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EVALUATION OF PHYSICO-CHEMICAL PROPERTIES AND ANTIOXIDANT ACTIVITY OF STIRRED YOGHURT FORTIFIED WITH POMEGRANATE AND CACTUS PEAR JUICES

Amany M. Hallim[1*], A. Rabie[1], Madiha A. El-Shewey[2] and Azza S. Abdel-Ghany[2]

1. Food Sci. Dept., Fac. Agric., Zagazig Univ., Egypt
2. Food Sci. Dept.(Rural Home Economics), Fac. Agric., Zagazig Univ., Egypt

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ABSTRACT: This study was carried out to estimate the effect of adding pomegranate (*Punica granatum* L) and cactus pear (*Opuntia ficus indica*) juices as natural ingredients on physico-chemical characteristics, antioxidant activity, microbiological examination and sensory evaluation of stirred yoghurt. Stirred yoghurt was prepared by using cow' s milk 3% fat, and pomegranate and cactus pear juices were added at the rate of 5%, 10% and 15% *W/W*. All treatments were inoculated with 2% of yoghurt starter and stored at 5°C up to the end of storage period (15 days) after complete a sulation. Physico-chemical properties of yoghurt samples such as total solids, protein, fat, pH, syneresis, viscosity was carried out .Also, microbiological examination and sensory evaluation were determined of all the treatments when fresh ,and then after 5, 10 and 15 days of cold storage at 5°C. The results showed that significant differences were found between the control and stirred yoghurt fortified with juices in the total solids, protein content, pH and titratable acidity up to the end of storage period(15 days). Addition of pomegranate and cactus pear juices led to significant increase in phenolic compounds and antioxidant activity of yoghurt treatments compared with the control sample. In all samples, it was observed that the titratable acidity increased over the storage period. Low values for viscosity and high values for syneresis were belonged to yoghurt containing 15% pomegranate and cactus pear juices. Sensory evaluation results showed that there were significant differences among the yoghurt samples. Stirred yoghurt (control) and stirred yoghurt containing 5% cactus pear or pomegranate juices gained significantly highest flavour and texture scores compared to stirred yoghurt treated with 10% or 15% juices. The results of current study demonstrated that the addition of juices from pomegranate and cactus pear to stirred yoghurt milk, significantly improved the quality of yoghurt and will increase its healthy benefits.

Key words: Fruit yoghurt, antioxidant activity, phenolic compounds, sensory evaluation.

INTRODUCTION

Yoghurt is a dairy product obtained from the lactic acid fermentation of milk. It is one of the most popular fermented milk products in the world. Yoghurt is a good source of essential nutrients like polyunsaturated fatty acid, protein and minerals espially calcium and phosphorous which maintain the physiological process in human body **(Sanchez *et al*., 2000)**. Yoghurt is the healthy dairy product because of its easily digestible due to its low amount of lactose compared to liquid milk. Yoghurt is also very effective in curing diarrhea, dysentery, constipation, lowing blood cholesterol and carcinogenesis **(Kamruzzaman *et al*., 2002).** The popularity of yoghurt as a food component has been linked to its sensory characteristics **(Routray and Mishra, 2011)**. The key to the increase in sales of yoghurt is a continuous evaluation and modification of the product to match consumer expectations **(Teshome *et al*., 2017)**.

***Corresponding author: Tel. :** +201212632101
E-mail address:amany01212632101@gimal.com

FAO and WHO recommend 5-15% of fruit concentration to use in making yoghurt (**Farahat and El-Batawy, 2013**). There is an increasing demand for fruit yoghurts. Therefore, addition of fruit juices, fruit flavours, fruit purees, and flavour extracts enhances versatility of taste, colour, and texture (**Teshome *et al.*, 2017)**. Fruit-supplemented yoghurt constituted a good source of Ca, Mg, Zn, P and K. The nutritional, variousness, organoleptic characteristic and fiber content of yoghurt were increased by addition of fruits **(Ayar *et al.*, 2006)**.

Pomegranate (*Punica granatum*) is known to have considerable health promoting properties with antimicrobial, antiviral, anticancer, antioxidant and antimutagenic effects **(Negi *et al*., 2003)**. The fresh juice contains 85.4% water and considerable amounts of total soluble solids, total sugars and reducing sugars. It is a rich source of antioxidants including anthocyanins, polyphenols,ascorbic acid, vitamin E, coenzyme Q-10 and alpha-lipoic acid (**Aviram *et al*., 2002**). The antioxidants level in pomegranate juice was found to be higher than in green tea and red wine **(Gil *et al*., 2000)**. Pomegranate juice was used as a healthful beverage, since it is a natural rich source of polyphenols, flavonoid and other antioxidant. It could be considered as functional ingredients for its anti-radical activities. It is good supplement for food **(Basu and Penugonda, 2009)**. Pharmacological properties of the juice were anti-inflammatory **(Adams *et al*., 2006)**, anticancer **(Adams *et al*., 2010; El-Din *et al.*, 2014)**.

Cactus pear (*Opuntia ficus indica*), a member of the cactaceae family, is cultivated worldwide. There are green fruits and also coloured fruits (red, yellow or purple) due to the presence of various pigments such as betalains and carotenes **(Tesoriere *et al*., 2005)**. Cactus pear fruit is rich in pectin, mucilage and minerals. Also, it is a good source of vitamins and amino acids. The pulp of cactus pear could be processed into many different products such as marmalades, jellies, natural sweeteners, wines and other alcoholic beverages, candies, canned, frozen fruit **(Moßhammer *et al*., 2006; Matter *et al*., 2016)**. Therefore, the aim of this study was to utilize pomegranate and cactus pear juices as natural ingredients to improve the acceptability, antioxidant activity and nutritional value of fruit flavoured yoghurts.

