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EXPLORING THE POTENTIAL OF ACTIVE EDIBLE COATING ON THE SHELF STABILITY OF DAIRY PRODUCTS

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The current study was conducted to evaluate the impact of active edible coating containing natural essential oils (EOs) on the storage stability of butter and soft cheese (SC). The major issue in storage stability of butter is lipid oxidation due to high fat content while in soft cheese is mold growth due to its high moisture content. SC samples (T_0, whey powder based edible coating of SC; T_1, whey powder based edible coating of SC containing 0.5% clove oil; T_2, whey powder based edible coating of SC containing 0.75% clove oil; T_3, whey powder based edible coating of SC containing clove oil 1.0%; T_4, whey powder based edible coating of SC containing 1.5% pepper mint oil; T_5, whey powder based edible coating of SC containing 2.0% pepper mint oil and T_6, whey powder based edible coating of SC containing 2.5% pepper mint oil) were analyzed for antioxidant activity during 30 days of storage. Similarly butter samples (T_0,corn starch based edible coating of butter; T_1; corn starch based edible coating of butter containing 0.2% black cumin oil; T_2, corn starch based edible coating of butter containing 0.3% black cumin oil; T_3, corn starch based edible coating of butter containing 0.4% black cumin oil; T_4, corn starch based edible coating of butter containing 1.5% ginger oil; T_5, corn starch based edible coating of butter containing 2.0% ginger oil; T_6, corn starch based edible coating of butter containing 2.5% ginger oil) were analyzed for antioxidant activity, FFA, fat and water activity (a_w) during 90 days of storage period at 2-5°C. Sensory evaluation of SC and butter was also done to determine the overall acceptability. Active edible coated SC samples containing clove oil and coated butter samples containing ginger oil showed the highly significant ($p<0.01$) results. So, the storage stability of SC and butter can be enhanced by using active edible coating containing EOs with better sensory attributes.

Keywords: Synthetic preservatives, storage stability, oxidative rancidity, natural antioxidants, mold, chymosin.

INTRODUCTION

Nowadays industries are facing problems against using chemical or synthetic preservatives to enhance the shelf stability of dairy products due to consumer awareness and bad health effects of such additives. Soft cheese and butter are dairy products that are consumed worldwide directly and indirectly in a number of food products due to its therapeutic and nutritional significance. Cheese is very popular in the world due to variety in functionality, flavor, texture and nutritional value. Soft cheese is biologically and biochemically active due to its high level of moisture contents and subsequently undergoes changes in flavor, functionality, loss in moisture, mold growth, texture, and causes oxidation during storage that ultimately causes the deterioration (Fox *et al.*, 2000). Fat is a major constituent in butter that plays a very vital role in flavor, nutritional value, appearance, body/texture and shelf stability. Butter due to its high fat contents is more vulnerable to oxidative deterioration that leads to the reduction of nutritional quality and also makes the food unacceptable for consumers. Oxidation of fats not only deteriorate the quality of soft cheese and butter, causes many human diseases like cardiovascular diseases, membrane damage, cancer and ageing so that antioxidants are added in foods to prevent or delay oxidation (Larick and Parker, 2001). According to Mata *et al.* (2007), the big problem of the dairy industry is the low storage stability of dairy products due to oxidation reactions such as fungal attack, degradation due to oxidative rancidity and mold growth. At present to prevent these problems synthetic or chemical preservatives are being used. Consumers have become more conscious about the selection of food due to awareness about the use of synthetic or chemical preservatives in the foods due to their toxicity and bad health effects. So natural antimicrobials and antioxidants had attracted great attention due to its harmless health effect to enhance the shelf life; increase food stability and also considered to be an essential part of food. This has become a big challenge for industries to reduce the use of conventional chemical preservatives for the safe end product (Tepe *et al.*, 2005).

In this perspective; the demand of edible coating is increasing day by day. Edible coating is a thin layer of material that covers the surface of the food and can be eaten as part of the whole product (Kang *et al.*, 2013). Edible coatings have also gained much attention because of increasing environmental pollution due to synthetic packaging (Andrade *et al.*, 2012).

