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Utilization of Pomegranate Peels Powder as a Novel Preservative in White Soft Cheese Making

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Abstract

Pomegranate peels powder (PPP) contain total phenolic compounds and antioxidation activity, which can provide numerous health benefits. White soft cheese was prepared from mixture of buffalo's and cow's milk and supplemented with different levels of pomegranate peels powder (0.5, 1 and 1.5%) and estimated for numerous storage quality parameters and oxidative stability under ambient (18±2°C) and refrigerated (6±2°C) conditions. Adding of PPP increased antioxidant activity, total nitrogen, soluble nitrogen, fat content and *Lactococci* count. Whilst the total bacterial counts, yeast & moulds and acid degree value decreased. Coliforms groups were not detected in all treatments. The counts of lactic acid bacteria increased up to the thirty days of storage and then decreased up to the end of storage period. Cheese sample supplemented with 1.5% PPP gained the highest total antioxidant activity. Moreover, T2 & T3 stored in 60 days at room temperature had lower total scores than other treatments. While T2 & T3 stored at ambient temperature for 30 days as well as T1 & T2 stored at refrigerator temperature for 45 days had superior total scores than other treatments. Generally, PPP contained elevated levels of phenolic compounds, consequently it revealed efficacy antimicrobial properties and high antioxidant activity. Therefore, the PPP can be used in production of functional white soft cheese. This study indicates that peel of pomegranate can be used commercially in the dairy industry as potential natural preservative.

Keywords: *White soft cheese; antioxidants; Pomegranate peels powder; Oxidative .*

Introduction

Lipid oxidation is one of the primary reasons of spoilage in quality of fatty foods and dairy products. It reduces the organoleptic properties of dairy products and imparts rancid and unacceptable flavors in oils and fats, thus making them unpleasant to consumers. Also, the oxidation of lipids produces many free radicals, which have been implicated in asthma, atherosclerosis, cancer, early aging, cardiovascular diseases chronic inflammation and cardiovascular diseases (Siddhuraju and Becker, 2003). In order to delay the oxidative reactions progress in dairy products, natural or artificial antioxidants are commonly added (Estévez

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and Cava, 2006). However, increasing interest for natural foods has obliged the food industry to contain natural antioxidants in several products to retard oxidative degradation of lipids, improve nutritional value and quality of foods, and substitute artificial antioxidants (Camo *et al*., 2008). An increased preference has been directed towards plant-based extracts as a source of phenolic antioxidants (Škerget *et al*., 2005) and antimicrobials in food products (Velasco and Williams, 2011). While extensive studies toward the use of polyphenols from rosemary, green tea and other herbs as a good natural antioxidants source (Bozkurt, 2006), interest in the antioxidant properties of pomegranate peels has lately emerged. Pomegranate (*Punica granatum*) is a powerful source of bioactive compounds and has been used in many centuries in traditional medicine. The antioxidant activity displayed by phenolic compounds from pomegranate peels has been mentioned in terms of inhibited the oxidation of lipid (Naveena *et al*., 2008).

Domiati cheese is the most common and popular soft cheese in Egypt. It is a distinct compare with other pickled cheeses by the high percentage of salt up to 15%) which is added directly to the cheese milk before rennet (Abou-Donia, 2007). It is consumed when fresh or after pickling period for several months (Ayad, 2009). It made from cow's milk, buffalo's milk or a mixture of both, by coagulating the milk with rennet. Although Domiati cheese has a tremendous market potential and is considered a delicacy, however, the product is rich in fat. Further, owing to its relatively high fat content, the product is susceptible to progress of rancidity and fat oxidation.

Therefore, the current investigation was aimed to study the utilization of pomegranate peels powder as a natural preservative in cheese and estimate the impact of various concentrations of pomegranate peels powder on the storage quality and cheese lipid oxidative stability.

Materials and Methods

Materials

Whole fresh cow’s and buffalo’s milk were obtained from the Herd of Animal Production Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt**.**

Active *Lactococcus lactis* sub sp. *cremoris* and *Lactococcus lactis* sub sp. *lactis* were obtained from Dairy Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt.

Methods

Preparation of pomegranate peels powder (PPP)

Pomegranate fruits were washed by deionized water then peeled. Pomegranate peels were air dried in a ventilated oven at 40°C for 48 h and ground and passed through a 24-mesh sieve to get a fine powder as described by Shan *et al*., (2009).