MATERIALS AND METHODS

Fresh cow's milk (3% fat) was obtained from Dairy Unit, Faculty of Agriculture, Zagazig University, Egypt. Fresh mature pomegranate and cactus pear fruits were purchased from local market at Zagazig. *Streptococcus salivavarius subsp thermophiles* (EMCC1044- DSM20479) and *Lactobacillus delbrueckiip subs bulgaricus* (EMCC1102-DSM 20080) were used as a yoghurt starter which was obtained from Egyptian Microbial Culture Collection MIRCEN (EMCC), Faculty of Agriculture, Ain Shams, University, Egypt. All chemicals used in this study were purchased from El-Gamhouria Co. for Chemicals and Medical Requisites.

Preparation of Fruit Juices

Fresh mature pomegranate and cactus pear fruits were washed and peeled then cut by knife aseptically. Arils were manually separated from the peals and piths. The fruit juice was extracted using an electric juicer and homogenizer (POLYTRON, Switzerland). Juices were filtered by clean cheese cloth and kept in the refrigerator (5°C) in the sterilized glass bottle until use.

Preparation of Yoghurt

Fresh cow's milk (3% fat) was heated at 90˚C for 15min, then cooled to 40±3ºC then divided to 7 equal portions. Pomegranate and cactus pear juices were heated at 72ºC for 15 sec. then cooled to 40±3˚C. Three portions were serve as control. Whereas, the other 6 portions were stirred with pasteurized pomegranate and cactus pear juices at the rate of 5, 10 and 15%. Juices were added immediately after incubation with 2% starter culture to avoid the quick reducing of pH and transferred all stirred yoghurt samples into plastic containers, lightly sealed and incubated at 42˚ C±1°C until complete curd formation. On the second day, the obtained yoghurt was mixed for 1 min using a sterile stainless steel blender to obtain the stirred yoghurt. The resultant stirred yoghurt samples were stored at 5˚C and analyzed after 1, 5, 10 and 15(days) of storage periods. Physico-chemical, microbiological examination and sensory were determined. Results were also statistically analysed. This experiment was carried out in tripalicates.

Chemical Analysis

All materials and yoghurt samples were chemically analyzed for total solids, protein, fat and titratable acidity according to **AOAC (2000).** The pH of yoghurt samples was determined by using pocket pH meter (IQ Scientific USA, Model IQ 125) at 4ºC.

Rheological Properties

Viscosity of yoghurt samples was measured according to **Aryana (2003)** using rotational viscometer type Lab. Line model 5437. The results were expressed as cps. Crud syneresis of yoghurt samples was determined using draining methods as described by **Farouq and Haque (1992)** as the amount of spontaneous whey (ml / 100g) drained off after 2 hr., at room temperature.

Colour measurement was conducted for all yoghurt samples (L*, a* and b*) by using Hunter lab colour analyzer (HunterlabColour Flex EZ, USA).

Microbiological Analyses

All yoghurt samples were enumerated for total bacterial count according to **American Public Health Association (1992a)** by using tryptone glucose extract agar medium. The plates were incubated at 37ºC for 2 to 3 days. The MRS agar with pH 6.2±0.1 was used for enumeration of *Lactobacillius delbrueckii* subsp *bulgaricus* according to **Dave and Shah (1996)**. The plates were incubated at 45ºC for 72 hr., *thermophilus* was enumerated on M17 agar after aerobic incubation at 37ºC for 48 hr., **(Terzaghi and Sandine, 1975)**.Moulds and yeasts were enumerated on acidified potato dextrose agar medium according to **Difco (1984).** The plates were incubated at 25ºC for 4-5 days.Total coliforms count was estimated by plating suitable dilution on violet red bile agar medium (VRBA) according to **American Public Health Association (1992b).** The plates were incubated at 35ºC for 24 hr. The small non mucous red colonies were counted.

Determination of Total Phenolic Content

The concentration of total phenols was measured by a UV spectrophotometer (Jenway-UV–VIS Spectrophotometer), based on a colorimetric oxidation/reduction reaction, as described by **Skerget *et al*. (2005).** The used oxidizing reagent was Folin-Ciocalteu reagent **(AOAC, 2007)**.

Radical Scavenging Activity (Scavenging DPPH)

The electron donation ability of the obtained extracts was measured by bleaching of the purple coloured solution of the 2, 2-diphenyl-1-picrylhydrazyl radical (DPPH) according to the method of **Hanato *et al*. (1988)** and modified by **Gulcin *et al*. (2004)**.

Sensory Evaluation

The sensory evaluation of yoghurt samples included flavour 45 points, body and texture 30 points, appearance 15 points, acidity10 points and overall acceptability 100 points. Yoghurt samples were evaluated by 10 panelists from the staff members of Food Science Department, Faculty of Agriculture, Zagazig University according to **Kasimoğlu *et al*. (2004)**.

Statistical Analysis

All data were statistically analysed using Statistix8.1 Package Program **(Statistix, 2009)**. The data were expressed as mean ± SD. Statistical differences among all treatments and storage periods were analyzed by least significant difference (LSD).

RESULTS AND DISCUSSION

Chemical Composition of Raw Materials

The chemical composition of cow milk, pomegranate and cactus pear juices are presented in Table 1. It was observed that the total solids, protein, fat, and ash contents of the cow milk were 10.98, 3.23, 3.01 and 0.71%, respectively. Also, the results showed that the cactus pear juice had high amounts of total solids, fat and ash and but decrease in protein compared to pomegranate juice. These results are in agreement with the results obtained by **Ali (2016)** and **Roghelia and Panchal (2016)**.