Edible coatings have the advantages that these are edible, give appealing appearance to food, non-polluting and biodegradable. Edible coatings can perform technological functions as they can be used by the incorporation of different food additives which help to extend the shelf life of food. Active edible coating is a carrier of active ingredients (antioxidants and antimicrobials) and can be incorporated with enzymes, vitamins, minerals, colorants, flavors, probiotics and nutraceuticals (Vasconez *et al.,* 2009). Keeping in view the bad health effects and consumer awareness about the use of synthetic antioxidants and antimicrobial agents, problems related to the storage stability of soft cheese, consumer demand about the use of natural essential oils as antioxidants and antimicrobial, unique role of active edible coating, the research work was designed with the hypothesis to produce soft cheese and butter with longer shelf life by the application of active edible coating containing natural essential oils as active ingredient.

MATERIALS METHODS

***Procurement of raw materials*:** Raw buffalo milk was used for soft cheese (SC) production obtained from the Dairy Farm, University of Agriculture, Faisalabad, Pakistan. Xanthan gum, lecithin, glycerol and whey powder (WP) were procured from local market of Faisalabad, Pakistan. Rennet (chymosin) used for the coagulation of milk and lyophilized thermophilic starter cultures (*Lactobacillus bulgaricus* and Strepto*coccus thermophilus*) used for cheese manufacturing were obtained from SACCO. Clove oil (CO) and peppermint oil (PMO) for soft cheese while black cumin oil (PMO) and ginger oil (GO) for butter were procured from Hafiz Jee Oil and Perfume Company (HJOPC) Lahore, Pakistan.

***Development of active edible coating for SC and butter*:** Edible coating for SC and butter was developed by following the method of Yongling *et al*. (2011) with little modification. In the preparation of active edible coating for soft cheese, 5g whey powder was used as base material of coating, 2g xanthan gum to enhance the viscosity and 0.5 g lecithin as emulsifier was taken in a 250 mL beaker. Ten mL glycerol as plasticizer was added in beaker and then made the total vol. 100 mL by adding the distilled water. Continuous stirring was done with sitter to homogenize the coating solution and the material was heated in water bath at 55 to 60°C for 8 min to make the coating solution viscous and uniform. Cooling was done by covering the beaker with aluminum foil at room temperature. After these three different concentrations (0.5, 0.75 and 1.0%) of clove and PMO (1.5, 2.0 and 2.5%) were added as active ingredient in coating solution and then stored at refrigeration temp (2-5°C). Similarly, in the preparation of active edible coating for butter, 3g corn starch, 2g xanthan gum and 0.5 g lecithin was taken in a 250 mL beaker. Ten mL glycerol as plasticizer was added in beaker and then made the total volume 100 mL by adding the distilled water. Continuous stirring was done with sitter to homogenize the coating solution and it was heated in water bath at 60-65°C for 8-10 min to make the coating solution viscous and uniform. Cooling was done by covering the beaker with aluminum foil at room temperature. After these three different concentrations (0.2, 0.3, and 0.4%) of BCO and GO (1.5, 2 and 2.5%) were added as active ingredient in coating solution and then applied on butter.

Treatment plan of SC

Treatment	Soft cheese coating	Clove oil (CO) (%)	Pepper mint (PMO) (%)
T_0 (Control)	-	-	-
T_1	+	0.5	-
T_2	+	0.75	-
T_3	+	1.0	-
T_4	+	-	1.5
T_5	+	-	2.0
T_6	+	-	2.5

Treatment plan of butter

Treatment	Butter coating	Black cumin oil (BCO) (%)	Ginger oil (GO) (%)
T_0 (Control)	-	-	-
T_1	+	0.2	-
T_2	+	0.3	-
T_3	+	0.4	-
T_4	+	+	1.5
T_5	+	+	2.0
T_6	+	+	2.5

***Chemical analysis of edible coating*:** Edible coating solution was analyzed for pH by using pH meter (Ong *et al*., 2007), acidity by titration method (AOAC, 2000) and water activity (a_w) by El-Nimr *et al*. (2010).

***Diphenyl-1-picrylhdrazyl (DPPH) scavenging activity*:** Method of Ghafoor *et al*. (2010) was used to check the free radical scavenging activity of SC and butter samples.

***Peroxide value (POV)*:** POV of SC and butter samples were determined by the method of AOAC 926.08 (2000).

***Measurement of Thiobarbituric acid reactive substance (TBARS) value*:** Method of Luo *et al*. (2011) was used to determine the (TBARS) value that is thiobarbituric acid reactive substances in butter and SC samples.

