Functional Low Fat Fruit Yoghurt

Magdy Osman✉; Amin Gouda; Khoulod Blassy and Mervat Hamed
Dairy Department, Faculty of Agriculture, Suez Canal University, Ismailia 41522, Egypt

Received: *12/7/2020*

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 ($p \leq 0.05$) differences between plain yoghurt (control) and functional low fat fruit 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 ($p \leq 0.05$) 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 constitutes 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 rule 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

✉Corresponding author e-mail: mmagdy20@hotmail.com

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 andhad anti-inflammatory properties. Guava pulp had a great amount of antioxidant such as ascorbic acid, polyphenols and many enzymes (Moussa and El-Gendy, 2019; Phama *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:

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

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 where 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 ($p \leq 0.05$).

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).

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
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 ($p \leq 0.05$). The T.S% of fruit pulp yoghurt treatments were increased significantly ($p \leq 0.05$) 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% andG15: guava, 15%. [a]Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

pH value

The pH values of all fruit pulp yoghurt treatments were low 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 ($p \leq 0.05$). 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	Storage period (days)			Mean
	Fresh	7	14	
C	4.75 ± 0.01	4.65 ± 0.02	4.50 ± 0.01	4.63 ^{a}
P5	4.15 ± 0.30	4.51 ± 0.09	4.57 ± 0.13	4.40 ^{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 ^{ab}
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 ^{e}
G15	4.12 ±0.03	3.93 ± 0.03	3.82 ± 0.03	3.95 ^{f}
Mean	**4.40 ^{a}**	**4.40 ^{a}**	**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% andG15: guava, 15%. [a]Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

Antioxidant scavenging activity %

Fruit pulps contain various antioxidant compounds which act against oxidizing agents (Jin *et al*., 2018). Adding fruit pulpsto the yoghurt increased the ASA % of the yoghurt (Table 4), the increase proportional linear were related to the increase in fruit pulpsin all treatments and the effect were significantly ($p \leq 0.05$). The highest value of ASA% was recorded in yoghurt contains 15% of guava pulp. These results are agreement with Ziena and Abd-Elhamid (2009). During the storage period, the ASA% gradually decreased up to 14 days, the effect of storage period was significantly ($p \leq 0.05$). Khalil (2013) 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 ($p \leq 0.05$) 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 ($p \leq 0.05$) 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 [f]
P5	13.03 ± 1.01	11.29±1.05	11.85 ± 0.30	12.05 [d]
P10	16.52± 1.10	15.88± 2.05	14.98± 0.86	15.79 [b]
P15	17.99± 2.14	17.93± 1.88	15.79± 1.29	17.23 [b]
M5	8.49± 0.02	8.19±0.02	8.12± 0.03	8.26 [f]
M10	10.62± 0.04	10.51± 0.08	10.41± 0.03	10.51 [e]
M15	12.46± 0.03	11.96± 0.03	11.87± 0.02	12.09[d]
G5	11.24± 0.25	11.20± 0.10	10.39± 0.10	10.94 [e]
G10	15.24± 0.50	15.08 ± 0.05	14.21± 0.09	14.84 [c]
G15	17.88± 0.04	17.85± 0.03	17.14± 0.05	17.72 [a]
Mean	12.88 [a]	12.87 [a]	12.20 [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% andG15: guava, 15%. [a]Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

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 [g]
P5	1.02±0.07	0.95±0.06	0.90±0.09	0.95[ef]
P10	1.11±0.05	1.06±0.08	1.03±0.05	1.06 [de]
P15	1.21±0.05	1.17±0.02	1.14±0.01	1.17 [d]
M5	0.83±0.02	0.82±0.02	0.77±0.01	0.80 [fg]
M10	0.91±0.02	0.89±0.02	0.85±0.02	0.88 [fg]
M15	0.97±0.02	0.94±0.01	0.92±0.02	0.94 [ef]
G5	3.60±0.19	3.34±0.16	3.01±0.16	3.31 [c]
G10	5.84±0.07	5.69±0.12	5.09±0.16	5.54 [b]
G15	8.22±0.21	7.89±0.14	7.51±0.34	7.87 [a]
Mean	2.43 [a]	2.36 [a]	2.19 [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% andG15: guava, 15%. aValues 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 notice 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 ($p \leq 0.05$). Along the storage period, the TFC decreased for all fruityoghurt treatments. The storage period significantly ($p \leq 0.05$) affected the TFC content of all fruit yoghurt treatments. These results were in agreement with the study of Jin *et al*. (2018).