Table 1. Chemical composition of cow milk, pomegranate and cactus pear juices

Chemical composition	Cow milk	Pomegranate juice	Cactus pear juice
Total solids (%)	10.98±1.30	14.06±0.06	15.63±0.07
Total protein (%)	3.23±0.16	1.34±0.04	1.23±0.03
Fat (%)	3.01±0.06	0.49±0.13	0.73±0.10
Ash (%)	0.71±0.18	0.07±0.03	0.43±0.03

Total Phenolic Compounds and Radical Scavenging Activity of Fruit Juices

Table 2 revels that, the total phenolic compounds of ethanolic pomegranate and cactus pear juices extracts were 255.68±86.62 and 391.66 ± 132.17 mg/100g, respectively. While the radical scavenging activity (%) of ethanolic pomegranate and cactus pear juices extracts were 84.82±1.40 and 85.84±1.35%, respectively. The total phenolic compounds of ethanolic cactus pear juice extract was higher than that determined in the study of **Matter *et al*. (2016)** (45.00 mg/100g). This may be due to the different category used in the other study. The results of total phenolics for pomegranate juice in the present study was lower than that mentioned by **Mabrouk *et al*. (2019).** These variations may be affected by many factors as cultivar source, growing and climatic conditions as well as extraction methods.

Chemical Composition of Different Types of Yoghurt

The results of total solids, proteins and fat contents of yoghurt samples are shown in Table (3). The results indicated that the yoghurt samples containing cactus pear juices had significantly ($P \leq 0.05$) higher value of total solids than other treatments. This may be refer to the higher total solids of cactus pear juices. The addition of fruit juices caused a decrease in protein and fat contents of fruit yoghurt compared with control. These results are in agreement with the results obtained by **Teshome *et al.* (2017)** who found that addition of mango and papaya juices with different proportions to yoghurt decreased protein and fat contents compared to the control yoghurt. During storage, the total solids and protein contents of the control and fruit yoghurt samples were significantly increased with advanced storage periods. The fat content of different types of yoghurt increased with progressing storage periods. This increment was significant ($P \leq 0.05$) at the end of storage period for(15 days) all yoghurt treatments. This may be refer to the evaporation of some moisture during cold storage period. The obtained results are in accordance with **Barakat and Hassan (2017)**.

Total Phenolic Content and Radical Scavenging Activity of Different Yoghurt

Total phenolic contents and antioxidant activity of yoghurt samples are presented in Table 4. There were significant differences in the total phenolic contents and antioxidant activity of the samples ($P < 0.05$). Addition of pomegranate and cactus pear juices led to significant increase in phenolic compounds and antioxidant activity of yoghurt treatments compared with the control sample. The highest values of total phenolic contents and antioxidant activity were (287.37 ± 18.15 mg/100g and 54.68 ±6.13%), respectively for yoghurt fortified with 15% cactus pear. These may be due to the high concentrations of phenolic and other antioxidant compounds in cactus pear. **Matter *et al*. (2016)** found that addition of cactus pear pulp to yoghurt increased the total phenolic compounds and radical scavenging activity of fortified yoghurt.

During storage, the total phenolic contents and antioxidant activity of the control and fruit yoghurt samples were significantly decreased with advanced storage periods. The obtained results are in line with **El-Din *et al*. (2014),**who found that addition of pomegranate juice to yoghurt increased the total phenolic compounds and radical scavenging activity of fortified yoghurt.

Table 2. Total phenolic compounds and radical scavenging activity of pomegranate and cactus pear juices

Item	Pomegranate juice	Cactus pear juice
Total phenolic compounds (mg/100g)	255.68±86.62	391.66±132.17
Radical scavenging activity (%)	84.82±1.40	85.84±1.35

Table 3. Chemical composition of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Component	Storage periods (day)	C	T1	T2	T3	T4	T5	T6	LSD
	Fresh	$12.92\pm0.02^{G,d}$	$13.24\pm0.02^{F,d}$	$13.31\pm0.02^{E,d}$	$13.62\pm0.02^{D.d}$	$13.74\pm0.02^{C,d}$	$13.92\pm0.02^{B,d}$	$14.64\pm0.04^{A,d}$	0.04
Total solids	**5**	$13.72\pm0.02^{F,c}$	$13.90\pm0.03^{E,c}$	$14.12\pm0.02^{D,c}$	$14.33\pm0.03^{C,c}$	$14.32\pm0.02^{C,c}$	$14.72\pm0.02^{B,c}$	$15.42\pm0.03^{A,c}$	0.043
(%)	**10**	$14.55\pm0.06^{E,b}$	$14.67\pm0.07^{E,b}$	$14.93\pm0.07^{D,b}$	$15.12\pm0.12^{C,b}$	$15.05\pm0.09^{CD,b}$	$15.32\pm0.04^{B,b}$	$16.15\pm0.04^{A,b}$	0.14
	15	$15.24\pm0.06^{D,a}$	$15.32\pm0.09^{D,a}$	$15.60\pm0.08^{C,a}$	$15.95\pm0.14^{B,a}$	$15.73\pm0.07^{C,a}$	$16.05\pm0.07^{B,a}$	$16.90\pm0.21^{A,a}$	0.20
	LSD	0.08	0.10	0.10	0.17	0.11	0.08	0.20	
	Fresh	$3.74\pm0.02^{A.d}$	$3.63\pm0.03^{B,d}$	$3.55\pm0.03^{C,d}$	$3.42\pm0.02^{D,d}$	$3.54\pm0.02^{C,d}$	$3.36\pm0.02^{E,d}$	$3.22\pm0.02^{F,c}$	0.04
Protein	**5**	$4.22\pm0.02^{A.c}$	$4.03\pm0.03^{B,c}$	$3.97\pm0.02^{C,c}$	$3.82\pm0.02^{D,c}$	$3.93\pm0.03^{C,c}$	$3.76\pm0.02^{E,c}$	$3.63\pm0.03^{F,bc}$	0.04
(%)	**10**	$5.04\pm0.09^{A,b}$	$4.70\pm0.05^{AB,b}$	$4.54\pm0.05^{AB,b}$	$4.41\pm0.05^{AB,b}$	$3.57\pm1.13^{C,b}$	$4.43\pm0.04^{AB,b}$	$4.00\pm0.57^{BC,b}$	0.84
	15	$5.36\pm0.06^{A.a}$	$4.96\pm0.09^{B,a}$	$4.86\pm0.08^{BC,a}$	$4.76\pm0.06^{CD,a}$	$4.58\pm0.08^{E,a}$	$4.85\pm0.07^{BCD,a}$	$4.72\pm0.08^{D,a}$	0.13
	LSD	0.11	0.10	0.09	0.08	0.12	0.08	0.53	
	Fresh	$3.13\pm0.15^{A,b}$	$2.73\pm0.15^{B.b}$	$2.50\pm0.10^{CD,b}$	$2.40\pm0.10^{CD,b}$	$2.60\pm0.10^{BC,b}$	$2.40\pm0.10^{CD,b}$	$2.30\pm0.10^{D,b}$	0.21
Fat	**5**	$3.23\pm0.15^{A,ab}$	$2.90\pm0.10^{B,ab}$	$2.60\pm0.10^{CD,b}$	$2.50\pm0.10^{DE,b}$	$2.70\pm0.10^{C,b}$	$2.50\pm0.10^{DE,b}$	$2.40\pm0.10^{E,b}$	0.19
(%)	**10**	$3.23\pm0.15^{A,ab}$	$2.90\pm0.10^{B,ab}$	$2.60\pm0.10^{CD,b}$	$2.50\pm0.10^{DE,b}$	$2.70\pm0.10^{C,b}$	$2.50\pm0.10^{DE,b}$	$2.40\pm0.10^{E,b}$	0.19
	15	$3.43\pm0.15^{A,a}$	$3.10\pm0.10^{B,a}$	$2.80\pm0.10^{CD,a}$	$2.70\pm0.10^{DE,a}$	$2.90\pm0.10^{C,a}$	$2.70\pm0.10^{DE,a}$	$2.60\pm0.10^{E,a}$	0.19
	LSD	0.29	0.22	0.19	0.19	0.19	0.19	0.19	

