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Improving the quality characteristics of white soft cheese using cranberry *(Vaccinium macrocarpon)* fruit extract

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Abstract

In this study, the influence of cranberry fruit extract on the chemical composition, ripening indices, oxidative stability, and microbiological as well as organoleptic properties of the white soft cheese was evaluated. Different concentrations of cranberry fruit extract powder (500, 750 and 1000 ppm) were added during the storage period at 5 ± 2ºC for 8 weeks. Cranberry fruit extract treatments had a significant effect on the yield and recovery of fat, protein and total solids of fresh cheese. Treated fresh or stored cheese have significantly less numbers of total, psychrotrophic, enterococci, proteolytic, lipolytic bacteria and yeast and mould counts than the control cheese. It could be concluded that cranberry extract could successfully used at concentration up to 750 ppm to improve the keeping quality of white soft cheese.

Introduction

Food preservatives are important for reducing food spoilage and waste, improving distribution of goods, and superior convenience. Interest in natural preservatives continues to increase, as they are presumably safe as they naturally occur in foods that have been used for centuries (Frankel, 1996). Polyphenols are general constituents of plant-derived foods and are the principal antioxidant in the human diet. They show a variety of biochemical activities, including antioxidant, apoptosis, antiaging, anticancer, antiinflammation, antiatherosclerosis, cardiovascular protection, and endothelial function enhancing activities, as well as angiogenesis inhibition and cell proliferation activities (Han *et al*., 2007). Several hundred molecules with polyphenol structures have been identified in culinary herbs and edible plants. Fruits and beverages, such as tea, red wine, and coffee, are the primary sources of polyphenols; however, vegetables, cereals and leguminous plants have also been shown to be good sources of polyphenols (Manach *et al*., 2004). Owing to the many beneficial health effects attributed to polyphenolic compounds (Singleton, 1981; Haslam and Lilley, 1988; Mukhtar *et al*., 1992; Chung *et al.*, 1998) their addition or incorporation into food systems has been previously advocated (O'Connell and Fox, 2001).

Cranberry (*Vaccinium macrocarpon*, Ait Ericaceae) is a native plant of North America. Cranberries represent a rich source of phenolic bioactives that may contribute to human health (Blumberg *et al*., 2013). The fruit and its juice exhibit various health benefits, including treatment of recurrent urinary tract infections by preventing the adherence of *Escherichia coli* to mucosal surfaces (Foo *et al.*, 2000), prevention of in vitro co-aggregation between gram-negative bacterial pairs involved in periodontal diseases (Weiss *et al*., 2002), protection against lipoprotein oxidation (Porter *et al*., 2001), antihypertensive (Reed, 2002), antibacterial (Côté *et al.,* 2010), and anticancer activity (Kandil *et al.*, 2002). The bioactive components that make up the cranberry juice have been well characterized (Lee *et al*., 2008). Several studies have shown anthocyanins, proanthocyanidins, and phenolic from cranberries are active components in molecular mechanism behind various health benefits of cranberries (Apostolidis *et al*., 2008; Wu *et al.*, 2009). In addition, there are antimicrobial effects of the cranberry on foodborne pathogens (Wu *et al*., 2008). The specific antimicrobial activity of cranberries was demonstrated toward numerous groups of pathogenic bacteria, including *Helicobacter pylori, Salmonella, Staphylococcus aureus, E. coli,* and *Campylobacter.* It is known that growth inhibition against microorganisms observed with cranberries is linked to low pH, but it was also hypothesized that other bioactive compounds in the cranberry, such as phenolics, may contribute to the observed antimicrobial actions (Wu *et al*., 2008). Indeed the

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antibiotic effect of the fruit has been associated with the high content of phenolic compounds which constitute a particularly diverse group in cranberry, including low-molecular weight phenolic acids, condensed tannins, proanthocyanidins, and flavonoids such as anthocyanin (in high content) and flavonols (Puupponen-Pimiä *et al*., 2005). Some fractions of cranberry polyphenols could present significant potential benefits for human health (Huttunen *et al.,* 2011). It is was reported that the addition of various polyphenolic compounds in cheese; single phenolic compounds including catechin, epigallocatechin gallate (EGCG), tannic acid, homovanillic acid, hesperetin and flavone, along with natural crude compounds such as grape extract, green tea extract and dehydrated cranberry powder, were added as functional ingredients during the cheese-making process (Han *et al*., 2011b). Several bioactive compounds including plant or fruit extracts have been applied to cheese and dairy products to improve the quality of the final products. The cheese products formulated with some polyphenolic compounds improved the antioxidant property and a high rate of polyphenolic compounds recuperation in cheese was observed (Han *et al*., 2011a). This study aims to evaluate the effect of adding cranberry *(Vaccinium macrocarpon)* fruit extract on the chemical composition, ripening indices, oxidative stability, microbiological and organoleptic properties of the white soft cheese during storage.

