World Journal of Dairy & Food Sciences 9 (1): 57-65, 2014
ISSN 1817-308X
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DOI: 10.5829/idosi.wjdfs.2014.9.1.1133

Impact of Mango and Pomegranate Peels Supplementation on Quality Characteristics of Yoghurt with or Without Whey Powder

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Abstract: Set yoghurt was prepared from buffalo's milk standardized to 3% fat and supplemented with 2% skim milk powder (SMP), why powder (WP), pomegranate peel powder (PPP), mango peel powder (MPP), WP+PPP (1:1) and WP+MPP (1:1). Survival of lactic acid bacteria, some chemical, functional properties and sensory quality of yoghurt samples were evaluated. There were non significant differences in dry matter and fat content among all treatment. Significant differences were observed in lactose, protein, ash, acidity diacetyl and acetaldehyde contents in all treatment of yoghurt. Yoghurt supplemented with PPP, MPP, WP+PPP and WP+MPP were rich with crude fibers and antioxidant contents. Supplementation the yoghurt with 2% PPP or MPP led to significant decrease in the counts of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp *bulgaricus* in resultant yoghurt compared with yoghurt supplemented with 2% WP and SMP. Extracts of PPP and MPP showed a high cytotoxic effect towards HePG2 (liver), HCT116 (colon) and MCF7 (breast) cells line. Yoghurt samples supplemented with WP+PPP and WP+MPP recorded higher flavor, appearance and overall scores than that of samples supplemented with PPP and MPP, respectively. So, addition of 1% WP in supplemented milk yoghurt with 1% PPP or MPP lead to significant increase in flavor score and enhance a sensory quality of yoghurt product compared with yoghurt samples supplemented with 2% PPP or MPP. It could be concluded, that mango or pomegranate peels powder should be incorporated with whey powder when used as ingredients in functional yoghurt.

Key words: Mango · Pomegranate peel powder · Quality characteristics · Yoghurt · Whey powder

INTRODUCTION

Fermented milk products are widely consumed for their benefits and refreshing effect. Yoghurt is increasingly popular fermented milk in Egypt, which usually produced from whole or partially skimmed cow's or buffalo's milk. In order to produce yoghurt with satisfactory quality, skim milk powder (SMP) is usually added to milk at 2-5% to increase the total solids content of the yoghurt milk. However, some ingredients as by products come from some food industries and have good functional properties can be used for this target such as, sodium caseinate or whey protein concentrate [1-3]. Whey powder (WP), pomegranate peel powder (PPP) and Mango peel powder (MPP) are by products have good functional properties and may added during manufacture of some food products to gain its some functional properties. Mango and pomegranate peels are the major by-products of mango and pomegranate juice industry; they are a good source of bioactive compounds such as polyphenols, carotenoids, vitamins, enzymes and dietary fibers [4, 5] which play an important role in prevention of diseases. Ashoush *et al*. [6] noticed that the pomegranate peel powder (PPP) and whey powder (WP) are a good source of total phenolic and had a great free radical scavenging activity and concluded that, the mixture of pomegranate peel powder and whey powder could be used as natural antioxidants to enhance the antioxidant properties of functional food. Also, Berardini *et al*. [7] stated that, it can be use mango peels as a good source of pectin and polyphenolics in food industries.

The present study was undertaken to evaluate the influence of addition mango and pomegranate peels powder with or without whey powder in yoghurt

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manufacture on the chemical composition, survival of lactic acid bacteria, functional properties and sensory quality of yoghurt.

MATERIALS AND METHODS

Materials

Ingredients: Fresh buffalo's milk was obtained from the herd of the dairy cattle at Faculty of Agriculture, Ain Shams University, Egypt. Skim milk powder (SMP) (97% DM) made in Poland was obtained from the local market of Cairo. Whey powder (WP) containing 11% proteins, was purchased from Green Land for Food Industries 10th of Ramadan City, Egypt. The full ripe pomegranate fruit wonderful variety and mango fruit zebda variety were obtained from the local market. Sodium carbonate and methanol were obtained from El-Gomhoreya Co., Cairo, Egypt. 1, 1-diphenyl-2-picrylhydrazyl radical (DPPH), Gallic acid and Folin-Ciocalteus phenol reagent was purchased from Sigma–Aldrich Inc. (St. Louis, MO, USA).