C: Control stirred yoghurt (3% fat). T1: stirred yoghurt (3 % fat) with 5% pomegranate juice
T2: stirred yoghurt (3% fat) with 10% pomegranate juice T3: stirred yoghurt (3 % fat) with 15% pomegranate juice
T4: stirred yoghurt (3% fat) with 5% cactus pear juice T5: stirred yoghurt (3 % fat) with 10% cactus pear juice
T6: stirred yoghurt (3% fat) with 15%cactus pear juice LSD: Least significant differences ($P \leq 0.05$)
Means followed by different capital letters in the same row are significantly different ($P \leq 0.05$).
Means followed by different small letters in the same column are significantly different ($P \leq 0.05$)

Table 4. Total phenolic compounds and radical scavenging activity of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Component	Storage periods (day)	C	T1	T2	T3	T4	T5	T6	LSD
Total phenolic compounds (mg/100 g)	Fresh	65.42±4.49^{E,a}	103.6±3.21^{D,a}	114.13±6.00^{D,a}	148.64±9.45^{C,a}	238.45±11.79^{B,a}	220.77±10.69^{B,a}	287.37±18.15^{A,a,}a	18.03
	5	34.27±4.68^{F,b}	92.68±5.53^{E,a}	98.49±10.95^{DE,b}	112.10±3.00$^{D.b}$	182.55±7.49^{C,b}	197.42±8.78^{B,b}	213.97±12.65^{A,b}	14.14
	10	20.65±5.53^{E,c}	51.03±0.29^{D,b}	57.30±1.05^{CD,c}	72.85±15.68^{C,c}	108.47±16.00^{B,c}	124.14±1.12^{B,c}	152.31±11.99^{A,c}	17.24
	15	11.30±2.70^{E,d}	46.60±9.37^{D,b}	50.55±8.03^{D,c}	65.13±6.10^{C,c}	98.23±2.17^{B,c}	104.93±4.29^{B,d}	124.92±13.37^{A,d}	13.12
LSD		8.41	10.68	14.00	18.38	20.19	13.67	26.83	
Radical scavenging activity (%)	Fresh	24.47±0.65^{C,a}	9.70±1.80^{D,a}	42.27±4.81^{B,a}	45.63±4.46^{AB,a}	46.15±8.92^{AB,a}	50.20±6.95^{AB,a}	54.68±6.13^{A,a}	9.64
	5	18.47±1.40^{D,b}	32.15±4.38^{C,ab}	36.83±2.65^{BC,ab}	38.37±6.15^{BC,ab}	35.46±5.46^{BC,ab}	44.74±6.04^{AB,ab}	48.31±8.93^{A,ab}	9.64
	10	12.73±3.50^{D,c}	26.77±4.50^{C,b}	32.45±6.66^{BC,bc}	36.08±10.18^{ABC,ab}	30.45±5.49^{BC,b}	38.53±7.05^{AB,b}	43.23±1.06^{A,b}	10.70
	15	10.10±0.69^{D,c}	20.73±3.56^{C,c}	24.93±2.20^{BC,c}	29.17±1.15^{B,b}	24.44±4.51^{BC,b}	35.80±2.31^{A,b}	38.34±3.09^{A,b}	4.89
LSD		3.66	7.00	8.39	12.00	11.90	11.13	10.65	

Means followed by different capital letters in the same row are significantly different ($P \leq 0.05$).

Means followed by different small letters in the same column are significantly different ($P \leq 0.05$).

The pH and Titratable Acidity

Changes in pH value of stirred yoghurt samples as effected by addition of pomegranate and cactus pear juices or by storage period flowed almost opposite to acidity as shown in Table 5. The effect of different fruit juices on pH and titratable acidity values were highly significant. Addition of pomegranate juices decreased the pH of yoghurt compared to the control but addition of cactus pear juice led to increase of the yoghurt pH compared to the control. This may be due to the pH of pomegranate juices (3-3.5) **(Mousavi *et al.*, 2011; Nirmala and Subba, 2011)** and the pH of cactus pear juice (5.3 - 6.2) **(Gurrieri *et al*., 2000; Sáenz and Sepúlveda, 2001)**.