Materials and Methods

Materials

Fresh raw buffalo's and cow's milk were obtained from the Milk Collection Unit, Faculty of Agriculture, Zagazig University. Dehydrated cranberry fruit extract powder was manufactured by Pharaonia Pharmaceuticals for EMA Pharm Pharmaceuticals, Egypt.

Cheese manufacturing

Fresh mixed milk 5% fat (buffalo: cow; 1:1) was pasteurized at 72°C for 15 sec. It was divided into four portions; one of portions was used as control. The dehydrated cranberry fruit extract powder was added to the rest three portions at a ratio of 500, 750 and 1000 ppm. Dehydrated cranberry fruit extract powder was thoroughly mixed in cheese milk. Treated and untreated cheese milk samples were salted at rate of 4% and 0.02% $CaCl_2$. Cheese was made according to the method described by Fahmy and Sharara (1950). The resultant cheese was placed in polyethylene packages and stored without brine at 5 ± 2°C for eight weeks. Three replicates were carried out from each treatment. The cheese was analyzed when fresh and every two weeks up to 8 weeks.

Compositional analyses

Cheese samples were analyzed for dry matter, fat on dry matter basis, protein, acidity as lactic acid (LA%) and pH value by the method described by AOAC (2000). Salt content was estimated as described by Bradley *et al.* (1992). The total nitrogen (TN%), soluble nitrogen (SN%) and non-protein nitrogen (NPN%) were determined by the semi-micro Kjeldahal method as described by Gripon *et al*. (1975). Total volatile fatty acids content was determined according to the method described by Kosikowski (1978). Cheese yields and component recovery were calculated according to Mehaia (2002). To determine the oxidative stability, the cheese samples were dried at 40ºC for 12 h in hot air oven, grounded and mixed with n-hexane as a solvent for extraction of oil. The solvent was evaporated in hot air oven and the extracted oils were analyzed for peroxide and acid values according to the method described in AOAC (2000).

Microbiological analysis

Total bacterial count was determined using plate count agar incubated at 32°C for 48 h. Psycrotrophs were grown on plate count agar incubated at 5°C for 10 days. Proteolytic bacteria were grown on skim milk agar and incubated at 30°C. Enterobacteriaceae and coliformi bacteria were determined on Violet Red Bile Glucose agar and Violet Red Bile Lactose, respectively and incubated at 30°C for 24-48 h. Staphylococcus aureus was enumerated by plating on Baird Parker egg yolk telluride medium following the surface-plate method, and incubated at 37°C for 48 h. Black colonies were recorded as *S. aureus*. Yeasts and moulds were enumerated after incubation at 25ºC for 5 days. Enterococci were counted on Kanamycin aesculin azide agar and incubated at 30°C for 3 days (Sarantinopoulos *et al.,* 2002).

Sensory evaluation

Cheese samples were sensory evaluated by the method described by Scott (1981).

Statistical analysis

A statistical analysis of the obtained results was carried out with The Duncan's Multiple Range test (DMRT) (Statistica 6.0, StatSoft Inc., Tulsa, OK, USA) at a significance level of $P < 0.05$, a protected least significant difference test (LSD) was used to compare treatment means.