Bacterial Starter Cultures: The bacterial culture used in this study, commercially named YC-X11 DIP 50u consists of a (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* 1:1) in the form of freeze-dried culture obtained from Chr. Hansens Laboratories, Denmark and prepared as the mother culture by adding 1% of lyophilized cell culture into 12% sterilized reconstituted skim milk powder and incubated at 42°C for 4-6 h before 24 h.

Experiment of Procedures

Preparation of Pomegranate and Mango Peels Powders: To preparation pomegranate peel powder (PPP) and mango peel powder (MPP), pomegranate and mango fruits were washed by distilled water then peeled and their edible portions were carefully separated. The peels were air dried in a ventilated oven at 50°C for 18 h and the dried peels were powdered using a hammer mill and sieved through a 150 mm sieve ground to a fine powder.

Production of Functional Yoghurt: Buffalo's milk was standardized to 3% fat and then divided to 6 equal portions. The first one was fortified with 2% SMP to serve as control (C), whereas the other five treatments (T1, T2, T3, T4 and T5) was fortified with 2% with WP, PPP, MPP, WP+PPP (1:1) or WP+MPP (1:1), respectively. All fortified milks were heat treated at 85°C for 15 min and subsequently cooled to 42°C and inoculated with 3% yoghurt starter culture The inoculated samples were filled into 100 ml plastic cups and incubated at 42°C till coagulation (pH 4.7) then cooled to 4°C. Three replicates were done for each treatment. The resulting yoghurts were stored at 4°C for 21 days.

Cytotoxicity Effect on Different Cell Lines (HePG2 and HCT116): Cell viability was assessed by the mitochondrial dependent reduction of yellow MTT (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyl tetrazolium bromide) to purple formazan [8]. The percentage of change in cell viability was calculated according to the formula:

((Absorbance of extract/Absorbance of negative control) -1) x 100

The cytotoxic activity test (*In vitro* bioassay on human tumor cell lines) was conducted and determined by the Bioassay-Cell Culture Laboratory, National Research Centre, Dokki, Giza, Egypt.

Analytical Methods: Dry matter, ash, protein and crude fibers of yoghurt treatments were determined according to A.O.A.C. [9]. Titratable acidity as lactic acid (TA), fat contents were determined as given by Ling, [10]. The lactose content was determined as described by Nickerson *et al*. [11]. Acetaldehyde and diacetyl contents were determined according to Lees and Jago [12] and [13], using the Conway micro diffusion-Semi carbazide method. Mango peels powders (MPP) and pomegranate peels powders (PPP) were extracted by using methanol: water (60:40 v/v) at solvent/powder ratio of 4:1 (v/w) as described by Bloor, [14]. While, to extract the bioactive compounds in fortified yoghurt treatments, a 20 g of sample were mixed with 30 ml methanol: water (60:40 v/v) and set at 4°C overnight. Solution was then passed through filter paper (Whatman No. 1) to collect the filtrate and concentrated using a rotary evaporator at 40°C. The mixture was centrifuged and the supernatant was adjusted to 25 ml. An aliquot of their extracts were used for the quantification of total phenolic and DPPH radical scavenging activity as follow: Total phenolic content was measured by the Folin–Ciocalteu as described by Singleton *et al*. [15]. Aliquots of 0.5 ml of each extracts were added to 0.5 ml of Folin-Ciocalteu reagent, followed by addition of 0.5 ml of an aqueous 20% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a model UV/VIS 1201 spectrophotometer (Shimadzu, Kyoto, Japan). A blank sample consisting of water and

reagents was used as a reference. Gallic acid was applied as a standard and the results were expressed as mg gallic acid equivalent (GAE). The ability of the extracts to scavenge DPPH free radicals was determined by the method described by Blois [16]. Aliquots (100µl) of each extracts were mixed with 2.9 ml of 0.1 mM DPPH in methanol. The control samples contained all the reagents except the extract. The decrease in absorbance at 517nm was measured after 30min of incubation at room temperature. Radical scavenging capacity of each extracts was expressed as percent DPPH radical scavenging effect using the following equation:

$$\text{Scavenging activity\%} = [(Abs_{control} - Abs_{sample})/Abs_{control}] \times 100$$

Lactobacilli counts were determined using MRS agar according to De Man *et al*. [17]. *Str. thermophilus* count using M17 agar medium [18]. The plates were incubated at 37°C for 48h. The organoleptic properties of different yoghurt samples were assessed by a regular taste panel of the members of the Food Science Department, Faculty of Agriculture, Ain Shams University, Cairo, Egypt. Yoghurt samples were evaluated for flavor (60 points), body & texture (30 points) and appearance (10 points) according to Bodyfelt *et al*. [19].