Also, it was noted that the pH values of all yoghurt samples showed significant ($P \leq 0.05$) decrease with advanced storage period until 15 days as a result of post- fermentation of lactose to lactic acid.

Furthermore, the relation between titratable acidity and pH always opposite. As shown in Table 5, titratable acidity increased with increasing pomegranate juice percentage in yoghurt samples, while decreased with increasing cactus pear juice percentage. The result of this study indicated that, 15% pomegranate flavoured yoghurt had the highest titratable acidity, but it had the lowest pH. Similar observation was reported by **Debashis *et al.* (2015)** who reported that, the acidity of yoghurt was increased with increasing of banana, papaya and watermelon percentages.

Titratable acidity contents of yoghurt for all treatments significantly increased during storage period. This could be explained on the basis that fruit juices had higher content of essential nutrients such as simple sugar, minerals and vitamins, which might enhance the growth of yoghurt culture **(Al-Farsi and Lee, 2008)**.

Rheological Properties

Fortification of yoghurt with pomegranate and cactus pear juices significantly decreased viscosity and increased whey syneresis compared with control strried yoghurt samples and this increasing was proportional to the fortification ratio (Table 6). These results might be due to decreasing the water holding capacity of juices or decreasing pH valuse of treatment containing juices. These results are in agreement with those reported by **Hassanein *et al.* (2014)** who stated that fortification of yoghurt with concentrated pomegranate decreased viscosity and increased syneresis of yoghurt treatments.

Also, viscosity values of the control and all the other treatments increased with progressing storage periods. This increment was significant ($P \leq 0.05$) at the end of storage period of all yoghurt treatments. This increment in viscosity through storage periods may be attributed to the development of gel structure and changes in protein-protein bound in a three-dimensional protein net of yoghurt and their rearrangement **(Shahbandari *et al*., 2016).**

Colour Characteristics

Colour characteristics of yoghurt fortified with pomegranate and cactus pear juices are given in Table 7. In general, colour of yoghurt is affected by addition of juices. Lightness values (L^*) of all yoghurt samples fortified with pomegranate and cactus pear juices were significantly lower than the control samples. Inversely, the redness values (a^*) increased with addition fruit juices of yoghurt samples. This increment was not significant ($P \geq 0.05$) for yoghurt samples fortified with pomegranate juice but it was significant ($P \leq 0.05$) of samples fortified with cactus pear juice compared with the control yoghurt. The yellowness values (b^*) of all yoghurt treatments fortified with juices were significantly lower than the control yoghurt. Similar observations were reported by **Cakmakci *et al*. (2014)** for incorporating carrot juice into set-type yoghurt.

Sensory Evaluation

The results of sensory evaluation of the prepared yoghurt samples (Table 8) revealed that, there were no significant differences between the control yoghurt T1, T4 and T5 for body and texture scores. The control yoghurt had the highest scores for body and texture followed by yoghurt fortified with cactus pear juice. Regarding appearance, there were significant differences between the control and the different type of yoghurt except yoghurt sample containing 5% cactus pear juice (T4).

Table 5. pH and titratable acidity values of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Item	Storage periods (day)	C	T1	T2	T3	T4	T5	T6	LSD
pH	Fresh	$4.33\pm0.03^{C,a}$	$4.25\pm0.03^{E,a}$	$4.11\pm0.04^{F,a}$	$4.03\pm0.07^{G,a}$	$5.23\pm0.03^{C,a}$	$5.35\pm0.04^{B,a}$	$5.46\pm0.04^{A,a}$	0.07
	5	$4.18\pm0.02^{C,b}$	$4.14\pm0.02^{C,b}$	$3.65\pm0.31^{D,b}$	$3.71\pm0.03^{D,b}$	$5.06\pm0.02^{B,b}$	$5.25\pm0.02^{AB,b}$	$5.31\pm0.02^{A,b}$	0.21
	10	$4.05\pm0.03^{D,c}$	$4.02\pm0.02^{D,c}$	$3.70\pm0.02^{E,b}$	$3.62\pm0.02^{F,c}$	$4.85\pm0.02^{C,c}$	$4.96\pm0.02^{B,c}$	$5.22\pm0.02^{A,c}$	0.04
	15	$3.95\pm0.02^{E,d}$	$4.02\pm0.02^{D,c}$	$3.61\pm0.02^{F,b}$	$3.50\pm0.02^{G,d}$	$4.72\pm0.02^{C,d}$	$4.84\pm0.02^{B,d}$	$4.92\pm0.02^{A,d}$	0.04
LSD		0.05	0.04	0.30	0.07	0.04	0.04	0.05	0.05
Titratable acidity	Fresh	$0.68\pm0.03^{D,d}$	$0.74\pm0.04^{B,d}$	$0.78\pm0.04^{AB,d}$	$0.83\pm0.03^{A,c}$	$0.61\pm0.03^{D,d}$	$0.57\pm0.04^{D,d}$	$0.50\pm0.03^{E,d}$	0.05
	5	$0.74\pm0.03^{C,c}$	$0.80\pm0.03^{B,c}$	$0.84\pm0.03^{A,c}$	$0.86\pm0.02^{A,c}$	$0.72\pm0.02^{C,c}$	$0.64\pm0.03^{D,c}$	$0.59\pm0.02^{E,c}$	0.04
	10	$0.81\pm0.02^{C,b}$	$0.87\pm0.03^{B,b}$	$0.92\pm0.03^{A,b}$	$0.94\pm0.03^{A,b}$	$0.80\pm0.03^{C,b}$	$0.76\pm0.03^{CD,b}$	$0.74\pm0.03^{D,b}$	0.05
	15	$0.92\pm0.03^{C,a}$	$0.99\pm0.03^{B,a}$	$1.02\pm0.03^{AB,a}$	$1.06\pm0.03^{A,a}$	$0.90\pm0.03^{CD,a}$	$0.88\pm0.02^{CD,a}$	$0.86\pm0.03^{D,a}$	0.05
LSD		0.05	0.05	0.05	0.05	0.05	0.06	0.05	

Means followed by different capital letters in the same row are significantly different ($P \leq 0.05$).
Means followed by different small letters in the same column are significantly different ($P \leq 0.05$).