***Fat content*:** Gerber method was used to determine the fat content in butter sample as described by Marshal (1993).

***Water Activity (a_w)*:** Water activity of butter samples was determined according to the method described by El-Nimr *et al*. (2010).

***Free Fatty Acid (FFA)*:** According to the standard method of AOAC 920.124 (1990), FFA were determined in butter samples.

***Sensory evaluation of SC and butter*:** Sensory evaluation of butter and SC was done according to the method described by Ganesan *et al.* (2014).

Statistical analysis: The obtained data was statistically analyzed using 2 factor factorial under CRD explained by Steel *et al*. (1997) to estimate the effect of active edible coating containing essential oils on the acceptability and quality of butter and SC.

RESULTS AND DISCUSSION

Antioxidative activity of SCDPPH: Storage days and treatments significantly ($p<0.01$) affected the DPPH activity of soft cheese (SC) (Table 1). Data showed that the highest value of DPPH activity (84.96%) was recorded in T_3 (WP based edible coating of SC containing 1.0% CO) at 1st day while the lowest value of DPPH activity (53.32%) was noted in control SC (T_0) at 30th day. In all cheese samples, control T_0 cheese show minimum DPPH value during storage periods. Results revealed that there was a significant difference among all the SC samples which were prepared with whey powder (WP) based active edible coating containing clove and peppermint oil as active ingredient. Results also shows that there was a positive correlation between essential oil concentration and DPPH activity as the concentration of clove oil (CO) and peppermint oil (PMO)was increased in edible coating of samples DPPH activity was also increased and vice versa. However, the higher concentrations of oil affected the sensory attributes. During storage of 30 days a significant decrease in DPPH activity of SC was noted in all SC samples but the reduction rate was less in the samples which contain higher concentration of CO and PMO. PMO and CO were found to be very effective in shelf life extension of SC due to their antioxidant potential to scavenge free radicals in SC samples that ultimately prevent the spoilage of SC samples. The results of DPPH activity were in agreement with the findings of Hala *et al*. (2010) who also noted that DPPH activity decreases during storage period.

Peroxide value (POV): The mean POV values for SC showed that active edible coating containing natural essential oils significantly ($p<0.01$) effected the POV of SC (Table 1). Data revealed that the maximum POV (1.826meq O_2/kg) was noted in T_0 at 30th day while the minimum POV (0.278meq O_2/kg) was recorded in T_3 (WP based edible coating of SC containing 1.0% CO) at 1st day. All the SC samples which were prepared with WP based active edible coating containing clove and peppermint oil as active ingredient showed consistent increase in POV during storage period of 30 days as compared to control (T_0). Among soft cheese samples, control (T_0) showed the highest POV value during storage intervals. Mean POV values for all SC samples at 15 and 30 days of storage showed a significant increase. There was inverse relationship between EOs concentration and POV as the concentration of EOs increased in SC samples POV decreased and vice versa

Table 1. Effect of treated soft cheese on DPPH activity (%) and POV (meqO_2/kg) during storage.

Treatments	Variants					
	DPPH			POV		
	1st Day	15 Days	30 Days	1st Day	15 Days	30 Days
T_0	76.80±1.05cd	65.20±0.47ghi	53.32±0.34jk	0.285±0.009d	0.720±0.017c	1.826±0.024ab
T_1	83.10±1.28de	76.07±1.68cde	65.31±1.08hij	0.281±0.006d	0.720±0.015c	1.725±0.014b
T_2	84.18±1.82def	76.82±0.58bcd	65.97±1.45ghi	0.280±0.006d	0.715±0.020c	1.720±0.047b
T_3	84.96±0.66def	77.25±1.55ab	66.70±1.38jkl	0.278±0.015d	0.710±0.006c	1.715±0.023b
T_4	83.01±2.24de	75.90±0.87abc	65.02±1.62ghi	0.285±0.013d	0.724±0.014c	1.721±0.035b
T_5	83.92±1.83de	76.35±1.70bcd	65.41±1.52ghi	0.284±0.007d	0.715±0.014c	1.720±0.040b
T_6	84.54±0.76def	76.90±1.52cde	66.10±1.07ijk	0.284±0.007d	0.710±0.020c	1.715±0.052b

In a column or row means having similar letters are statistically NS ($P>0.05$); Interaction means comparison is represented by (a-z) letters.