Statistical Analysis: Data were analyzed using analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \leq 0.05$ to determine the significant differences in results using JMP 4.0 statistical software package [20].

RESULTS AND DISCUSSION

Chemical Composition of Yoghurt Treatments: Data in Table 1 indicated that, dry matter content of the yoghurt samples ranged from 13.96 to 14.36% and fat from 3.0 to 3.2%. Protein content ranged from 3.98 to 4.46, while lactose and crude fibers contents ranged from 4.12 to 5.35 and 0.12 to 0.43, respectively. There were non significant differences in dry matter and fat content among all treatment. Significant differences were observed in crude fibers, lactose, protein and ash contents in all treatment of yoghurt. Samples supplemented with PPP had significantly the highest crude fibers content and the lowest lactose content followed by samples supplemented with MPP. Yoghurt samples supplemented with 2% WP and SMP had lactose% higher than other. These could be due to the differences of chemical composition between SMP, WP, PPP and MPP. Pomegranate and mango peels powder contain higher amount of crude fibers compared with skim milk and whey powder [7, 21, 22]. On the contrary, the lactose content in whey and skim milk powders is higher than that in mango and pomegranate peels powder.

Data in Table 2 indicated that, titratable acidity was significant lower in yoghurt supplemented with 2% PPP and MPP than that in samples supplemented with 2% SMP and WP. The differences were remarkable along of the storage period. This observation might be due to the negative effect of mango and pomegranate peels powder on the growth and/or activity of lactic acid bacterial starter cultures. Also, that could be due to the higher lactose content in yoghurt supplemented with WP or SMP compared with samples supplemented with PPP or MPP that enhances the growth of lactic acid bacteria [23]. Generally, a gradual increase in the acidity was recorded for all yoghurt samples all over the storage period. This may be due to the activity of fermented milk cultures [24].

From data in Table 2, it can be observed that, there were significant differences in diacetyl and acetaldehyde contents along all yoghurt treatment. Moreover, diacetyl and acetaldehyde contents were significant higher in yoghurt samples supplemented with 2% SMP and WP

Table 1: Chemical composition of fresh yoghurt supplemented with mango & pomegranate peels powder with or without whey powder.

Component%	SMP	WP	PPP	MPP	WP+PPP	WP+MPP
Dry matter	14.22±0.04^{b}	13.96±0.09^{c}	14.36±0.06^{a}	14.21±0.09^{b}	14.12±0.07^{b}	14.17±0.03^{b}
Fat	3.1±0.1^{a}	3.2±0.01^{a}	3.1±0.1^{a}	3.0±0.1^{a}	3.1±0.2^{a}	3.0±0.1^{a}
Protein	4.46±0.08^{a}	4.02±0.05^{cd}	3.98±0.05^{d}	4.12±0.08^{bc}	4..10±0.03^{c}	4.21±0.01^{b}
Lactose	5.11±0.04^{b}	5.35±0.03^{a}	4.12±0.02^{d}	4.16±0.08^{d}	4.76±0.03^{c}	4.81±0.07^{c}
Ash	1.070±0.01^{d}	1.034±0.01^{e}	1.365±0.01^{b}	1.575±0.02^{a}	1.231±0.03	1.365±0.02^{b}
Crude fibers	ND	ND	0.43±0.02^{a}	0.19±0.02^{c}	0.22±0.02^{b}	0.12±0.01^{d}

Data are expressed as means±SD (n = 3). Mean values in the same raw within each parameter bearing the same superscript do not differ significantly ($P \leq 0.05$); ND: Not detected

Where:

SMP: yoghurt supplemented with 2% skim milk powder
WP: yoghurt supplemented with 2% whey powder
PPP: yoghurt supplemented with 2% pomegranate peel powder
MPP: yoghurt supplemented with 2% mango peel powder
WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder
WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