Table 6. Viscosity and whey syneresis values of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Component	Storage periods (day)	C	T1	T2	T3	T4	T5	T6	LSD
Viscosity (cp)	fresh	$5296.67\pm25.17^{A,b}$	$5106.67\pm30.55^{AB,b}$	$4769.67\pm35.12B^{CD,d}$	$4500.00\pm20.00^{D,c}$	$5003.33\pm35.12^{ABC,c}$	$4700.00\pm30.00^{CD,d}$	$4823.33\pm595.01^{BCD,b}$	396.79
	5	$5800.00\pm30.00^{A,ab}$	$5700.00\pm20.00^{A,a}$	$5200.00\pm20.00^{BC,c}$	$5056.67\pm106.93^{CD,c}$	$5340.00\pm268.51^{B,b}$	$5206.67\pm30.00^{BC,c}$	$5000.00\pm30.00^{D,ab}$	195.31
	10	$6100.00\pm20.00^{A,a}$	$6006.67\pm20.28^{B,a}$	$5500.00\pm20.00^{D,b}$	$5306.67\pm20.82^{E,b}$	$5800.00\pm20.00^{C,a}$	$5506.67\pm20.82^{D,b}$	$5300.00\pm20.00^{E,ab}$	35.64
	15	$5943.33\pm626.44^{A,a}$	$5870.00\pm597.75^{A,a}$	$5700.00\pm20.00^{A,a}$	$5510.00\pm26.46^{A,a}$	$6006.67\pm30.55^{A,a}$	$5706.67\pm20.82^{A,a}$	$5493.33\pm20.82^{A,a}$	574.22
LSD		591.20	564.12	46.44	145.74	257.25	48.92	561.52	
Syneresis (ml / 100g)	fresh	$28.67\pm1.53^{C,a}$	$33.67\pm1.53^{BC,a}$	$35.00\pm2.00^{AB,a}$	$38.00\pm2.00^{A,a}$	$29.67\pm2.52^{C,a}$	$31.67\pm1.53^{BC,a}$	$34.33\pm2.08^{B,a}$	3.35
	5	$23.00\pm2.00^{D,bc}$	$26.67\pm1.15^{BC,b}$	$29.00\pm2.00^{AB,bc}$	$32.00\pm2.00^{A,bc}$	$24.00\pm2.00^{CD,bc}$	$26.00\pm2.00^{BCD,b}$	$29.00\pm2.00^{AB,bc}$	3.33
	10	$20.33\pm1.53^{C,c}$	$23.00\pm2.00^{BC,c}$	$27.00\pm2.00^{A,c}$	$29.00\pm2.00^{A,c}$	$21.00\pm2.00^{C,c}$	$23.00\pm2.00^{BC,b}$	$26.00\pm2.00^{AB,c}$	3.40
	15	$25.00\pm2.00^{C,b}$	$28.00\pm2.00^{BC,b}$	$32.00\pm2.00^{AB,ab}$	$34.00\pm2.00^{A,b}$	$26.00\pm2.00^{C,ab}$	$26.67\pm2.00^{C,b}$	$31.00\pm2.00^{AB,ab}$	4.26
LSD		3.35	3.22	3.77	3.77	4.03	4.95	3.80	

Means followed by different capital letters in the same row are significantly different ($P \leq 0.05$).
Means followed by different small letters in the same column are significantly different ($P \leq 0.05$

Table 7. Colour characteristics of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Treatment	L*	a*	b*
C	87.71±0.02^{A}	-3.36±0.01^{B}	12.84±0.01^{A}
T1	82.93±0.03^{B}	-2.01±0.01^{B}	9.84±0.01^{B}
T2	79.29±0.01^{C}	2.29±0.01^{B}	8.65±0.01^{C}
T3	77.35±0.01^{D}	3.66±0.01^{B}	8.13±0.05^{D}
T4	57.83±0.01^{E}	45.73±15.61^{A}	-11.44±0.01^{E}
T5	49.29±0.01^{F}	47.29±0.01^{A}	-13.87±0.01^{F}
T6	45.05±0.01^{G}	48.48±0.01^{A}	-14.21±0.01^{G}
LSD	0.02	10.33	0.04

L*: lightness, a*: redness, b*: yellowness.

Means with the different small letters in each column are significantly at P≤ 0.05.

