | 8.26 ± 0.10 | 8.50 ± 0.27 | 8.33<sup>e</sup> |
| G5         | 9.41± 0.01 | 9.59± 0.03 | 8.94± 0.03 | 9.31<sup>b</sup> |
| G10        | 9.65± 0.02 | 9.85 ± 0.03 | 9.35 ± 0.10 | 9.61<sup>a</sup> |
| G15        | 8.92± 0.03 | 9.12 ± 0.03 | 8.69 ± 0.06 | 8.19<sup>c</sup> |

Mean | 8.84<sup>b</sup> | 9.05<sup>d</sup> | 8.52<sup>e</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 with the same row with different superscript (a, b, c...) are significantly different (p<0.05).
| Treatments | Storage period (days) | Mean |
|------------|----------------------|------|
|            | Fresh | 7     | 14    |
| C          | 75.33± 2.08 | 73.33± 0.58 | 71.67± 2.52 | 73.44<sup>d</sup> |
| P5         | 75.00± 1.00 | 71.67± 1.15 | 70.67± 2.08 | 72.44<sup>d</sup> |
| P10        | 85.33±1.53 | 84.67± 0.58 | 85.67± 1.53 | 85.22<sup>b</sup> |
| P15        | 85.33±1.15 | 87.00± 3.61 | 88.00± 1.73 | 86.77<sup>b</sup> |
| M5         | 83.00± 1.73 | 86.33± 0.58 | 86.00± 1.73 | 85.11<sup>b</sup> |
| M10        | 91.33± 0.58 | 93.00± 1.00 | 92.33± 1.15 | 92.22<sup>a</sup> |
| M15        | 87.33± 1.53 | 86.00± 2.65 | 83.00± 1.00 | 85.44<sup>b</sup> |
| G5         | 87.00± 1.73 | 85.33± 2.08 | 81.33± 0.58 | 84.55<sup>bc</sup> |
| G10        | 87.67± 1.15 | 83.00± 0.00 | 76.67± 4.04 | 82.44<sup>c</sup> |
| G15        | 70.67± 3.79 | 67.33± 1.53 | 66.67± 1.53 | 68.22<sup>e</sup> |
| Mean       | 82.80<sup> a </sup> | 81.76<sup> a </sup> | 80.20<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 with 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 fruits yoghurt to give highest overall acceptability comparable with plain yoghurt. Finally it was quite clear that low fat yoghurt with addition of 10% and 15% mango or 15% persimmon then 5% guava pulps give highest score for organoleptic properties compared with other ratios (treatments) and control. Addition of these fruits to low fat yoghurt improved the body & texture of yoghurt. So, we can recommended to enhance low fat yoghurt flavour by adding these fruits for improve the flavour of resultant fruit yoghurt.

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