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 ($p \leq 0.05$) 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 ($p \leq 0.05$) for all fruit yoghurt treatments. These results are in agreement with Kavas and Kavas (2016).

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 ^{e}f
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 ^{a}	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% andG15: guava, 15%. [a]Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

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 ($p \leq 0.05$) 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^{bc}
P5	8112.00±208.00	7945.00±99.00	397.00± 26.00	5484.66^{d}
P10	11012.00±926.00	8844.00±240.00	380.00± 14.00	6745.33^{cd}
P15	10564.00± 929.00	8456.00± 120.00	299.00± 4.00	6439.66^{cd}
M5	7968.33± 20.21	8381.67± 33.29	6589.00± 31.51	7646.33 ^{abc}
M10	8786.00± 21.00	9895.67±16.62	6868.67±31.07	8516.77^{ab}
M15	9564.33±42.15	10956.67± 35.12	5621.00±25.51	8714.٠٠^{a}
G5	7662.33±27.97	8183.00± 53.36	5973.33±110.15	7272.88^{abc}
G10	8390.33±20.01	9003.67± 91.27	6279.67± 35.12	7890.22 ^{abc}
G15	9189.67±168.79	9981.33± 19.14	5646.67± 37.86	8272.55^{ab}
Mean	8860.43^{a}	8974.03^{a}	4386.73^{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% andG15: guava, 15%. ^{a}Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

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 ($p \leq 0.05$) affected the total score values of all fruit yoghurt treatments (Table 9). Also, the storage period significantly ($p \leq 0.05$) 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^{-1}) 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 ^{b}
P5	8.11 ± 0.10	8.85 ± 0.06	7.31 ± 0.16	8.08 ^{f}
P10	8.92± 0.06	8.64 ± 0.14	8.66± 0.13	8.74 ^{cd}
P15	8.21± 0.09	8.59± 0.27	8.21± 0.09	8.33 ^{e}
M5	8.62± 0.29	8.95 ± 0.02	8.30 ± 0.22	8.62 ^{d}
M10	8.93± 0.05	9.00 ± 0.11	8.71 ± 0.08	8.88 ^{c}
M15	8.71± 0.08	8.26 ± 0.10	8.50 ± 0.27	8.33 ^{e}
G5	9.41± 0.01	9.59 ± 0.03	8.94 ± 0.03	9.31 ^{b}
G10	9.65 ± 0.02	9.85 ± 0.03	9.35 ± 0.10	9.61 ^{a}
G15	8.92 ± 0.03	9.12 ± 0.03	8.69 ± 0.06	8.19 ^{c}
Mean	8.84^{b}	9.05 ^{a}	8.52 ^{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% andG15: guava, 15%. ^{a}Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

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

Treatments	Storage period (days)			Mean
	Fresh	7	14	
C	75.33± 2.08	73.33± 0.58	71.67± 2.52	73.44^{d}
P5	75.00± 1.00	71.67± 1.15	70.67± 2.08	72.44^{d}
P10	85.33±1 .53	84.67± 0.58	85.67± 1.53	85.22^{b}
P15	85.33± 1.15	87.00± 3.61	88.00± 1.73	86.77^{b}
M5	83.00± 1.73	86.33± 0.58	86.00± 1.73	85.11^{b}
M10	91.33± 0.58	93.00± 1.00	92.33± 1.15	92.22^{a}
M15	87.33± 1.53	86.00± 2.65	83.00± 1.00	85.44^{b}
G5	87.00± 1.73	85.33± 2.08	81.33± 0.58	84.55^{bc}
G10	87.67± 1.15	83.00± 0.00	76.67± 4.04	82.44^{c}
G15	70.67± 3.79	67.33± 1.53	66.67± 1.53	68.22^{e}
Mean	82.80 ^{a}	81.76 ^{a}	80.20 ^{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% andG15: guava, 15%. ^{a}Values are means ± standard deviations of triplicate determinations. Means with the same row with different superscript (a, b, c…) are significantly different ($p \leq 0.05$).