Table 2. Effect of treated soft cheese on TBARS (mg malonaldehyde /kg) during storage.

Treatments	Variants		
	TBARS		
	1st Day	15 Days	30 Days
T_0	0.167±0.004d	0.291±0.003b	0.376±0.008a
T_1	0.163±0.007d	0.230±0.005c	0.321±0.004b
T_2	0.157±0.003d	0.228±0.011c	0.318±0.008b
T_3	0.153±0.003d	0.225±0.008c	0.312±0.005b
T_4	0.165±0.003d	0.234±0.005c	0.326±0.006b
T_5	0.159±0.005d	0.231±0.009c	0.322±0.002b
T_6	0.157±0.008d	0.226±0.010c	0.312±0.008b

In a column or row means having similar letters are statistically NS ($P>0.05$); Interaction means comparison is represented by (a-z) letters.

but overall values of all the SC samples decreased during storage. Free radicals were produced during the storage of SC leads to the formation of aldehydes and ketones, resulted in the production of off flavor/bad smell and rancidity that ultimately causes the spoilage of cheese. PMO and CO due to their antioxidative potential inhibited the production of free radicals that ultimately prevented the spoilage of SC samples. Results of POV were in line with the findings of various other researchers, they also observed that POV decreases during storage (Mervat *et al*., 2010; O'Connor and O'Brien, 2006).

***Measurement of TBARS value*:** The mean TBARS values of SC samples revealed that active edible coating composed of natural essential oils and storage days had significant ($p<0.01$) impact. Control showed the highest (0.376 mg malonaldehyde /kg) value of TBARS at 30th day while the lowest TBARS (0.139 mg malonaldehyde /kg) value was found in T_3(WP based edible coating of SC containing 1.0% CO) at 1stday. All the SC samples which were prepared with WP based active edible coating containing clove and PMO as active ingredient showed the gradual increase in thiobarbituric acid (TBA) value during storage period of 30th days as compared to control. Results also showed that TBA value was negatively correlated with CO and PMO concentration. Mean TBA values for SC samples at different storage intervals showed a significant increase. Results of TBARS values were in accordance with the earlier findings of Simsek (2011) who has reported that TBA value decreases during storage.

***Antioxidative activity of butter DPPH*:** Results revealed that active edible coating containing essential oils and storage period significantly ($p<0.01$) affected the DPPH activity of butter samples (Table 3). Data showed that the highest (81.60%) value of DPPH activity was recorded in T_6 (WP based edible coating of butter containing 1.0% CO) at 1stday while the lowest (51.75%) value was noted in control butter sample (T_0) at 90th day. In all the butter samples, control (T_0) showed the lowest DPPH value during storage intervals. Results also revealed that there was a significant difference among all the butter samples which were prepared with corn starch (CS) based active edible coating containing black cumin and ginger oil (GO) as active ingredient. There was a positive correlation between natural essential oil concentration and DPPH activity as the concentration of BCO and GO was increased in edible coating of butter samples DPPH activity was also increased and vice versa but higher concentration affected the sensory attributes. During storage of 90 days a significant decrease in DPPH activity of butter was noted in all butter samples but the reduction rate was less in the samples which contain higher concentration of BCO and GO. BCO and GO were very effective to prolong the shelf life of edible coated butter due to their activity against the production of free radicals that ultimately prevented the

Table 3. Effect of treated butter on DPPH activity (%) and POV (meqO_2/kg) during storage.

Treatments	Variants					
	DPPH			POV		
	1st Day	45 Days	90 Days	1st Day	45 Days	90 Days
T_0	74.42±1.31ab	63.20±0.74ghi	51.75±0.71pqr	0.140±0.003op	0.550±0.007i	1.610±0.023b
T_1	76.42±1.78bcd	68.23±1.32gjk	57.45±1.11jkl	0.110±0.002op	0.470±0.006ij	1.450±0.046c
T_2	78.20±0.81cde	70.40±1.29ab	59.50±0.69klm	0.100±0.006op	0.440±0.012ijk	1.420±0.035cd
T_3	80.31±1.39bdf	72.10±1.78abc	60.20±0.99klm	0.100±0.012op	0.420±0.015jkl	1.400±0.029cde
T_4	78.35±0.56cde	70.34±0.95ab	58.90±1.36gjk	0.090±0.001op	0.410±0.006jkl	1.420±0.035cd
T_5	79.50±1.92adf	71.30±1.78abc	60.10±0.82klm	0.080±0.002op	0.380±0.006jkl	1.370±0.035cde
T_6	81.60±1.40def	73.64±0.79acd	62.30±1.35mno	0.071±0.003op	0.360±0.007jm	1.330±0.029de

In a column or row means having similar letters are statistically NS ($P>0.05$); Interaction means comparison is represented by (a-z) letters.