White soft cheese making

Mix of buffalo's and cow's milk (1:1) standardized to 6% fat, milk was heated at 72±1°C/15 s in thermostatically controlled water bath, then cooled to about 40±2°C according to Abd-Elhamid (2012). Pomegranate peels powder (PPP) was added to warm milk at the rate of 0, 0.5, 1.0 and 1.5% (C, T1, T2 and T3; respectively). 1% starter was added to prepared milk containing PPP and 6% of sodium chloride, and then add microbial rennet with ratio of 0.02 g/l of milk. The inoculated milks were incubated at 40±2°C until complete coagulation. The curd was ladled into 40 cm^3 wooden frames lined with cheese cloth. Allowed to drain, wrapped in cheese cloth, and then covered with muslin cloth. A weight of about 50% of the curd weight was placed on top and left overnight for complete drainage. The curd was cut into cubes, weighed, and then pickling by canning about 300 g of cheese in plastic cans of 750 g capacity, filled with its own drained whey after adjusting to about 6% salt, sealed manually, then stored at room and refrigerator temperatures; 18±2 and 6±2°C; respectively. All samples were stored at ambient and refrigerator temperature and it was analyzed when fresh, 15, 30, 45 and 60 days of storage. Chemical, microbiological and sensory evaluation were determined after each storage period, the whole experiment was triplicate.

Chemical analysis

Total solids were determined according to Hooi *et al*., (2004). While, fat content, total and soluble nitrogen were determined according to AOAC (2020), pH was measured using laboratory pH meter (model 68 ESD 19713) with a combined glass electrode.

Determination of antioxidant activity

Samples were extracted using methods described by Zieliński *et al*., (2008). The 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay was carried out according to the method described by Lee *et al*., (2003).

Determination of acid value (AV)

ADV is a measure of the amount of free fatty acids that generated in dairy products in a certain period, it was determined according to Richardson *et al.,* (1985).

Determination of peroxide value (POV)

Peroxide value is the number of milliequivalents of peroxide per kilogram of fat samples, where hydroperoxide is the primary product of lipid oxidation; it was analyzed according to AOCS (1975) procedure. The lipids of cheese samples were extracted as previously described by Folch *et al*., (1957) method.

Thiobarbituric acid (TBA) Measurement

Thiobarbituric acid was determined according to the method described by (Tripaldi *et al*., 2020).

Microbiological analysis

Total bacterial count was determined according to Marshall (1992), Lactococci count was estimated by using the selective media for Lactococci MRS media as suggested by the IDF Standard 117B method (1997). While, coliform count, mould & yeast were determined according to IDF Standard 94A method (1985).

Sensory evaluation

The organoleptic properties of WSC were carried out by 10 panelists from the staff members of Dairy Science Department, Faculty of Agriculture, Al-Azhar University, Assiut branch. The organoleptic evaluation was conducted for the sensory attributes of the cheese samples at fresh and after 15, 30, 45 and 60 days of storage according to Mehta *et al*., (2017).

Table 1. Chemical composition of WSC supplemented with different levels of PPP during storage at ambient (18±2°C) and at refrigerator temperature (6±2°C)