Table 2: Acidity, diacetyl and acetaldehyde of yoghurt samples supplemented with mango and pomegranate peels powder with or without whey powder along the storage at 4°C for 21 days

	Storage period (days)				
Treatment	Fresh	3	7	14	21
Acidity%					
SMP	0.81±0.01^{b}	0.87±0.02^{b}	0.91±0.01^{b}	1.12±0.04^{b}	1.21±0.04^{b}
WP	0.86±0.01^{a}	0.90±0.03^{a}	0.96±0.01^{a}	1.19±0.05^{a}	1.28±0.01^{a}
PPP	0.72±0.01^{e}	0.79±0.02^{cd}	0.83±0.02^{cd}	0.92±0.03^{c}	1.09±0.05^{d}
MPP	0.71±0.01^{e}	0.76±0.01^{d}	0.81±0.01^{d}	0.91±0.01^{c}	1.05±0.03^{d}
WP+PPP	0.77±0.01^{c}	0.80±0.02^{c}	0.84±0.01^{c}	0.96±0.01^{c}	1.13±0.03^{c}
WP+MPP	0.75±0.01^{d}	0.81±0.02^{c}	0.83±0.02^{cd}	0.95±0.03^{c}	1.16±0.01^{bc}
Acetaldehyde (µml/100g)					
SMP	287.45±17.4^{a}	275.23±4.9^{a}	248.51±7.8^{a}	187.87±11.2^{a}	160.12±6.3^{a}
WP	290.14±6.4^{a}	280.40±9.1^{a}	251.82±9.2^{a}	184.43±3.7^{a}	157.54±7.9^{a}
PPP	216.71±7.7^{c}	207.11±8.7^{c}	189.07±7.8^{d}	156.13±10.7^{bc}	140.97±3.5^{b}
MPP	206.67±3.5^{c}	200.43±9.1^{c}	180.67±2.5^{d}	151.56±5.8^{c}	138.76±1.8^{b}
WP+PPP	254.06±3.9^{b}	247.69±9.1^{b}	223.11±5.1^{b}	167.84±4.5^{b}	142.48±4.2^{b}
WP+MPP	245.34±6.2^{b}	236.21±13.2^{b}	207.65±6.7^{c}	156.78±7.1^{bc}	140.12±7.0^{b}
Diacetyl (µml/100g)					
SMP	20.15±0.93^{b}	22.08±1.01^{a}	19.70±0.3^{a}	14.86±0.04^{a}	10.34±0.4^{a}
WP	21.88±1.71^{a}	22.78±0.4^{a}	18.98±0.3^{a}	14.78±0.04^{a}	9,87±1.5^{a}
PPP	13.56±0.98^{d}	13.93±1.4^{d}	11.83±1.6^{c}	9.20±0.04^{cd}	6.89±0.15^{b}
MPP	13,62±1.3^{d}	14.81±0.05^{cd}	11.89±1.4^{c}	8.31±0.04^{d}	6.04±0.2^{b}
WP+PPP	16.54±0.9^{c}	17.65±0.9^{b}	15.43±0.9^{b}	10.75±0.04^{bc}	7.10±0.4^{b}
WP+MPP	15.67±1.2^{cd}	15.56±0.7^{c}	13.46±1.0^{c}	11.09±0.04^{b}	6.54±0.1^{b}

Data are expressed as means±SD (n = 3). Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($P \leq 0.05$).

Where:

SMP: yoghurt supplemented with 2% skim milk powder
WP: yoghurt supplemented with 2% whey powder
PPP: yoghurt supplemented with 2% pomegranate peel powder
PP: yoghurt supplemented with 2% mango peel powder
WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder
WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

Table 3: Total phenolic content and antioxidant activity of mango and pomegranate peels powder

Treatment	Total phenolic (mg GAE/g)	Scavenging activity%
MPP	19.02±0.27^{b}	93.89±0.20^{b}
PPP	26.19±0.23^{a}	96.24±0.15^{a}
WP	ND	72.15±0.15^{c}