Table 1. Compositional characteristics changes of white soft cheese with dehydrated cranberry fruit extract during storage period at 5ºC for 8 weeks

Items	Storage period (weeks)	Treatments				
			Cranberry fruit extract (ppm)			LSD
		Control	500	750	1000	
Moisture,%	Fresh	66.67^{a}	66.64^{a}	67.21^{a}	67.78^{a}	1.66
	2	63.84^{c}	64.23^{bc}	65.04^{b}	67.17^{a}	0.99
	4	62.25^{b}	63.12^{b}	64.5^{a}	65.53^{a}	1.05
	6	60.71^{c}	61.32^{c}	62.54^{b}	64.67^{a}	0.74
	8	56.68^{c}	59.22^{b}	61.71^{a}	62.37^{a}	0.79
	Treatment mean	62.03^{c}	62.91^{c}	64.20^{b}	65.50^{a}	1.24
TN /Dm,%	Fresh	6.15^{a}	6.10^{a}	6.18^{a}	6.31^{a}	0.54
	2	6.42^{a}	6.27^{a}	6.33^{a}	6.66^{a}	0.57
	4	7.03^{a}	6.66^{a}	6.91^{a}	6.85^{a}	0.49
	6	7.14^{a}	6.75^{b}	6.90^{ab}	7.12^{a}	0.31
	8	7.65^{a}	7.16^{a}	7.25^{a}	7.27^{a}	1.16
	Treatment mean	6.88^{a}	6.59^{b}	6.71^{ab}	6.84^{ab}	0.25
Fat/Dm,%	Fresh	47.78^{a}	46.35^{a}	46.66^{a}	46.16^{a}	5.78
	2	48.59^{b}	48.08^{b}	48.73^{b}	50.77^{a}	1.87
	4	48.38^{a}	48.35^{a}	49.41^{a}	49.74^{a}	2.98
	6	47.69^{b}	47.24^{b}	48.40^{b}	50.29^{a}	1.39
	8	47.56^{ab}	46.75^{b}	49.18^{a}	49.17^{a}	2.11
	Treatment mean	48.00^{bc}	47.35^{c}	48.48^{b}	49.23^{a}	0.844
Salt/Moisture,%	Fresh	6.26^{a}	5.86^{b}	2.86^{c}	2.76^{c}	0.35
	2	6.05^{a}	5.86^{a}	3.04^{b}	2.9^{b}	0.34
	4	6.15^{a}	6.07^{a}	3.38^{b}	3.12^{b}	0.28
	6	6.37^{a}	6.25^{a}	3.78^{b}	3.5^{c}	0.25
	8	6.28^{a}	6.22^{a}	4.06^{b}	3.92^{b}	0.30
	Treatment mean	6.22^{a}	6.05^{a}	3.42^{b}	3.24^{c}	0.18
Acidity,% as lactic acid	Fresh	0.26^{a}	0.28^{a}	0.29^{a}	0.29^{a}	0.05
	2	0.43^{a}	0.39^{ab}	0.36^{b}	0.35^{b}	0.04
	4	0.65^{a}	0.47^{b}	0.43^{bc}	0.38^{c}	0.07
	6	0.76^{a}	0.58^{b}	0.53^{b}	0.45^{c}	0.07
	8	1.1^{a}	0.78^{b}	0.7c	0.57^{d}	0.05
	Treatment mean	0.64^{a}	0.50^{b}	0.46^{b}	0.41^{b}	0.09
pH values	Fresh	6.12^{a}	6.11^{a}	6.12^{a}	6.12^{a}	0.05
	2	5.84^{c}	5.95^{b}	5.99^{ab}	6.02^{a}	0.04
	4	5.56^{c}	5.73^{b}	5.89^{a}	5.93^{a}	0.07
	6	5.46^{c}	5.64^{b}	5.82^{a}	5.87^{a}	0.09
	8	5.36^{d}	5.53^{c}	5.67^{b}	5.78^{a}	0.118
	Treatment mean	5.67^{c}	5.79^{b}	5.90^{a}	5.94^{a}	0.10

Data are means of experiment examined in duplicate.

$^{a–d}$ Means in the same row with different letters differ significantly at $P \leq 0.05$ by DMRT.

Results and Discussion

Pilot experiments were carried out to evaluate the effect of different ratios of dehydrated cranberry fruit extract powder on the quality of white soft cheese. The obtained results showed that the cranberry fruit extract could be successfully used at the concentration more than 500 ppm to improve of keeping quality of white soft cheese.