Chemical properties	Storage period (days)	Treatment*							
		Control		T1		T2		T3	
		A	R	A	R	A	R	A	R
TS %	0	40.73	40.73	41.37	41.37	41.78	41.78	41.90	41.90
	15	44.01	41.81	45.43	42.08	45.60	42.22	45.77	42.32
	30	45.80	42.79	46.57	43.17	46.76	43.57	46.89	43.85
	45	46.40	43.22	47.45	43.61	47.81	43.87	47.98	44.24
	60	47.78	43.48	48.81	44.46	49.39	44.99	49.66	45.55
Fat %	0	16.67	16.67	16.67	16.67	16.70	16.70	16.73	16.73
	15	17.60	17.53	17.60	17.67	17.63	17.73	17.80	17.80
	30	18.63	17.77	18.70	18.10	18.77	18.27	18.93	18.37
	45	20.50	19.37	21.03	19.53	22.17	19.73	22.67	19.97
	60	20.67	20.10	21.27	20.17	22.30	20.43	22.87	20.73
pH	0	6.72	6.72	6.51	6.51	6.34	6.34	6.07	6.07
	15	5.58	6.63	5.51	6.19	5.48	5.71	5.42	5.63
	30	5.03	6.54	5.00	6.09	4.92	5.66	4.88	5.58
	45	4.57	6.46	4.41	6.01	4.36	5.67	4.27	5.54
	60	4.51	6.42	3.93	5.93	3.82	5.74	3.52	5.48
TN %	0	2.57	2.57	2.61	2.61	2.66	2.66	2.69	2.69
	15	2.64	2.59	2.68	2.63	2.73	2.70	2.74	2.71
	30	2.72	2.63	2.76	2.68	2.86	2.80	2.90	2.82
	45	2.85	2.68	2.90	2.79	2.97	2.88	3.05	2.89
	60	2.86	2.71	2.95	2.84	3.02	2.92	3.09	2.94
SN %	0	0.076	0.076	0.076	0.076	0.081	0.081	0.086	0.086
	15	0.105	0.097	0.131	0.099	0.164	0.104	0.167	0.108
	30	0.144	0.112	0.165	0.116	0.189	0.134	0.195	0.140
	45	0.186	0.135	0.198	0.135	0.216	0.149	0.228	0.152
	60	0.205	0.157	0.217	0.166	0.235	0.171	0.243	0.179

*Control cheese: had no additive. T1, T2 and T3: pomegranate peels powder was added with the percentages of 0.5, 1 and 1.5%, respectively. A (Ambient temperature), Ref.(Refrigerator temperature) TS= Total Solids, TN= Total Nitrogen, SN= Soluble Nitrogen

Results and Discussion

The Chemical composition of WSC with PPP

The results in Table (1) showed the chemical composition of WSC supplemented with different levels of PPP stored at ambient and refrigerator temperatures.

Total solids content (TS)

The TS content of WSC made with different levels of PPP are presented in Table 1. The TS content of WSC was increased as the storage periods progressed up to 60 days in all treatments. This would possibly result from the loss of moisture during storage. These results are in harmony with those found by Kebary *et al*., (2018). In addition, regarding to samples stored at ambient temperature, the total solids in WSC at the beginning of the storage was 40.73, 41.37, 41.78% and 41.90 in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 47.78, 48.81, 49.39 and 49.66% after 60 days. While samples stored at refrigerator the total solids reached 43.48, 44.46, 44.99 and 45.55% after 60 days. It is clear that control samples had lower TS than that of cheeses fortified with PPP, which were gradually increase as the PPP concentration increased. This increase can be due to the PPP added, which contained high TS, or might be due to the development of acidity that led to shrink contract the curd that helps to expel the whey from the curd (Kebary *et al*., 2018). Similar findings were reported by Ahmad *et al*., (2014) in moisture content of Kalari during ambient storage. On the other hand, TS contents of WSC found to high of the samples stored at ambient temperature than that in cheese stored at refrigerator temperature in all treatments.

Fat content

The fat content of WSC made with different levels of PPP is shown in Table 1. In all treatments, as the storage period progressed, fat content gradually increases to reach the maximum fat content at the end of storage periods at refrigerator or ambient temperatures. In addition, regarding samples stored at ambient, fat content in WSC at the beginning of the experiment was 16.67, 16.67, 16.70 and 16.73% in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 20.67, 21.27, 22.30 and 22.87% after 60 days. While samples stored at refrigerator the fat content reached 20.10, 20.17, 20.43 and 20.73% after 60 days. It could be noticed that control samples had the lowest fat content. While, cheeses fortified with PPP had higher fat content as the PPP concentration increased. This might be due to its acidity levels were high and this led to an increase in the expulsion of the whey from the cheese and curd shrinkage, which increase TS. These results are in agreement with Kebary *et al*., (2018). On the other hand, the fat content of WSC was higher in samples stored at ambient temperature than that of cheese stored at refrigerator temperature in all treatments.