Table 4. Effect treated butter on TBARS (mg malonaldehyde /kg) and fat (%) during storage.

Treatments	Variants					
	TBARS			Fat		
	1st Day	45 Days	90 Days	1st Day	45 Days	90 Days
T_0	0.080±0.000kl	0.210±0.006fg	0.320±0.006b	79.48±0.612a	79.55±0.687a	79.75±0.595bc
T_1	0.080±0.000kl	0.170±0.000h	0.270±0.006c	79.49±0.572a	79.52±0.266a	79.68±0.456b
T_2	0.070±0.000klm	0.170±0.000h	0.250±0.000cde	79.50±0.375a	79.50±0.641a	79.67±0.804b
T_3	0.070±0.000klm	0.150±0.000hi	0.240±0.006de	79.50±0.566a	79.50±0.577a	79.67±0.341b
T_4	0.090±0.000jk	0.170±0.008h	0.270±0.006c	79.50±0.843a	79.52±0.843a	79.70±1.057bc
T_5	0.070±0.003klm	0.160±0.009hi	0.250±0.006cde	79.51±0.254a	79.51±0.803a	79.69±0.323bc
T_6	0.062±0.003lmn	0.160±0.006hi	0.240±0.008de	79.52±0.722a	79.52±0.774a	79.70±0.531bc

In a column or row means having similar letters are statistically NS ($P>0.05$); Interaction means comparison is represented by (a-z) letters.

spoilage of butter samples. The results of DPPH activity were in agreement with the findings of Sultan *et al*. (2009) they also found that DPPH activity decreases during storage. Hala *et al*. (2009) also showed the same results.

***Peroxide value (POV)*:** The mean POV values for butter showed that active edible coating containing natural essential oils and storage period significantly ($p<0.01$) effected the POV of butter samples (Table 3). Data revealed that the maximum POV (1.610meq O_2/kg) was reported in control (T_0) at 90th day while the minimum POV (0.07meq O_2/kg) was noted in T_6(CS based edible coating of butter containing 2.5% GO) at 1stday. All the butter samples which were prepared with CS based active edible coating containing black cumin and GO as active ingredient showed the consistent increase in POV during storage period as compared to control. Among butter samples, T_0 showed the highest POV value during different storage intervals. Mean POV for all butter samples at 45 and 90 days of storage showed a significant increase. Moreover, there was a negative correlation between EOs concentration and POV. Moreover, free radicals were produced during the storage of butter; leads to the formation of aldehydes and ketones resulted in the production of off flavor/ bad smell and rancidity that ultimately causes the spoilage of butter. BCO and GO due to their antioxidative potential inhibited the production of free radicals. Results of POV are in line with the findings of Ozkan *et al*. (2007) and Simsek (2011) who observed that POV decreases during storage.

***Measurement of TBARS value*:** The results presented in Table 4 indicate that increase in storage time results in an increased production of TBARS, and all the treatments significantly reduced the TBARS values on respective storage days. Control showed the highest value of TBARS (0.320 mg malonaldehyde /kg) at 90th day while the lowest TBARS (0.062 mg malonaldehyde /kg) value was noted in T_6 (CS based edible coating of butter containing 2.5% GO) at 1st day. All the butter samples which were prepared with CS based active edible coating containing black cumin and GO as active ingredient showed the gradual increase in TBA value during storage period of 90 days as compared to control. Results also showed that there was a negative correlation between natural essential oil concentration and TBARS value. Mean TBARS values for SC samples at 15 and 30 days of storage showed a significant increase. Results of TBARS were resembled with the earlier findings of Dagdemir *et al*. (2009) who also reported that TBA value decreases during storage.