Compositional characteristics

Compositional characteristics of fresh white soft cheese samples during storage period were shown in Table 1. Cheeses treated with dehydrated cranberry fruit extract had higher moisture contents and lower fat as well as protein contents than the control cheese. Titratable acidity increased continuously until the end of storage period ($P \leq 0.05$). The control cheese samples had a higher titratable acidity than the cheese samples with dehydrated cranberry fruit extract powder ($P \leq 0.05$). This may be attributed to the inhibitory effect of cranberry fruit extract concentration on the activities of total bacteria (Côté *et al*., 2011) as discarded in Table 4. The dry matter of all cheese samples increased during storage ($P \leq 0.05$). Increasing of dehydrated cranberry fruit extract concentration in cheese samples had a lower dry matter contents than the control ($P \leq 0.05$). Fat and dry matter content of cheese samples increased with increasing the levels of dehydrated cranberry fruit extract (750-1000 ppm), but decreased in cheese samples with 500 ppm and control cheese samples. Salt contents of cheese samples were affected significantly ($P \leq 0.05$) with increasing dehydrated cranberry fruit extract powder in the samples.

Table 2. Proteolysis and lipolysis of white soft cheese with dehydrated cranberry fruit extract during storage period (at 5ºC for 8 weeks)

Items	Storage period (weeks)	Treatments				LSD
		Control	Cranberry fruit extract (ppm)			
			500	750	1000	
SN/TN,%	Fresh	5.18^{b}	5.67^{a}	5.08^{b}	4.99^{b}	0.44
	2	5.96^{a}	5.61^{ab}	5.49^{ab}	5.28^{b}	0.49
	4	12.02^{a}	11.1^{a}	9.02^{b}	8.39^{b}	1.90
	6	16.66^{a}	14.22^{b}	12.26^{bc}	10.54^{c}	2.06
	8	17.87^{a}	14.83^{ab}	14.32^{ab}	12.20^{b}	3.47
	Treatment mean	11.54^{a}	10.29^{ab}	9.23^{b}	8.28^{b}	2.12
NPN/TN,%	Fresh	3.21^{a}	3.19^{a}	3.02^{a}	2.97^{a}	0.54
	2	4.93^{a}	4.43^{b}	4.33^{b}	4.05^{b}	0.44
	4	6.21^{a}	5.73^{a}	4.87^{b}	4.56^{b}	0.75
	6	10.64^{a}	7.31^{b}	5.55^{c}	5.20^{c}	0.46
	8	11.21^{a}	8.64^{b}	6.53^{b}	6.78^{b}	2.16
	Treatment mean	7.24^{a}	5.86^{b}	4.90^{bc}	4.71^{c}	1.05
T.V.F.A (as ml of 0.1 N NaOH/100 g cheese)	Fresh	9.30^{a}	6.17^{b}	5.67^{c}	5.58^{c}	0.32
	2	11.95^{a}	8.56^{b}	8.12^{c}	7.59^{d}	0.42
	4	15.58^{a}	11.82^{b}	9.41^{c}	8.18^{d}	0.41
	6	19.47^{a}	13.08^{b}	10.41^{c}	9.10^{d}	0.40
	8	29.57^{a}	14.29^{b}	11.22^{c}	9.97^{d}	0.68
	Treatment mean	17.16^{a}	10.77^{b}	8.98b^{c}	8.08^{c}	2.01

Data are means of experiment examined in duplicate.

$^{a-c}$ Means in the same row with different letters differ significantly at $P \leq 0.05$ by DMRT.

Cheese yields and components recovery

Yield and recovery of protein and fat of fresh cheese samples with cranberry fruit extract showed no significant effect both milk protein and fat recoveries in the cheese or the cheese yield. Control and treated cheeses (500, 750 and 1000 ppm) exhibited 85.02±4.72, 87.29±3.19, 88.34±3.24 and 91.62±7.23% protein recovery, respectively, and 86.72±3.06, 87.31±9.29, 87.82±2.77 and 88.13±2.29 % fat recovery, respectively. The yields for control and cranberry fruit extract (500, 750 and 1000 ppm) were 27.47±0.95, 28.43±0.78, 28.90±1.11 and 29.83±.35 %, respectively. A major advantage of the dehydrated cranberry fruit extract is the inclusion of whey proteins and all fat in cheese, as whey drainage, is reduced or eliminated, thereby increasing cheese yield. Incorporation of whey proteins raised cheese yield, due to the higher moisture level in cheese samples, resulting from the greater water holding capacity of whey proteins.