pH values

The pH values of WSC made with different levels of PPP are shown in Table 1. The pH values of the cheeses fortified with PPP showed lower values than

control samples overall the storage period which can be due to the acidic and phenolic compounds present in PPP (Devatkal *et al*., 2010). In addition, regarding samples stored at ambient temperature, the pH values of WSC at the beginning of the experiment was 6.72, 6.51, 6.34 and 6.07 in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 4.51, 3.93, 3.82 and 3.52 and after 60 days. While samples stored at refrigerator the total solids reached 6.42, 5.93, 5.74 and 5.48 after 60 days. This decrease might be due to the formation of acidic degradation products (Rashidinejad *et al*., 2013). Also, Kebary *et al*., (2018) attributed this increment to prebiotic effect of PPP that stimulate the growth of lactic acid bacteria and increases the ability to ferment lactose and consequently decrease pH of cheese. Moreover, the pH values were decrease with increasing of storage periods up to 60 days at refrigerator or ambient temperatures in all treatments. These results are in harmony with those stated by Hala *et al*., (2010).

Furthermore, the pH values of WSC found to lower in samples stored at ambient temperature than that in cheese stored at refrigerator temperature. These results are in agreement with those reported by Saleh and Khalil (2019).

Soluble nitrogen (SN) and total nitrogen (TN)

The SN and TN values of WSC made with different levels of PPP are shown in Table 1. It could be noticed that cheese fortified with PPP had an increase of SN as well as TN than that of control samples in all treatments. This increase could be attributed to the activity of proteinases and peptidases released from starter culture microorganisms, which resulted in higher proteolysis. This increase in SN could also be due to the enzyme activity, which agree with the results obtained by Moatsou *et al*., (2004). Moreover, SN as well as TN values were increase as the storage periods proceeded up to 60 days at refrigerator or ambient temperatures in all treatments. These results are in lined with those reported by Saleh and Khalil (2019). In addition, SN and TN of WSC found to high of the samples stored at ambient temperature than that of cheese stored at refrigerator temperature in all treatments.

Acid value (AV)

The AV of WSC made with different levels of PPP is shown in Table 2. The AV of the cheeses treated with PPP showed lower values in comparing with control samples on all days of storage in all treatments. In addition, regarding to samples stored at ambient temperature, the AV of WSC at the beginning of the experiment was 0.50, 0.47, 0.45 and 0.42 in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 1.38, 1.22, 1.15 and 1.06 after 60 days. While samples stored at refrigerator the AV reached 0.82, 0.77, 0.72 and 0.68 after 60 days. Moreover, the AV were increase with increasing of storage periods up to 60 days at refrigerator or ambient temperatures in all treatments. This may be attributed to the liberation of free fatty acids Caused by the fat hydrolysis, which cause gradual increase in rancidity during storage period. In addition, T3 recorded lowest acid value followed by T2 and T1 when fresh and during the storage period. From the obtained results, the acid value decreased with increasing

of PPP which containing phenolic compounds act as antioxidant and this improved cheese properties. These results are agreement with pervious investigators (Gutiérrez-Larraínzar *et al*., 2012). Furthermore, AV of WSC found to be higher in samples stored at ambient temperature than cheese stored at refrigerator temperature in all treatments.

Peroxide value (POV)

The POV of WSC made with different levels of PPP are shown in Table 2. The obtained data showed that, the POV of WSC at the beginning of storage was 0.98, 0.95, 0.93 and 0.92 in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 3.04, 2.05, 1.73 and 1.68 after 60 days. While samples stored at refrigerator the POV reached 1.79, 1.74, 1.60 and 1.55 after 60 days. WSC supplemented with the different concentrations of PPP had lower POV than that of control samples in all treatments. The data demonstrated that the POV increased as the storage period progressed at refrigerator or ambient temperatures in all treatments, while POV increase with increasing the concentration of PPP in cheese due to the phenols compounds and antioxidants activity, which improved and extend shelf life of WSC. These results are in agreement with those reported by (El-Shourbagy and El-Zahar, 2014). In addition, POV of WSC found to higher in the samples stored at ambient temperature compare with samples stored at refrigerator temperature in all treatments.