Data are expressed as means±SD (n = 3). Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($P \leq 0.05$), ND: Not detected

than samples contained 2% PPP and MPP. This is may be due to the effect of addition PPP and MPP on the growth and\or activity of starter cultures. Incorporation WP with PPP or MPP caused significant increase in diacetyl and acetaldehyde contents compared with supplementation of PPP or MPP. The acetaldehyde content gradually decreased in all yoghurt samples as the storage period progressed. While, diacetyl content increased till the 3rd day of the storage period followed by gradual decrease till the end of storage period (21 days). The decrease in acetaldehyde content during the storage period may be due to the ability of some lactic acid bacterial strains to reduce acetaldehyde to ethanol or oxidize it to acetic acid [25, 26]. While, the decrease in diacetyl mostly be due to slow reduction of diacetyl to acetone as reported by Diressen and Puhan [27] and Roushdy *et al*. [25].

Total Phenolic Content and Antioxidant Activity Evaluation: From the data presented in Table 3, it could be noticed that the pomegranate peel powder (PPP) and mango peel powder (MPP) are a good source of total phenolic and had a great free radical scavenging activity. These results are in agreement with those obtained by Ashoush and Gadallah [5] and Ashoush *et al*. [6].

Table 4: Total phenolic content and antioxidant activity of yoghurt samples supplemented with mango and pomegranate peels powder with or without whey powder along the storage at 4°C for 21 days

	Storage period (days)				
Treatment	Fresh	3	7	14	21
Total phenolic (mg GAE/g)					
SMP	ND	ND	ND	ND	ND
WP	ND	ND	ND	ND	ND
PPP	16.6±0.5^{a}	16.3±0.19^{a}	15.5±0.3^{a}	11.19±0.5^{a}	10.78±0.02^{a}
MPP	13.0±0.2^{b}	12.6±0.11^{b}	12.5±0.1^{b}	8.77±0.05^{b}	7.68±0.05^{b}
WP+PPP	9.11±0.1^{c}	8.82±0.12^{c}	8.67±0.09^{c}	6.93±0.11^{c}	5.84±0.11^{c}
WP+MPP	6.83±0.5^{d}	6.57±0.4^{d}	6.48±0.34^{d}	4.65±0.52^{d}	3.56±0.52^{d}
Scavenging activity%					
SMP	26.15±0.09^{f}	24.2±0.1^{e}	22.3±0.1^{f}	12.6±0.09^{f}	10.7±0.09^{f}
WP	72.2±0.8^{e}	69.3±0.09^{d}	66.4±0.1^{e}	47.1±0.09^{e}	42.3±0.09^{e}
PPP	90.7±0.19^{b}	87.8±0.19^{a}	83.9±0.2^{b}	77.2±1.16^{b}	75.3±0.2^{b}
MPP	85.26±0.56^{d}	81.1±0.09^{c}	79.2±0.1^{d}	72.2±0.09^{d}	70.5±0.1^{d}
WP+PPP	91.60±0.09^{a}	88.4±1.03^{a}	85.8±0.1^{a}	80.2±0.26^{a}	79.1±0.1^{a}
WP+MPP	86.87±0.19^{c}	85.9±0.19^{b}	80.3±0.19^{c}	76.3±0.19^{c}	74.3±0.2^{c}

Data are expressed as means±SD (n = 3). Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($P \leq 0.05$), ND: Not detected

Where:

SMP: yoghurt supplemented with 2% skim milk powder
MPP: yoghurt supplemented with 2% mango peel powder
WP: yoghurt supplemented with 2% whey powder
WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder
PPP: yoghurt supplemented with 2% pomegranate peel powder
WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

Total phenolic content (TPC) of PPP and MPP fortified products increased comparing with other treatments (Table 4). TPC generally dropped during storage specially decreased remarkably after 14 days of storage. Similar trend was found in the same table with antioxidant activity. From the previous data, it can be concluded that the level of phenolic content of mango and pomegranate peels are so high. In addition, by their free radical scavenging capacities, they can lead to a high antioxidant activity. As a consequence, we can consider mango and pomegranate peels, which are the agro-industrial waste of this fruits as a functional food ingredient because of their antioxidant properties.