Proteolysis and lipolysis of white soft cheese samples during storage

The SN/TN, NPN/TN % content and total volatile fatty acids content during storage of cheese samples are presented in Table 2. Proteolysis and lipolysis levels of all cheese samples showed increasing continuously during storage period. All cheese samples showed an increase in SN/TN and NPN/TN% with advance of storage period. However, these increases were significantly lower ($P \leq 0.05$) in treated samples than the control samples. Generally, SN/TN% content of cheese samples had significant differences between control and the other treatments along the ripening period may be due to the significant differences effect of cranberry fruit extract in total viable counts (Table 4). Also, these differences may be due to the differences in moisture content and titratable acidity. The increasing in soluble nitrogen content in all cheese samples throughout the ripening period may be due to the protein breakdown occurred by the growth and activities of microflora and/or proteolysis with proteolytic enzyme. The cheese samples which treated with dehydrated cranberry fruit extract powder had showed lower significantly ($P \leq 0.05$) in total volatile fatty acids content than the control cheese samples. The main agents responsible for lipolysis are the natural lipase of milk, moulds and lactic acid bacteria, which have little activity.

Table 3. Oxidative stability of white soft cheese with dehydrated cranberry fruit extract during storage period at 5ºC for 8 weeks

Items	Storage period (weeks)	Treatments				LSD
		Control	Cranberry fruit extract (ppm)			
			500	750	1000	
Peroxide value (meq/kg)	Fresh	4.90[a]	4.80[a]	4.64[b]	4.62[b]	0.11
	2	5.65[a]	4.96[b]	4.84[b]	4.73[b]	0.25
	4	6.32[a]	5.61[b]	5.35[bc]	5.19[c]	0.30
	6	6.89[a]	5.91[b]	5.52[c]	5.26[d]	0.24
	8	8.18[a]	6.34[b]	5.62[c]	5.33[c]	0.57
	Treatment mean	6.39[a]	5.52[b]	5.19[c]	5.03[d]	0.09
Acid value (mg KOH/g oil)	Fresh	0.65[a]	0.61[a]	0.58[a]	0.57[a]	0.09
	2	0.76[a]	0.71[ab]	0.66[ab]	0.63[b]	0.12
	4	0.86[a]	0.79[ab]	0.74[ab]	0.68[b]	0.15
	6	1.15[a]	0.87[a]	0.81[a]	0.74[a]	0.99
	8	1.26[a]	1.02[b]	0.87[bc]	0.79[c]	0.17
	Treatment mean	0.94[a]	0.80[b]	0.73[bc]	0.68[c]	0.10

Data are means of experiment examined in duplicate.
[a–c] Means in the same row with different letters differ significantly at $P \leq 0.05$ by DMRT.

Oxidative stability

Results presented in Table 3 showed that cheeses made with dehydrated cranberry fruit extract powder had lower peroxide values ($P \leq 0.05$) compared with control cheese. Control cheese had the highest peroxide values (8.18 meq/kg oil) after 8 weeks of storage. The addition of dehydrated cranberry fruit extract improved cheeses stability for oxidation. Cranberry fruit extract (containing phenolic compounds) has the ability to act as an antioxidant (Gutiérrez-Larraínzar *et al*., 2012). The peroxide values were increased significantly in all different experimental cheese which improved storage period. Also, the results indicated that the peroxide values decreased with increasing of cranberry fruit extract powder concentration. It was reported that a functional cheese product containing polyphenolic compounds was developed, and the polyphenolic retention efficiency and antioxidant property of the product evaluated (Han *et al.*, 2011a,b). As storage period improved, the acid value increased gradually in all treatments as shown in Table 3. The acid value of control cheese was significantly higher than that of experimental cheese and this attributes to the extensive fat hydrolysis and liberation of free fatty acids, which cause gradual increase in rancidity during storage. Control cheese had the highest acid value followed by samples with 500, 750 and 1000 ppm of dehydrated cranberry fruit extract powder. Control cheese recorded 1.26 mg KOH/g oil after 8 weeks of storage.