Thiobarbituric acid (TBA) value

The TBA of WSC made with different levels of PPP is shown in Table 2. The obtained data shows that, WSC supplemented with the different concentrations of PPP had lower TBA than that of control samples in all treatments. The data demonstrated that, the TBA increased as the storage period progressed at refrigerator or ambient temperatures in all treatments. It could be noticed that, regarding the ambient storage, The TBA of WSC at the beginning of storage was 0.45, 0.43, 0.42 and 0.40 in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 0.98, 0.86, 0.84 and 0.76 after 60 days of storage. While samples stored at refrigerator the total solids reached 0.85, 0.75, 0.72 and 0.66 after 60 days. Cheese samples supplemented with PPP as natural antioxidants had lower TBA values when compared with control cheese up to 60 days. This means that phenolic compounds of natural antioxidant had highly efficient antioxidative than control cheese. These results are in accordance with the results of Mohdaly *et al*. (2010). Although TBA values followed an increasing trend, the values of the cheeses treated with 1% and 1.5% pomegranate peels powder were decrease than control samples on all periods of storage. Comparatively lower TBA values of supplemented cheese may be interpreted to antioxidant properties of pomegranate peels powder (Devatkal *et al.,* 2010). In addition, TBA of WSC found to high of the samples stored at ambient temperature than that of cheese stored at refrigerator temperature in all treatments.

Table 2. Antioxidant activity, acid value, peroxide value and TBA of WSC supplemented with different levels of PPP at ambient (18±2°C) and at refrigerator temperature (6±2°C)

Chemical properties	Storage period (days)	Treatment*							
		Control		T1		T2		T3	
		A	R	A	R	A	R	A	R
Acid value	0	0.50	0.50	0.47	0.47	0.45	0.45	0.42	0.42
	15	0.57	0.52	0.55	0.50	0.52	0.49	0.49	0.45
	30	0.65	0.57	0.59	0.55	0.58	0.54	0.56	0.49
	45	0.98	0.64	0.87	0.62	0.82	0.58	0.71	0.55
	60	1.38	0.82	1.22	0.77	1.15	0.72	1.06	0.68
Peroxide value	0	0.98	0.98	0.95	0.95	0.93	0.93	0.92	0.92
	15	1.09	1.02	1.03	0.99	1.01	0.99	0.97	0.96
	30	1.62	1.08	1.37	1.05	1.34	1.05	1.28	1.01
	45	2.25	1.21	1.64	1.11	1.60	1.08	1.59	1.07
	60	3.04	1.79	2.05	1.74	1.73	1.60	1.68	1.55
Thiobarbituric acid	0	0.45	0.45	0.43	0.43	0.42	0.42	0.40	0.40
	15	0.61	0.52	0.52	0.49	0.49	0.46	0.47	0.45
	30	0.78	0.63	0.65	0.60	0.58	0.54	0.55	0.51
	45	0.86	0.77	0.78	0.67	0.75	0.63	0.69	0.57
	60	0.98	0.85	0.86	0.75	0.84	0.72	0.76	0.66
Antioxidant activity %	0	6.62	6.62	20.31	20.31	49.73	49.73	86.97	86.97
	15	5.10	6.08	18.28	18.09	45.20	46.62	85.44	85.78
	30	4.17	5.29	16.72	17.21	42.79	44.41	82.06	83.53
	45	3.34	4.71	15.19	16.57	40.13	42.48	79.86	81.51
	60	2.55	3.97	14.49	15.82	37.61	40.09	77.03	78.72

*To clarify the treatments, see Table 1.

Antioxidant activity (AA)

The AA of WSC made with different levels of PPP is shown in Table 2. The obtained data shows that, WSC supplemented with PPP had higher AA than control samples. Moreover, the data showed that the radical scavenging activity (RSA/DPPH) (%) of pomegranate peel powder increased with increasing of PPP concentration in all treatments. T3 with 1.5% PPP recorded highest level of AA followed by T2 with 1% PPP, then T1 with 0.5% PPP, while control samples recorded the lowest activity in the case of both ambient and refrigerator temperatures. On the other hand, gradually decrease in AA was noticed as the storage period progressed in all treatments. These results are in agreement with those reported by Amarowicz *et al*., (2004). It could be concluded that PPP can used as industrial by products of dairy as a natural preservation retard oxidation and extend the shelf life of WSC. In addition, AA of WSC found to high of the samples stored at ambient temperature than that of cheese stored at refrigerator temperature in all treatments.