Survival of Lactic Acid Bacteria: Survivability of *Str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* (log cfu/ml) in yoghurt supplemented with mango and pomegranate peels with or without whey powder during the storage at 4°C for 21 days are shown in Fig 1 and 2. The results indicated that, supplementation the yoghurt with 2% PPP or MPP led to significant decrease in the counts of *Str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* in resultant yoghurt compared with yoghurt supplemented with 2% WP and SMP. This decrease could be due to the higher lactose content in whey and skim milk powders compared with mango and pomegranate peels powder. The lactose content plays an important role in stimulation and growth the lactic acid bacteria in the yoghurt. Also, pomegranate and mango peels contain some anti-nutrients such as tannin and phytate [28, 29]. That may be decrease the growth and\ or activity of lactic acid bacterial strains in supplemented yoghurt. Addition of 1% WP with 1% PPP or MPP to milk yoghurt improved the survivability of two lactic acid bacteria in yoghurt product during the storage period compared with addition 2% PPP or MPP. So, it can be stated that, addition of whey powder with mango or pomegranate peels to yoghurt milk may be reduce the negative effect of PPP and MPP addition on the survival of the lactic acid bacteria in yoghurt product during the cold storage. *Str. thermophilus* and *Lb. delbrueckii* ssp. *bulgaricus* counts slightly decreased during the first week of storage and then gradually decreased till the end of the storage period. The gradual decrease in lactic acid bacterial counts was due to the sensitivity of these bacteria to acid developed along the storage period. The results are in harmony with those obtained by Ibrahim *et al*. [30], Oliveira *et al*. [31], Paseephol and Sherkat [32] and El-Batawy [24].

Safety of Using Pomegranate or Mango Peel on Human Tissues: The MTT is well established method used to assess mitochondrial competence [8]. Both of the pomegranate and mango peels gave moderate activity on

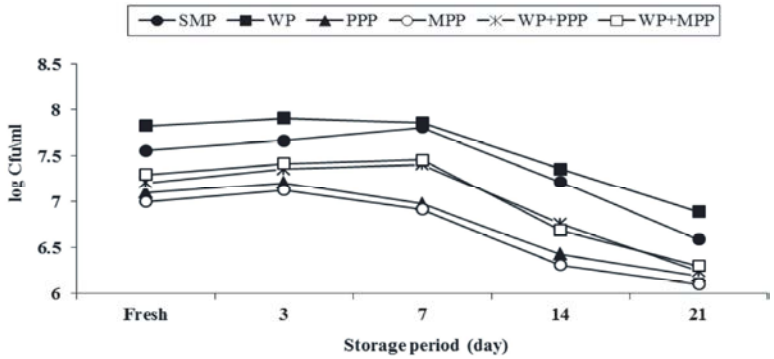

Fig. 1: *Str. thermophilus* counts (log cfu/ml) of yoghurt samples supplemented with mango and pomegranate peels powder with or without whey powder along the storage at 4°C for 21 days.

Where:

SMP: yoghurt supplemented with 2% skim milk powder

WP: yoghurt supplemented with 2% whey powder

PPP: yoghurt supplemented with 2% pomegranate peel powder

MPP: yoghurt supplemented with 2% mango peel powder

WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder

WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

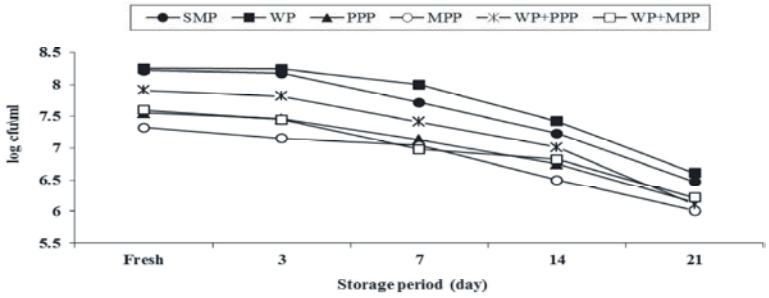

Fig. 2: *Lb. delbrueckii ssp. bulgaricus* counts (log cfu/ml) of yoghurt samples supplemented with mango and pomegranate peels powder with or without whey powder along the storage at 4°C for 21 days.