Table 8. Sensory evaluation of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Treatment	Storage period (day)	C	T1	T2	T3	T4	T5	T6	LSD
Body and texture (30)	Fresh	29.50±0.50^{A,a}	28.20±1.10^{ABC,a}	26.80±0.84^{CD,a}	26.00±0.71^{D,a}	28.40±0.89^{AB,a}	28.20±1.48^{ABC,a}	27.20±1.92^{BCD,a}	1.50
	5	29.30±0.67^{A,a}	28.30±0.45^{AB,a}	26.70±0.67^{CD,a}	25.50±1.12^{D,a}	27.80±0.91^{BC,a}	27.40±1.95^{BC,a}	27.00±0.71^{BC,ab}	1.34
	10	27.90±0.74^{A,b}	27.00±0.71^{AB,b}	26.40±0.89^{BC,a}	24.80±0.84^{D,ab}	26.70±0.67^{BC,a}	25.80±1.10^{CD,ab}	24.80±1.30^{D,bc}	1.19
	15	26.40±0.65^{C,c}	25.20±0.84^{AB,c}	24.00±0.71^{BC,b}	23.80±1.48^{BC,b}	23.30±2.22^{BC,b}	23.40±2.79^{BC,b}	22.80±2.59^{C,c}	2.36
LSD		0.89	1.08	1.05	1.44	1.78	2.60	2.38	
Appearance (15)	Fresh	14.40±0.89^{A,a}	13.00±0.71^{BC,a}	12.80±0.84^{BCD,a}	11.40±0.55^{E,a}	13.80±0.45^{AB,a}	12.60±1.14^{CD,a}	11.70±1.20^{DE,a}	1.12
	5	14.00±1.00^{A,ab}	12.30±0.45^{BC,ab}	11.30±0.67^{CD,b}	11.00±1.00^{D,a}	12.40±1.14^{B,ab}	12.20±0.84^{BC,ab}	11.40.0.55^{BCD,a}	1.09
	10	13.20±0.84^{A,bc}	12.20±0.45^{AB,ab}	11.00±1.22^{BC,bc}	10.60±1.52^{C,ab}	11.60±1.67^{BC,b}	12.00±0.71^{ABC,ab}	11.20±1.10^{BC,a}	1.49
	15	12.20±0.84^{A,c}	11.60±1.14^{A,b}	10.00±0.71^{BC,c}	9.60±0.55^{C,b}	11.50±1.12^{A,b}	11.20±0.45^{AB,b}	11.00±2.00^{ABC,a}	1.41
LSD		1.20	0.99	1.19	1.32	1.58	1.10	1.77	
Acidity (10)	Fresh	9.40±0.55^{A,a}	9.20±0.45^{AB,a}	9.20±0.84^{AB,a}	8.40±0.82^{B,a}	9.00±0.71^{B,a}	8.30±0.67^{B,a}	8.40±0.89^{B,a}	0.93
	5	8.80±0.84^{A,ab}	8.40±0.96^{AB,ab}	7.50±1.12$^{AB,.b}$	7.20±1.30^{B,ab}	8.00±1.00^{AB,ab}	7.50±1.00^{AB,ab}	7.30±1.10^{B,a}	1.37
	10	8.40±0.89^{A,ab}	8.00±0.71^{A,b}	7.20±0.91$^{AB.b}$	6.30±1.72^{B,bc}	7.80±1.30^{A,ab}	6.20±1.30^{B,b}	5.80±0.84^{B,b}	1.48
	15	8.00±0.71^{A,b}	6.80±0.84^{B,c}	6.40±0.96^{BCD,b}	5.60±0.55^{CD,c}	6.60±1.14^{BC,b}	6.40±1.14^{BCD,b}	5.40±0.89^{D,b}	1.18
LSD		1.01	1.02	1.29	1.59	1.42	1.41	1.25	
Flavour (50)	Fresh	43.90±0.89^{A,a}	43.90±0.74^{A,a}	43.30±0.97^{AB}	44.20±0.57^{A,a}	44.00±0.71^{A,a}	44.10±0.74^{A,a}	42.90±0.55^{B,a}	0.98
	5	43.40±0.96^{A,a}	43.60±0.65^{A,a}	42.60±0.89^{A}	42.80±0.84^{A,ab}	43.80±0.91^{A,b}	43.40±1.39^{A,b}	42.80±1.64^{A,a}	1.41
	10	43.40±1.29^{A,a}	42.70±0.84^{AB,a}	42.60±1.82^{AB}	41.60±0.55^{B,ab}	43.00±0.94^{AB,bc}	42.80±0.84^{AB,ab}	42.00±1.87^{AB,ab}	1.63
	15	41.00±1.22^{A,b}	41.20±1.64^{A,b}	41.00±1.73^{A}	41.40±1.52^{A,b}	41.40±1.67^{A,c}	42.20±1.64^{A,b}	40.60±1.95^{A,b}	2.12
LSD		1.48	1.40	1.90	1.28	1.50	1.62	2.15	
Overall acceptability (100)	Fresh	97.20±2.20^{A,a}	94.30±1.79^{BC,a}	92.10±2.01^{CD,a}	90.00±2.00^{D,a}	95.20±1.92^{AB,a}	93.20±0.84^{BC,a}	90.20±1.92^{D,a}	2.41
	5	95.50±1.50^{A,a}	92.60±1.64^{B,a}	88.10±1.64^{CD,b}	86.50±2.78^{D,b}	92.00±1.84^{D,b}	90.50±1.90^{BC,a}	88.50±2.45^{CD,a}	2.61
	10	92.90±2.01^{A,b}	89.90±1.24^{B,b}	87.20±3.29^{BC,b}	83.30±1.10^{D,c}	89.10±1.56^{BC,b}	86.80±2.17^{C,b}	83.80±2.77^{D,b}	2.79
	15	87.60±1.39^{A,c}	84.80±2.17^{AB,c}	81.40±3.27^{BC,c}	80.40±2.88^{C,c}	82.80±3.56^{BC,c}	83.20±3.11^{BC,c}	79.80±3.35^{C,c}	3.77
LSD		2.42	2.33	3.56	3.09	3.16	2.50	3.59	

Means followed by different capital letters in the same row are significantly different ($P \leq 0.05$).

Means followed by different small letters in the same column are significantly different ($P \leq 0.05$)

Furthermore, there were was significant different between control and the other types of yoghurt for appearance and colour attribute, control yoghurt had the highest values followed by yoghurt fortified with cactus pear juice. Regarding body and texture attribute, addition of pomegranate and cactus pear juices reduced body and texture values of fortified yogurt. Flavor was increased by addition of pomegranate, and cactus pear juices. Regarding over all acceptability, the highest mean value was related to control sample and sample containing 15% cactus pear. Storage period had slightly effect on all traits.

According to this result, cactus pear yogurt has the most acceptability in point view of consumer. These results are in agreement with those reported by **Matter *et al.* (2016)** who found that addition of cactus pear pulp to yoghurt enhanced the sensory evaluations of resultant yoghurt. Also, **Gomah *et al.* (2014)** found that addition of pomegranate juice to yoghurt enhanced the sensory evaluations of resultant yoghurt.