The microbiological composition of WSC supplemented with PPP:

Total bacterial count (TBC)

The TBC of WSC made with different levels of PPP is shown in Table 3. The obtained data showed that, WSC supplemented with different concentrations of PPP had lower TBC than control samples in all treatments. It could be noticed that, regarding the ambient storage, total bacterial count of WSC at the beginning of the

experiment was 7.8, 7.7, 7.6 and 7.4 log cfu/gm in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 7.5, 7.5, 7.4 and 7.3 log cfu/gm after 60 days. While samples stored at refrigerator temperature, the TBC reached 7.0, 6.7, 6.4 and 6.4 log cfu/gm after 60 days. These results may be attributed to the antimicrobial properties of pomegranate peels powder (Devatkal *et al*., 2010). Moreover, the gradual increasing of PPP levels led to gradual decrease of TBC in all treatments. The TBC were higher in the samples stored at ambient temperature than that of the samples stored at refrigerator temperature in all treatments. In addition, the data showed that, TBC were increase with increasing storage period up to 30 days then decline gradually in all treatments. These results were in agreement with those reported by Omar *et al*., (2006).

Table 3. changes in microbiological composition of WSC supplemented with different levels of PPP at ambient (18±2°C) and at refrigerator temperature (6±2°C)

Component (%)	Storage period (days)	Treatment*							
		C		T1		T2		T3	
		A	R	A	R	A	R	A	R
Total count	0	7.8	7.8	7.7	7.7	7.6	7.6	7.4	7.4
	15	8.0	7.9	7.9	7.9	7.7	7.8	7.6	7.8
	30	8.1	7.9	8.0	7.9	7.9	7.9	7.7	7.8
	45	7.8	7.5	7.7	7.5	7.6	7.2	7.6	7.2
	60	7.5	7.0	7.5	6.7	7.4	6.4	7.3	6.4
Lactococcus count	0	6.7	6.7	6.8	6.8	7.1	7.1	7.4	7.4
	15	6.9	6.8	7.5	7.1	7.7	7.2	7.8	7.4
	30	7.0	6.8	7.5	7.2	7.8	7.3	7.9	7.5
	45	6.8	6.1	7.5	7.3	7.8	7.4	7.8	7.5
	60	6.5	5.9	7.2	7.0	7.2	7.2	7.6	7.3
Yeasts & Molds	0	ND	ND	ND	ND	ND	ND	ND	ND
	15	ND	ND	ND	ND	ND	ND	ND	ND
	30	2.7	ND	2.30	ND	ND	ND	ND	ND
	45	11.3	7	5.0	3	3.0	ND	ND	ND
	60	25.3	16	12.0	9.7	8.0	6.3	ND	ND
Coliform group	0	ND	ND	ND	ND	ND	ND	ND	ND
	15	ND	ND	ND	ND	ND	ND	ND	ND
	30	ND	ND	ND	ND	ND	ND	ND	ND
	45	ND	ND	ND	ND	ND	ND	ND	ND
	60	ND	ND	ND	ND	ND	ND	ND	ND

*To clarify the treatments, see Table 1. ND: Not Detected

Lactococci count

The Lactococci count of WSC made with different levels of PPP is shown in Table 3. The obtained data shows that, WSC supplemented with the different concentrations of PPP had higher Lactococci count than control samples in all treatments. Moreover, the gradual increasing of PPP levels led to gradual increase of Lactococci count in all treatments. Regarding the ambient storage, the Lactococci count in cheese samples was 6.7, 6.8, 7.1 and 7.4 log cfu/gm in control, samples supplemented with 0.5, 1 and 1.5% PPP, respectively and reached 6.5, 7.2, 7.2 and 7.6 log cfu/gm after 60 days. While samples stored at refrigerator temperature, Lactococci count reached 5.9, 7.0, 7.2 and 7.3 log cfu/gm after 60 days. This increment may be due to prebiotic effect of PPP. These results are in agreement with those reported by Kebary *et al*., (2018). The Lactococci count were

higher in samples stored at ambient temperature compare with samples stored at refrigerator temperature in all treatments. In addition, the data showed that, Lactococci count were increase with increasing storage period up to 30 days then decline gradually in all treatments.