HePG2 cell line (liver), HCT116 cell line (colon) and MCF7 (breast) as shown in Table 5. Some articles have an effect is weak, but the continuity of use increases the positive impact. While whey powder extract had no activity on HCT116 cell line (11.1%) or on liver cell line as shown in Table 5. The results showed that the positive impact of pomegranate and mango peels has shifted in without effect or becomes detrimental effect on colon cell lines after interaction between protein and them. This result may be due to the strong interaction between some active groups of mango peel or pomegranate phenolic components and milk protein as described by Hassan *et al*. [33], Ng *et al*. [34] and Ge *et al*. [35]. Chitpan [36] suggesting that the hydrogen bonding may occur between the phenolic carboxyl groups in phenolic compounds and the functional groups (i.e. amide groups) of the milk protein.

Organoleptic Properties: Table 6 revealed that, there were significant differences in flavour scores between the all treatment samples. The scores for flavour of yoghurt samples supplemented with 2% WP or SMP were higher than that of samples supplemented with 2% PPP or MPP. So, it can be deduced that, Supplementation milk yoghurt with PPP or MPP reduced the flavor score of yoghurt product compared to supplementation with SKM and WP. This may be due to the flavor compounds in both PPP and MPP which affected on the flavor of supplemented yoghurt. Flavor consists both of the perception in mouth (sweetness, acidity or bitterness) and on the odor, produced by several volatile compounds. Mango peels contain many flavor compound such as tannin and phytate [28], while, pomegranate peels are rich in hydrolyzable tannins, mainly punicalin, pedunculagin and punicalagin [29]. In addition, pomegranate peel contains

Table 5: Safety of using pomegranate or mango peel aqueous extract (100-0.78mg/ml) on human tissues using cytotoxic activity test measuring MTT

	Tissues					
	Cytotoxicity (%) at 100 µg/ml (PPP)	Cytotoxicity (%) at 100 µg/ml (MPP)	Cytotoxicity (%) at 100 µg/ml (WP)	Cytotoxicity (%) at 100 µg/ml (SMP)	Cytotoxicity (%) at 100 µg/ml (WP + PPP)	Cytotoxicity (%) at 100 µg/ml (WP + MPP)
Colon	35.4	31.4	0	5	0	0
Liver	33.2	26.1	1	7	0	0
Breast	51.2	29.8	2	10	0	0

Where:

PPP: Pomegranate peel powder
MPP: Mango peel powder
WP: Yoghurt supplemented with 2% whey powder
SMP: yoghurt supplemented with 2% skim milk powder
WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder
WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

Table 6: Sensory quality of yoghurt samples supplemented with mango & pomegranate peels powder with or without whey powder along the storage at 4°C for 21 days