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.

REFERENCES

Abbasi, A. M., F. Liu, X. Guo, X. Fu, T. Li and R. H. Liu (2017). Phytochemical composition, cellular antioxidant capacity and antiproliferative activity in mango (*Mangifera indica* L.) pulp and peel. International Journal of Food Science and Technology, 52: 817-826.

Amal, A., A. Eman and S. Z. Nahla (2016). Fruit flavored yogurt: Chemical, functional and rheological properties. International Journal of Environmental and Agriculture Research, 2: 57-66.

AOAC (2000). Official Methods of Analysis of AOAC International. (Ed. Horwitz, W.), 17th Ed., Suite 500, 481 North Fredric avenue Gaithersburg, Maryland, USA.

Arslan, S. and S. Bayrakci (2016). Physicochemical, functional, and sensory properties of yogurts containing persimmon. Turkish Journal of Agriculture and Forestry, 40: 68-74.

Barros, L., L. Cabrita, M. V. Boas, A. M. Carvalho and I. C. F. R. Ferreira (2011). Chemical, biochemical and electrochemical assays to evaluate phytochemicals and antioxidant activity of wild plants. Food Chemistry, 127: 1600-1608.

Caleja, C., L. Barros, A. L. Antonio, M. Carocho, M. B. P. P. Oliveira and I. C. F. R. Ferreira (2016). Fortification of yogurts with different antioxidant preservatives: a comparative study between natural and synthetic additives. Food Chemistry*,* 210: 262-268.

CoStat program (2005). Version 6.311. Copyright (1998-2005) CoHort Software, Monterey, California, USA.

Curi, P. N., B. S. Tavares, A. B. Almeida, R. Pio, M. Pasqual, P. M. Peche and V. R. Souza (2017). Characterization and influence of subtropical persimmon cultivars on juice and jelly characteristics. Anais da Academia Brasileira de Ciências, 89: 1205-1220.

De Vrese, M., C. Laue, B. Offick, E. Soeth, F. Repenning, A. Thoß and J. andSchrezenmeir (2015). A combination of acid lactase from *Aspergillus oryzae* and yogurt bacteria improves lactose digestion in lactose maldigesters synergistically: A randomized, controlled, double-blind cross-over trial. Clinical Nutrition, 34: 394-399.

El-Batawy, O. I., L. S. Ashoush and N. S. Mehanna (2014). Impact of mango and pomegranate peels supplementation on quality characteristics of yoghurt with or without whey powder. World Journal Dairy Food Science, 9: 57-65.

El-kholy, W. M. (2018). Preparation and properties of probiotic low fat frozen yoghurt supplemented with powdered doum (*Hyphaene thebacia*) fruit. Egptian Journal of Dairy Science, 46: 67-78.

Elliker, P. R., A. W. Anderson and G. Hannesson (1956). An agar culture medium for lactic acid streptococci and lactobacilli. Journal of Dairy Science, 39: 1611-1612.

Hashemi, S. M. B., A. M. Khaneghah, F. J. Barba, Z. Nemati, S. S. Shokofti and F. Alizadeh (2017). Fermented sweet lemon juice (*Citrus limetta*) using *Lactobacillus plantarum* LS5: Chemical composition, antioxidant and antibacterial activities. Journal of Functional Foods, 38:409-414.

Hassan, A. M. A. (2017). The effect of using exopolysaccharide producing bacterial cultures on physicochemical properties of some dairy products. Ph. D thesis, Dairy Department, Faculty of Agriculture, Suez Canal University, Egypt.

IDF (International Dairy Federation) Standard 99 C (1997). Sensory evaluation of dairy products by scoring reference method.

Ismail, M. M., M. F. Hamad and E. M. Elraghy (2017). Rheological, Physicochemical, microbial and sensory properties of bio-rayebmilk fortified with guava pulp. International Journal of Food Science and Biotechnology, 1: 9-20.

Jiménez-Sánchez, C., J. Lozano-Sánchez, N. Marti, D. Saura, M. Valero, A.. Segura-Carretero and A. Fernández-Gutiérrez (2015). Characterization of polyphenols, sugars, and other polar compounds in persimmon juices produced under different technologies and their assessment in terms of compositional variations. Food Chemistry, 182: 282-291.