Yeast, Moulds and Coliform group

The yeast, moulds and coliform counts of WSC made with different levels of PPP are shown in Table 3. The obtained data shows that, WSC supplemented with the different concentrations of PPP was free of yeasts and moulds in fresh samples or up to 15 days of storage with or without PPP, but it was detected and increase gradually with the progress of storage than 30 days till 60 days in all treatments. These results were in agreement with those reported by Omar *et al*., (2006). The cheeses made with PPP had lower counts of yeasts and moulds than that of control samples during storage period at refrigerator or ambient temperatures. These results may be attributed to the antimicrobial phenolic compounds in PPP. These compounds can degrade the cell wall, disrupt the cytoplasmic membrane, damage membrane proteins and interfere with membrane-integrated enzymes, which may eventually lead to cell death (Shan *et al*., 2007). Similar findings were obtained by Devatkal e*t al*., (2010).

Moreover, Coliform group were not detected in all treatments, this may be due to high hygienic condition during manufacturing and storing of cheese. In addition, the counts of yeasts and moulds were higher in the samples stored at ambient temperature than that of the samples stored at refrigerator temperature in all treatments.

Generally, it is clear from data above that there a great difference in microbial counts among the control cheese and cheeses made with PPP. Low microbial counts found may be due to pasteurization of cheese milk and high hygienic condition during manufacturing and storing of cheese.

The organoleptic properties of WSC fortified with PPP

The organoleptic properties of WSC made with different levels of PPP is shown in Table 4. The data revealed that, the organoleptic properties such as flavor, body & texture and appearance of WSC were influenced by percentages of PPP during storage periods at refrigerator and ambient temperatures up to 60 days. Mean values of the organoleptic scores within each treatment, were examined by panel test and score were awarded for flavor (50), body & texture (35) and appearance (15 points) according to Dinakar and Mistry (1994).

The obtained data shows that, WSC supplemented with different concentrations of PPP had higher flavor than that of control samples in all treatments. The obtained data observed that, T3 stored at refrigerator or ambient temperature had the superior flavor followed by T2, then T1. This might be due to the prebiotic effect of PPP that enhance the growth of lactic acid bacteria, which subsequently increases the metabolic activity of starter bacteria, which increased changes of cheese matrix such as proteolysis ability. These results are

disagreement with those reported by El-Said *et al*., (2014), who reported that there were no significant differences in flavor scores among cheeses fortified with PPP and control cheese.

Table 4. Effect of varying concentrations of organoleptic properties on AA of WSC during storage periods at refrigerator and ambient temperatures up to 60 days

Microbial type	Storage (days)	Control	Treatments*		
			T1	T2	T3
Ambient temperature					
Flavor (50)	**Fresh**	**41**	**42**	**43**	**45**
	15	41	43	45	46
	30	45	46	47	48
	45	43	44	45	44
	60	37	39	40	38
Body & Texture (35)	Fresh	30	31	32	32
	15	31	32	33	32
	30	32	33	33	34
	45	29	30	31	32
	60	27	29	30	31
Appearance (15)	Fresh	12	11	10	9
	15	13	11	11	10
	30	14	12	12	11
	45	13	13	12	11
	60	12	13	13	12
Total score (100)	Fresh	84	85	87	86
	15	87	88	90	88
	30	92	92	93	93
	45	86	88	87	87
	60	78	82	81	81
Refrigerator temperature					
Flavor (50)	Fresh	41	42	43	45
	15	41	43	44	45
	30	42	43	45	46
	45	44	45	46	47
	60	39	41	42	43
Body & Texture (35)	Fresh	30	31	31	32
	15	30	31	32	33
	30	32	32	33	33
	45	33	33	34	33
	60	31	30	31	32
Appearance (15)	Fresh	12	11	10	9
	15	14	12	11	10
	30	13	12	11	11
	45	12	14	12	10
	60	12	13	12	12
Total score (100)	Fresh	84	85	86	82
	15	87	87	88	84
	30	88	89	90	86
	45	90	93	93	87
	60	84	85	86	83

Regarding body & texture, the presented data showed that, the body & texture of WSC was influenced by PPP incorporation and during storage periods at refrigerator and ambient temperatures up to 60 days. The obtained data observed that, T3 had higher scores of body & textures in the samples stored at room

temperature on 45 days compared with other samples, while control samples at room temperature recorded the lowest value ever on the 60 days. This may be attributed to increased hardness caused by loss of moisture, breakdown of fat and degradation of proteins by bacterial action. Furthermore, the data indicated that the scores were increase with increasing the percentage of PPP. This increment may be due to the antimicrobial and antioxidant properties of PPP that may have resulted into less degradation of proteins and fats in treated samples. These results were in agreement with those reported by Hala *et al*.**,** (2010).