	Storage period (days)				
Treatment	Fresh	3	7	14	21
Flavor (60)					
SMP	57±0.9^{a}	57±0.2^{a}	56±0.1^{a}	50±1.76^{a}	43.3±1.70^{a}
WP	57.7±0.5^{a}	57±0.2^{a}	56±1.5^{a}	51±1.98^{a}	45±1.21^{a}
PPP	52.7±0.2^{c}	50±1.2^{c}	45±0.1^{e}	40±2.09^{d}	39±1.33^{b}
MPP	51±0.9^{d}	48±1.5^{d}	42±1.9^{d}	38±0.87^{e}	36±1.68^{c}
WP+PPP	55±1.5^{b}	54±1.7^{b}	51±0.9^{b}	45±1.28^{b}	40±1.19^{b}
WP+MPP	54±1.8^{bc}	53±0.8^{b}	50±1.2^{b}	43±1.44^{c}	38±1.54^{b}
Body & texture (30)					
SMP	28±0.80^{ab}	28±0.48^{b}	27±0.22^{a}	25±0.53^{b}	23±0.42^{b}
WP	29±0.58^{a}	29±0.52^{a}	27±0.24^{a}	26±0.32^{a}	24±0.67^{a}
PPP	27±0.62^{b}	27±0.76^{c}	26±0.33^{ab}	24±0.48^{c}	22±0.63^{c}
MPP	27±0.67^{b}	27±0.63^{c}	25±0.34^{b}	23±0.70^{d}	21±0.63^{d}
WP+PPP	27±0.90^{b}	27±0.89^{c}	26±0.48^{ab}	24±0.79^{c}	21±0.70^{d}
WP+MPP	27±0.58^{b}	26±0.63^{d}	25±0.89^{b}	24±0.52^{c}	21±0.48^{d}
Appearance (10)					
SMP	9±0.97^{a}	8±0.57^{b}	8±0.52^{a}	7±0.47^{a}	6±0.67^{a}
WP	9±0.97^{a}	9±0.84^{a}	8±0.67^{a}	7±0.85^{a}	6±0.53^{a}
PPP	7±0.71^{c}	7±0.48^{c}	7±0.32^{b}	5±0.32^{c}	4±0.47^{c}
MPP	7±0.79^{c}	7±0.57^{c}	6±0.63^{c}	5±0.82^{c}	4±0.63^{c}
WP+PPP	8±0.67^{b}	8±0.63^{b}	7±0.48^{b}	6±0.99^{b}	5±0.48^{b}
WP+MPP	8±0.53^{b}	8±0.52^{b}	8±0.57^{a}	6±0.53^{b}	5±0.32^{b}
Total scores (100)					
SMP	94.3±0.47^{b}	93±0.47^{b}	90±0.52^{a}	82±0.70^{b}	73±0.67^{b}
WP	96±0.47^{a}	96±0.70^{a}	91±0.79^{a}	84±0.67^{a}	75±0.67^{a}
PPP	87±0.52^{d}	84±0.57^{e}	78±0.52^{c}	69±0.63^{e}	65±0.52^{cd}
MPP	84±0.67^{e}	82±0.53^{f}	73±0.74^{d}	66±0.48^{f}	61±0.57^{e}
WP+PPP	90±0.52^{c}	89±0.52^{c}	85±0.52^{b}	75±0.74^{c}	66±0.52^{c}
WP+MPP	89±0.42^{c}	87±0.48^{d}	84.3±0.74^{b}	73±0.67^{d}	64±0.32^{d}

Data are expressed as means±SD (n = 10). Mean values in the same column within each parameter bearing the same superscript do not differ significantly ($P \leq 0.05$).

Where:

SMP: yoghurt supplemented with 2% skim milk powder
WP: yoghurt supplemented with 2% whey powder
PPP: yoghurt supplemented with 2% pomegranate peel powder
MPP: yoghurt supplemented with 2% mango peel powder
WP+PPP: yoghurt supplemented with 1% whey powder + 1% pomegranate peel powder
WP+MPP: yoghurt supplemented with 1% whey powder + 1% mango peel powder

hydroxybenzoic acids such as gallagic, ergot alkaloid (EA) and EA glycosides [37], anthocyanidins are principally cyanidin, pelargonidin and delphinidin [38] and flavonoids such as kaempferol, luteolin and quercetin [39]. These compounds may be an important role in the flavor of yoghurt supplemented with PPP and MPP. There no significant differences in body & texture score along all treatment. This may be due to the fiber content in PPP and MPP which redress the decrease in protein content in samples with PPP and MPP. Addition of PPP or MPP had significant decrease in yoghurt appearance score compared with addition of SMP or WP.

It can be observed that, yoghurt samples supplemented with WP+PPP and WP+MPP recorded higher flavor, appearance and overall scores than that of samples supplemented with PPP and MPP respectively. So, addition of 1% WP in supplemented milk yoghurt with 1% PPP or MPP lead to significant increase in flavor score and enhance a sensory quality of yoghurt product compared with yoghurt samples supplemented with 2% PPP or MPP. So, the mixture of mango or pomegranate peels powder and whey powder could be used as natural antioxidants to enhance the antioxidant properties of functional yoghurt with acceptable sensory quality. In general, sensory quality for all yoghurts were slightly decreased during the first 7 days of storage period and then gradually decreased till the end of the storage period. This decrease may be due to the acidity development or the production of other microbial exerted metabolism which affect on sensory properties [24].

CONCLUSION

It could be concluded that, use of mango and pomegranate peels powder as good source of fibers and antioxidant in yoghurt manufacture led to enhance the nutritional and functional values of this product, but use of these ingredients may be decrease the sensory quality of the final product. Therefore the usage of whey powder with MPP or PPP may be reduced the effect of MPP or PPP on the sensory quality of final product. So, mango or pomegranate peels powder should be incorporated with whey powder when used as ingredients in functional yoghurt.

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