Jin, X., W. Chen, H. Chen, W. Chen and Q. Zhong (2018). Comparative evaluation of the antioxidant capacities and organic acid and volatile contents of mango slurries fermented with six different probiotic microorganisms. Journal of Food Science, 83: 3059-3068.

Karaman, S., Ö. S. Toker, F. Yüksel, M. Çam, A. Kayacier and M. Dogan (2014). Physicochemical, bioactive, and sensory properties of persimmon-based ice cream: Technique for order preference by similarity to ideal solution to determine optimum concentration. Journal of Dairy Science, 97: 97-110.

Kavas, N. and G. Kavas (2016). Probiotic frozen yoghurt production using camel milk (*Camelus dromedarius*) with improved functions by strawberry guava (*Psidium littorale* var. *cattleianum*) fortification. British Journal of Applied Science and Technology, 14: 1-12.

Khalil, R. A. M. (2013). The use of pomegranate juice as a natural source for antioxidant in making functional yoghurt drink. Egyptian Journal of Dairy Science, 41: 137-149.

Lee, S. C., J. H. Kim, S. M. Jeong, D. R. Kim, J. U. Ha and K. C. Nam (2003). Effect of far infrared radiation on the antioxidant activity of rice hulls. Journal Agriculture Food Chemistry, 51: 4400-4403.

Lees, G. J. and G. R. Jago (1969). Methods for the estimation of acetaldehyde in cultured dairy products. Australian Journal Dairy Technology, 10: 181-184.

Li, X., L. Chan, B. Yu, P. Curran and S. Q. Liu (2014). Influence of *Saccharomyces cerevisiae* and *Williopsis saturnus* var. *mrakii* on mango wine characteristics. Acta Alimentaria, 43: 473-481.

Mahmood, A., N. Abbas and A. H. Gilani (2008). Quality of stirred buffalo milk yogurt blended with apple and banana fruits. Pakistan Journal Agricultural Sciences, 45: 275- 279.

Manisha, W. H., R. Rajak and D. Jat (2017). Oxidative stress and antioxidants: an overview. International Journal of Advanced Research and Review, 2: 110-119.

Mehanna, N. M., F. M. Ibrahim and L. L. El-Nawasany (2013). Impact of some hydrocolloids on the physical characteristics and quality of non-fat yoghurt. Egypt. Journal Dairy Science, 41: 163-170.

Moussa, M. E. M. and M. A. El-Gendy (2019). Physiochemical, microbiological and sensory properties of guava whey blend beverages. Middle East Journal of Applied Sciences, 9: 326-331.

Nguyen, P. T., O. Kravchuk, B. Bhandari and S. Prakash (2017). Effect of different hydrocolloids on texture, rheology, tribology and sensory perception of texture and mouth feel of low-fat pot-set yoghurt. Food Hydrocolloids, 72: 90-104.

Parvez, G. M., U. Shakib, M. A. Khokon and M. Sanzia (2018). A short review on a nutritional fruit: guava. Open Access: Toxicology and Research, 1: 1-8.

Phama, D. C., N. H. Vua, W. M. Samhaberb and M. T. Nguyena (2019). Physicochemical characteristics and aroma analysis of passion fruit juice and guava juice concentrated by a novel evaporation concept. Chemical Engineering, 75: 43-48.

Ravichandran, K., N. M. M. T. Saw, A. A. A. Mohdaly, A. M. M. Gabr, A. Kastell, H. Riedel, Z. Cai, D. Knorr and I. Smetanska (2013). Impact of processing of red beet on betalain content and antioxidant activity. Food Research International, 50: 670-675.

Ronak, P., A. H. Jana, M. Hiral and S. Balakrishnan (2016). Process standardization for the manufacture of mango flavoured steamed sweetened concentrated yoghurt (Bhapadahi). Journal of Dairy, Veterinary and Animal Research, 4: 293-303.

Routray, W. and H. N. Mishra (2011). Scientific and technical aspects of yoghurt aroma and taste: a review. Comprehensive Reviews in Food Science and Food Safety, 10: 208-220.

Sagdic, O. I., H. Ozturk, Cankurt and F. Tornuk (2012). Interaction between some phenolic compounds and probiotic bacterium in functional ice cream production. Food Bioprocess Technology, 5: 2964-2971.