Microbiological Analysis

It is shown from Table 9 that the total bacterial count of yoghurt fortified with pomegranate and cactus pear juices was lower than that in the control samples during all storage periods up to 15 days. The yoghurt samples fortified with 15% pomegranate juice or 15% cactus pear juice had the lowest total bacterial count. Also, the obtained results showed that the yeasts and moulds were not detected till the 10^{th} day of storage periods for control and other stirred yoghurt treatments. The yeast and moulds of all stirred yoghurt samples were detected at the end of storage period. The control stirred yoghurt had the lowest yeast and molds counts compared to other treatments. Meanwhile, the coliform bacteria was not detected in the control and all the other treatments during all storage periods. The general trend of these results is in agreement with those reported by **El-Nagga and Abd El-Tawab (2012) and Matter *et al*. (2016)**.

Table 9. Changes in some bacterial groups (cfu/g) of yoghurt fortified with pomegranate and cactus pear juices during storage at 5°C for 15 days

Bacterial group	Storage period (day)	C	T1	T2	T3	T4	T5	T6
	Fresh	120	42	25	12	30	18	5
Total bacterial count	**5**	82	28	12	7	18	9	3
($\times 10^7$)	**10**	67	14	9	5	12	6	2
	15	41	8	4	3	9	4	1
	Fresh	ND	ND	ND	ND	ND	ND	ND
Yeasts and moulds	**5**	ND	ND	ND	ND	ND	ND	ND
($\times 10^2$)	**10**	ND	ND	ND	ND	ND	ND	ND
	15	2	15	28	42	8	20	33
	Fresh	ND	ND	ND	ND	ND	ND	ND
Coliform bacteria	**5**	ND	ND	ND	ND	ND	ND	ND
($\times 10^2$)	**10**	ND	ND	ND	ND	ND	ND	ND
	15	ND	ND	ND	ND	ND	ND	ND

ND: Not detected

Conclusion

From the current study, it could be concluded that the enrichment of yoghurt by addition of pomegranate and cactus pear juices will enhances the physical, chemical and sensory properties of yoghurt and thus the quality and acceptability of yoghurt. Also, using different fruit additives give more yoghurt choices to the consumers in the market.

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تقييم الخواص الفيزيائية والكيميائية والنشاط المضاد للأكسدة لليوغورت المقلب بكل من عصير الرمان والتين الشوكى

أمانى ماهر حليم[١] - عبد الحميد ربيع[١] - مديحة عبد الجواد الشيوى[٢] - عزة صبيح عبد الغنى[٢]

١- قسم علوم الأغذية - كلية الزراعة - جامعة الزقازيق – مصر

٢- قسم علوم الأغذية (شعبة الاقتصاد المنزلى الريفى) - كلية الزراعة - جامعة الزقازيق – مصر

يهدف هذا البحث إلى دراسة تأثير إضافة كلا من عصير الرمان والتين الشوكي كإضافات طبيعية على الخصائص الفيزيائية والكيميائية والنشاط المضاد للأكسدة، والاختبارات الميكروبية، والخواص الحسية ودرجة القبول العام لليوغورت المقلب. تم تصنيع الزبادي المقلب باستخدام لبن بقرى يحتوى على ٣% دهن وأضيف كل من عصير الرومان وعصير التين الشوكى بنسب ٥% و١٠% و١٥%،كل على حده كما اضيف البادىء بنسبة ٢% لكل المعاملات وأجريت عملية التحضين ثم التخزين على درجة ٥°م -٧°م±١°م بعد تمام عملية التجبن حتى نهاية فترة التخزين (١٥ يوماً)، وتم تقدير الخصائص الفيزيائية والكيميائية لعينات الزبادي المقلب الناتج على فترات مختلفة أثناء التخزين لمدة ١٥ يوماً مثل المواد الصلبة الكلية، البروتين، الدهن، الحموضة، الرقم الهيدروجيني، معدل انفصال الشرش، اللزوجة وأيضا الاختبارات الميكروبيولوجية، وتقييم الخواص الحسية للمعاملات خلال فترة الطزاجة وبعد ٥ و١٠ و١٥ يومًا من التخزين على درجة حرارة الثلاجة (٥°م -٧°م±١°م)، وأوضحت النتائج أن هناك اختلافات كبيرة بين اليوغورت المقلب الكنترول واليوغورت المقلب المحتوى على عصائر الفاكهة في محتوى المواد الصلبة، البروتين، pH، والحموضة الكلية أثناء التخزين، وأظهرت النتائج أن إضافة تلك العصائر إلى اليوغورت المقلب أدى إلى زيادة معنوية في محتوى المركبات الفينولية والنشاط المضاد للأكسدة مقارنة باليوغورت المقلب الكنترول، وزادت الحموضة خلال فترة التخزين بينما حدث انخفاض في رقم pH، وأعطت العينات المحتوية على ١٥% من عصير الرمان والتين الشوكى أدنى قيم للزوجة وأعلى قيم لانفصال الشرش، كما أظهرت نتائج التقييم الحسي أن هناك فروق ذات دلالة إحصائية بين عينات اليوغورت حيث أن اليوغورت المقلب الكنترول واليوغورت المقلب المحتوى على عصير التين الشوكى والرمان بنسبة ٥% حصل على أعلى درجات القبول بالنسبة للنكهة والقوام مقارنة بعينات اليوغورت المقلب المحتوى على العصائر بنسبة ١٠% أو١٥%، ومن نتائج الدراسة الحالية نجد أن إضافة عصائر الفاكهة إلى اليوغورت أدى الى تحسين جودة الزبادي وزيادة فوائده الصحية.

المحكمـــــون:

١- أ.د. حازم فايد عبد الرؤوف فايد أستاذ الألبان – كلية التكنولوجيا والتنمية – جامعة الزقازيق.

٢- أ.د. على عبدالرحمن عبدالجليل أستاذ الألبان – كلية الزراعة – جامعة الزقازيق.