Microbiological changes of cheese during storage period

Changes in some microbiological properties of cheese samples were shown in Table 4. The results showed that the total bacterial counts increased continuously during storage period. Psycrotrophic counts of the samples were changed < 0.11-2.98 log cfu/g. Psycrotroph counts of all samples were to $10^3 \leq$ cfu/g. Psycrotroph counts of the samples were affected by dehydrated cranberry fruit extract powder concentration and decreased with the increase of extract concentration. Psycrotrophic counts of the samples treated with 1000 ppm dehydrated cranberry fruit extract powder were lowest. Proteolytic and lipolytic bacterial counts increased during the first 4 weeks then decreased at the end of storage period as compared with control samples and also decreased with increasing dehydrated cranberry fruit extract powder concentration. *Enterobactericeae*, coliform and *S. aureus* were not detected in any cheese samples (except in control sample for *Enterobactericeae*). High enterococci (feacal streptococci) counts were detected in the most of the samples. These bacteria reached levels above 4 log cfu/g in some of samples examined. Enterococci were often found in the environment of the dairy industry (equipment and

Table 4. Microbiological changes of white soft cheese with dehydrated cranberry fruit extract during storage period at 5ºC for 8 weeks

Log cfu/g	Storage period (weeks)	Treatments				LSD
		Control	Cranberry fruit extract (ppm)			
			500	750	1000	
Total bacterial	Fresh	5.12[a]	4.39[b]	3.96[c]	3.26[d]	0.27
	2	5.45[a]	5.19[a]	4.76[b]	3.51[c]	0.30
	4	6.17[a]	5.37[b]	4.73[c]	4.03[d]	0.56
	6	6.87[a]	5.94[b]	5.01[c]	4.18[d]	0.40
	8	6.92[a]	6.27[b]	5.67[c]	4.81[d]	0.22
	Treatment mean	6.11[a]	5.43[b]	4.83[c]	3.96[d]	0.31
Psychrotrophic	Fresh	2.63[a]	1.75[b]	0.72[c]	0.49[c]	0.44
	2	2.91[a]	1.74[b]	0.67[c]	0.38[c]	0.29
	4	2.79[a]	1.58[b]	0.35[c]	0.11[d]	0.14
	6	2.83[a]	1.37[b]	0.13[c]	-	0.10
	8	2.98[a]	2.07[b]	0.93[c]	-	0.29
	Treatment mean	2.83[a]	1.70[b]	0.56[c]	0.20[d]	0.13
proteolytic	Fresh	2.58[a]	1.82[b]	1.08[c]	0.67[d]	0.20
	2	2.88[a]	2.17[b]	1.27[c]	1.15[c]	0.48
	4	3.1[a]	2.52[b]	1.55[c]	1.03[d]	0.29
	6	1.99[a]	1.11[b]	0.34[c]	-	0.49
	8	1.25[a]	0.66[b]	-	-	0.15
	Treatment mean	2.36[a]	1.66[b]	0.85[c]	0.57[c]	0.32
Lipolytic	Fresh	2.26[a]	1.66[b]	0.78[c]	0.67[c]	0.23
	2	2.59[a]	2.03[b]	1.07[c]	0.93[c]	0.27
	4	2.85[a]	2.39[b]	1.28[c]	1.05[c]	0.31
	6	3.02[a]	2.52[b]	1.45[c]	1.25[c]	0.23
	8	2.34[a]	1.71[b]	1.31[c]	0.98[c]	0.34
	Treatment mean	2.61[a]	2.07[b]	1.18[c]	0.98[d]	0.15
Enterococci	Fresh	3.67[a]	3.06[b]	2.92[c]	2.14[d]	0.10
	2	4.12[a]	3.23[b]	3.04[c]	2.19[d]	0.17
	4	4.14[a]	3.14[b]	3.15[b]	2.13[c]	0.07
	6	4.61[a]	3.29[b]	3.18[b]	2.19[c]	0.17
	8	4.15[a]	3.10[b]	2.80[b]	1.98[c]	0.32
	Treatment mean	4.14[a]	3.16[b]	3.02[c]	2.13[d]	0.12
Yeast and mould	Fresh	2.64[a]	2.03[b]	1.97[b]	2.01[b]	0.51
	2	3.24[a]	2.23[b]	1.96[c]	1.33[d]	0.23
	4	3.76[a]	2.93[a]	3.55[b]	2.04[c]	0.39
	6	4.32[a]	3.20[b]	2.96[c]	2.15[d]	0.20
	8	4.28[a]	3.68[b]	3.39[c]	2.48[d]	0.27
	Treatment mean	3.65[a]	2.81[b]	2.77[b]	2.00[c]	0.31

Data are means of experiment examined in duplicate.