Regarding appearance and color, the data showed that control samples had higher appearance and color scores than that of other treatments. There were decreasing trend in the appearance and color scores for cheeses fortified with PPP whenever the PPP concentration increased during storage periods at refrigerator and ambient temperatures up to 60 days. Change was observed in the scores of pomegranate peels treated cheeses in comparison to control. The fresh WSC prepared from mixed milk had a white color. While cheese fortified with PPP has a slightly yellowish color which gradually fading as the storage period proceeded **(**Chandralekha *et al*., 2012**)**. Thus, the appearance values of treated cheeses were increase with increasing the storage periods at refrigerator or ambient temperatures till 60 days in all treatments. These results were in lined with those reported by **(**Ahmad *et al*., 2014). On the other hand, T3 was the lowest of all of them in scores. This may be attributed to samples were appeared yellowish when compared with control samples and variation the traditional color of WSC.

Regarding total scores, the data indicated that, the total scores of WSC was influenced by addition of PPP and condition of storage at refrigerator or ambient temperatures up to 60 days. Moreover, T2 and T3 stored on 60 days at ambient temperature had lower total scores than that of all other treatments, while T2 & T3 stored at ambient temperature after 30 days as well as T1 & T2 stored at refrigerator temperature on 45 days had superior total scores than that of other treatments. Similar findings were also mentioned by Ahmad *et al*., (2014) in Kalari during ambient storage.

Conclusion

It could be concluded that, PPP contained high levels of phenolic compounds, consequently it exhibited effective antimicrobial properties and high antioxidant activity. Therefore, the PPP might be used to production of functional WSC. This study indicates that peel of pomegranate can be used commercially in the dairy manufacture as potential natural preservative.

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استخدام مسحوق قشر الرمان كمادة حافظة جديدة في صناعة الجبن الأبيض الطري

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الملخص

يحتوي مسحوق قشر الرمان (PPP) على العديد من المركبات الفينولية ونشاط مضاد للأكسدة، والتي يمكن أن توفر العديد من الفوائد الصحية. تم تحضير الجبن الأبيض الطري من خليط اللبن الجاموسي والبقري بنسبة (1:1)، وتم إضافة مسحوق قشر الرمان بنسب (0.5 و1 و1.5%) وتم تقييم ثبات الأكسدة ومعايير جودة التخزين تحت درجة حرارة الغرفة ودرجة حرارة الثلاجة، وقد أدت إضافة PPP إلى زيادة نشاط مضادات الأكسدة والنيتروجين الكلي والنيتروجين القابل للذوبان ونسبة الدهن وعدد ال Lactococci، بينما انخفض العدد الكلي للبكتيريا والفطريات والخمائر ودرجة ال pH وكذلك درجات التقييم الكلي. ولم يتم اكتشاف مجموعات القولون في جميع المعاملات، كما زاد عدد بكتيريا حمض اللاكتيك حتى ثلاثين يومًا من التخزين ثم انخفض حتى نهاية فترة التخزين. وقد حصلت عينة الجبن المدعمة بـ PPP ٪1.5على أعلى نشاط مضاد للأكسدة. وقد حصلت المعاملات T2 و T3 المخزنة لمدة 60 يومًا في درجة حرارة الغرفة علي درجات إجمالية أقل من جميع المعاملات الأخرى. في حين أن المعاملات T2 و T3 المخزنة في درجة حرارة الغرفة لمدة 30 يومًا وكذلك المعاملات T1 و T2 المخزنة في درجة حرارة الثلاجة لمدة 45 يومًا كان لهما درجات إجمالية أعلى من تلك الموجودة في المعاملات الاخرى في جميع المعاملات. بشكل عام، يحتوي PPP على مستويات عالية من المركبات الفينولية، وبالتالي أظهر خصائص فعالة مضادة للميكروبات ونشاطًا عاليًا لمضادات الأكسدة، لذلك يمكن استخدام PPP لإنتاج جبن طري أبيض وظيفي. كما تشير هذه الدراسة إلى أن قشر الرمان يمكن استخدامه تجاريًا في صناعة الألبان كمواد حافظة طبيعية محتملة.