Scibisz, I., M. Ziarno, M. Mitek and D. Zaręba (2012). Effect of probiotic cultures on the stability of anthocyanins in blueberry yoghurts. LWT-Food Science Technology, 49: 208-212.

Senadeera, S. S., P. H. P. Prasanna, N. W. I. A. Jayawardana, D. C. S. Gunasekara, P. Senadeera and A. Chandrasekara (2018). Antioxidant, physicochemical, microbiological and sensory properties of probiotic yoghurt incorporated with various *Annona* species pulp. Heliyon, 4: 1-18.

Souza, J. M. A., S. Leonel, J. H. Modesto, R. A. Ferraz and B. H. L. Gonçalves (2018). Fruit physicochemical and antioxidant analysis of mango cultivars under subtropical conditions of Brazil. Journal of Agricultural Science and Technology, 20: 321-331.

Srisuvor, N., N. Chinprahast, C. Prakitchaiwattana and S. Subhimaros (2013). Effects of inulin and polydextrose on physicochemical and sensory properties of low-fat set yoghurt with probiotic-cultured banana purée. LWT-Food science and Technology, 51: 30-36.

Tanwar, B., B. Andallu and S. Chandel (2014). Influence of processing on physicochemical and nutritional composition of *Psidium guajava* L. (Guava) products. International Journal of Agriculture and Food Science Technology, 5: 47-54.

Vahedi, N., M. M. Tehrani and F. Shahidi (2008). Optimizing of fruit yoghurt formulation and evaluating its quality during storage. American-Eurasian Journal Agriculture and Environmental Science, 3: 922-927.

Yaqub, S., U. Farooq, A. Shafi, K. Akram, M. A. Murtaza, T. Kausar and F. Siddique (2016). Chemistry and functionality of bioactive compounds present in persimmon. Journal of Chemistry, 2016: 1-13.

Ziena, H. M. and A. M. Abd-Elhamid (2009). Production of functional yogurt: effect of natural antioxidant from guava (*Psidium guajava*) leaf extract. Journal of Agriculture and Food Science Technology, Alexandria University Egypt, 8: 102-116.

زبادي وظيفي منخفض الدسم بالفواكه

مجدي عثمان، أمين جوده، خلود بلاسي، مرفت حامد
قسم الألبان - كلية الزراعة - جامعة قناة السويس - الإسماعيلية ٤١٥٢٢ - جمهورية مصر العربية

تم دراسة تأثير إضافة لب الفواكه (الكاكا والمانجو والجوافة) للزبادي منخفض الدسم (٠.٧%) بنسب مختلفة (٥ و١٠ و ١٥ %) والتخزين على درجة حرارة ٥±١ °م لمدة ١٤ يوم. كما تم دراسة تأثير ذلك على الخواص الكيميائية والريولوجية والعدد الكلي لبكتريا حامض اللاكتيك وكذا الخواص الحسية للمنتج عند اليوم الأول والسابع والرابع عشر. وأتضح وجود فروق معنوية بين الزبادي المدعم بالفاكهة وغير المدعم بالمواد الصلبة الكلية والمواد المضادة للأكسدة والمواد الفينولية والفلافونيدات الكلية، والتي زادت بزيادة إضافة نسب لب الفاكهة، بينما كانت قيم الـ pH منخفضة بزيادة الإضافـة وطوال فترة التخزين. وقد أوضحت النتائج أن الزبادى منخفض الدسم المدعم بـ ١٥% كان أعلي في قيم مضادات الأكسدة والفينولات والفلافونيدات في كلا من لب الجوافة والمانجو والكاكا علي التوالي. كما أوضحت النتائج أن الزبادي منخفض الدسم والمدعم بالجوافة اظهر زيادة معنوية في العدد الكلي لبكتريا حامض اللاكتيك مقارنة بالكنترول والمعاملات الأخرى. وقد سجلت المعاملات المحتوية على ١٠% مانجو و١٥% كاكا و٥% جوافة أعلى قيم في التقييم الحسي للزبادي مقارنة بالكنترول والمعاملات الأخرى. كما أدى إضافة الفواكه للزبادي إلى تحسين الخواص الريولوجية والحسية كالقوام والنكهة مقارنة بالكنترول.