[a–d] Means in the same row with different letters differ significantly at $P \leq 0.05$ by DMRT

plant personal). Yeast and mould counts in the samples were ranged from 1.33 to 4.32 log cfu/g. yeast and moulds may grow in the lower pH values, and the higher numbers of these organisms in the cheese samples may originate from the added dehydrated cranberry fruit extract powder. Yeast and mould counts of the samples were affected by increasing dehydrated cranberry fruit extract powder concentration. The ability of an array of PCs, e.g., ferulic acid, tea catechins, oleuropein, ellagic acid and p-coumaric acid, to inhibit the growth of bacteria *(Salmonella enteritidis, Staphylococcus aureus, Listeria monocytogenes)* and fungi in milk has been reported (Payne *et al*., 1989; Tassou and Nychas, 1994; Rosenthal *et al.*, 1997, 1999; Schaller *et al.,* 2000). The antimicrobial effect of PCs, which is not exclusive to milk systems (Chung *et al*., 1998), is probably related to the inhibition of bacterial enzymes, alterations in cell wall permeability, an increase in the hydrogen ion activity of the microbial environment, a reduction in the surface and/or interfacial tension and perhaps most importantly, chelation of essential minerals, particularly iron with a concomitant impairment of the microbial oxidative metabolic system (Marouchoc, 1979; Singleton, 1981; Chung *et al*., 1998). Interestingly, Rosenthal *et al.* (1997, 1999) reported that tea catechins and ferulic acid inhibit the growth of pathogenic bacteria (coliforms and *Salmonella*) with little effect on lactic acid bacteria, presumably because of the fermentative metabolism of the latter. As stated above, some PCs have been shown to inhibit the growth of fungi. However, others, such as oleuropein, have been reported to enhance the growth of fungi but to markedly inhibit the production of aflatoxins (Bullerman and Gourma, 1987). Such properties

Table 5. Sensorial changes of white soft cheese with dehydrated cranberry fruit extract during storage period (at 5ºC for 8 weeks)

Items	Storage period (weeks)	Treatments				LSD
			Cranberry fruit extract (ppm)			
		Control	500	750	1000	
Appearance (10)	Fresh	8.40^{a}	8.20^{a}	7.80^{a}	7.00^{a}	1.37
	2	7.50^{a}	7. 20^{a}	7.10^{a}	7.10^{a}	0.95
	4	6.20^{a}	6.60^{a}	8.33^{a}	6.80^{a}	1.62
	6	6.60^{a}	7.20^{a}	7.40^{a}	7.40^{a}	1.27
	8	6.00^{b}	7.00^{ab}	7.20^{a}	7.60^{a}	1.05
	Treatment mean	6.94^{b}	7.24^{a}	7.57^{a}	7.18^{ab}	0.45
Body and texture (40)	Fresh	35.00^{a}	35.00^{a}	35.33^{a}	36.00^{a}	2.87
	2	34.33^{b}	36.00^{ab}	37.33^{a}	38.67^{a}	2.82
	4	34.17^{a}	34.00^{a}	35.00^{a}	35.33^{a}	5.10
	6	35.00^{a}	36.00^{a}	36.67^{a}	37.00^{a}	2.71
	8	32.00^{a}	34.33^{a}	33.67^{a}	34.67^{a}	5.15
	Treatment mean	34.10^{c}	35.07^{bc}	35.60^{ab}	36.33^{a}	1.12
Flavour (50)	Fresh	40.67^{a}	41.00^{a}	40.00^{a}	41.33^{a}	12.89
	2	41.17^{a}	41.67^{a}	41.00^{a}	41.67^{a}	8.67
	4	35.00^{a}	37.33^{a}	36.33^{a}	34.33^{a}	5.27
	6	40.00^{a}	41.00^{a}	41.00^{a}	40.00^{a}	6.82
	8	39.00^{a}	37.33^{a}	39.67^{a}	38.00^{a}	9.90
	Treatment mean	39.17^{a}	39.67^{a}	39.60^{a}	39.07^{a}	2.49
Total scores (100)	fresh	84.07^{a}	84.2^{a}	83.13^{a}	84.33^{a}	17.13
	2	83.00^{c}	84.87^{b}	85.43^{b}	86.44^{a}	12.43
	4	75.37^{a}	77.93^{b}	79.66^{ac}	76.40^{a}	11.99
	6	81.60^{b}	84.2^{a}	85.07^{a}	84.40^{a}	10.8
	8	77.00^{c}	78.66^{b}	80.54^{a}	80.27^{a}	16.1
	Treatment mean	80.21^{b}	81.97^{a}	82.77^{a}	82.37^{a}	13.98

Data are means of experiment examined in duplicate.

$^{a-c}$ Means in the same row with different letters differ significantly at $P \leq 0.05$ by DMRT.

would appear to be advantageous in mould-ripened cheeses where the growth of moulds is desirable while the production of mycotoxins may present a health risk (Jarvis, 1983). The presented data of this study are in agreement with Gutiérrez-Larraínzar *et al*. (2012) who found that the Gram-positive bacteria were more sensitive than Gram-negative ones for the majority of the phenolic compounds.

Sensorial characteristics of cheese

Mean scores of the sensory panels for cheese samples were listed in Table 5. These data showed that appearance, texture and flavor of cheeses were affected by addition of fruit extract to cheese milk. The effect of fruit extract powder addition was slight rose on appearance-color. Body and texture properties had higher consistency than control cheese samples. Increasing fruit extract powder addition in cheese had insignificant to flavor. Han *et al.* (2011a) described the potential of milk supplementation with polyphenols (Single phenolic compounds, including catechin, epigallocatechin gallate (EGCG), tannic acid, homovanillic acid, hesperetin and flavones, and natural crude compounds, such as grape extract, green tea extract, and dehydrated cranberry powder, were added as functional ingredients to the prepared cheese) in the developed novel cheese products with incorporated nutraceutical bioactive compounds. Phenolic compounds varied in terms of their recuperative rates in cheese curd with different molecular weights, structures, and polarities. They evidenced different levels of retention in the cheese curds, which varied widely in terms of their effects on gel-formation behaviors, depending on their molecular properties, and their hydrophobicity was particularly relevant. Cheese curds with polyphenolic compounds at a concentration of 0.5 mg/mL showed effective free radical-scavenging activity (Han *et al.*, 2011a). The nutritional value of cheese product was improved by adding bioactive phenolic compounds

to the cheese curd. These results suggest that we may apply this approach to other dairy products for better quality and functionality of the products. Further studies need to be made on the actual consequences in cheese making, and we furthermore anticipate that this technology could be applied to other dairy products like yogurt or milk shake containing phenolic compounds as functional ingredient. From the foregoing results, it could be concluded that the addition of dehydrated cranberry fruit extract powder increased moisture contents of Tallage cheese. The titratable acidity of cheese samples decreased with cranberry fruit extract addition. The ripening indices, SN/TN%, NPN/TN% and TVFA of cheeses decreased with increase the level of cranberry fruit extract. The herb levels of the samples might be expected to influence the microbial counts. Moreover, cranberry fruit extract treatments had a significant effect on the yield and recovery of fat, protein and total solids of the fresh cheese produced. The sensory properties of samples with cranberry fruit extract addition had higher scores compared with control cheese, but there was a slight rose appearance-color in produced cheese with high concentrations of cranberry fruit extract. The most acceptable cheeses were those made 750 ppm with cranberry fruit extract to improve the keeping quality of white soft cheese.

Conclusion

The commercial development of ingredients from plants to enhance the properties of foods for both nutritional purposes and for preservation is currently of major interest. Natural flavonoids may offer an alternative to protect lipids from oxidation in foods. Cranberries are a rich source of phenolic acids, anthocyanins, flavonol glycosides and proanthocyaninidins. The results of present study suggest that the cranberry extract can be use as a functional ingredient by improving the storage stability in white soft cheese. Treated cheese with cranberry fruit extract have significantly less numbers of total, psychrotrophic, enterococci, proteolytic, lipolytic bacteria, yeast and mould counts than the control cheese. Cranberry fruit extract treatments had a significant effect on the yield and recovery of fat, protein and total solids of fresh cheese. Treatment 750 ppm is recommended for white soft cheese could successfully improve the keeping quality without affecting the final product.

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