***Chemical analysis of butter Fat content*:** Results revealed that treatments, storage days have NS ($p>0.05$) variation in the fat contents of butter samples (Table 4). Finding of this experiment showed that there was NS difference among the butter samples which were formulated with CS based edible coating containing BCO and GO as active ingredient. During storage period of 90 days a minor increase in fat contents of butter was observed in samples which were formulated with edible coating containing natural EOs in different concentrations. Mean fat values for all butter samples at 45 and 90 days of storage showed a minor increase. Minor increase in fat content of butter samples was might be due to addition of BCO and GO. The slight increase in fat content of butter during storage was might be due to lipolysis and loss of moisture. The findings of this parameter were in accordance with the results of Simsek (2011) and Sagd *et al*. (2004), who observed the slight increase in fat content during storage of butter.

***Water activity (a_w)*:** Results revealed that treatments and storage days have significant ($p<0.05$) variation on a_w of butter (Table 5). All the butter samples which were formulated with CS based edible coating containing BCO and GO as active ingredient have more a_w as compared to T_0 butter during storage. During storage of 90 days a continuous decrease in a_w of butter was noted in butter samples which were formulated with edible coating containing different concentrations of EOs. Mean values of a_w for butter samples at 45 and 90 days of storage showed a significant decline. Edible coating serves as a barrier against moisture loss by covering the surface of butter samples so less moisture loss was observed in edible coated samples of butter. The overall values of a_w in all butter samples decrease but the rate of reduction is slow in all butter samples as compare to control butter. Results of a_w match with the earlier findings of Koca

Table 5. Effect of treated butter on water activity (a_w) and FFA (%) during storage.

Treatments	Variants					
	a_w			FFA		
	1st Day	45 Days	90 Days	1st Day	45 Days	90 Days
T_0	0.932±0.017a	0.730±0.006c-h	0.560±0.006lm	0.216±0.005f	0.376±0.007de	0.603±0.020ab
T_1	0.930±0.017a	0.740±0.006b-g	0.590±0.006klm	0.218±0.010f	0.349±0.008de	0.559±0.022bc
T_2	0.930±0.012a	0.770±0.012bcd	0.590±0.006klm	0.219±0.004f	0.345±0.006de	0.556±0.008bc
T_3	0.928±0.023a	0.780±0.017bcd	0.600±0.012jkl	0.219±0.007f	0.342±0.004e	0.552±0.009bc
T_4	0.929±0.015a	0.760±0.017b-e	0.630±0.006i-l	0.219±0.006f	0.349±0.006de	0.556±0.015bc
T_5	0.930±0.021a	0.780±0.015bcd	0.660±0.006g-k	0.220±0.006f	0.346±0.005de	0.551±0.026bc
T_6	0.930±0.017a	0.800±0.015bc	0.670±0.012f-k	0.220±0.005f	0.342±0.006e	0.545±0.014bc

In a column or row means having similar letters are statistically NS ($P>0.05$); Interaction means comparison is represented by (a-z) letters.

and Metin (2004) they also observed that a_w decreases in butter samples during storage.

***Free fatty acid (FFA)*:** The results presented in Table 5 indicate that increase in storage time results in an increased production of FFA, and all the treatments significantly reduced the FFA production on respective storage days. Data showed that the maximum FFA (0.603%) value was noted in T_0butter at 90th day. Butter samples which were formulated with CS based active edible coating containing BCO and GO as active ingredient showed the gradual increase in FFA during storage of 90 days as compared to T_0 butter. The overall values for butter showed consistent increase in FFA during storage. Mean values of FFA for butter samples at 45 and 90 days of storage showed a significant increase. FFA increase during storage in butter samples mainly due to the lipolysis but the rate of FFA production was slow in all the butter samples as compare to control butter due to effect of edible coating containing EOs. The findings of the FFA were similar with the results of Samet *et al*. (2009) who observed almost the same results in butter during storage.

***Sensory evaluation*:** Figures 1-8 showed that edible coating composed of natural essential oils have highly significant ($P<0.01$) effect on the sensory attributes (flavor, appearance, texture and overall acceptability) of SC and butter. Figure 4 shows that at the 30th day of storage period the order of overall acceptability of SC was T0 < T5 < T1 < T5 < T2< T3< T6 (highest score have T_6 and lowest have T_0). Similarly Figure 8 shows that at the 90th day of storage period the order of overall acceptability of butter was T_0< T1 < T4 < T2 < T3< T5 < T6 (highest score have T_6 and lowest have T_0). SC and butter sample containing higher concentration of essential oil received higher scores for each sensory attribute.

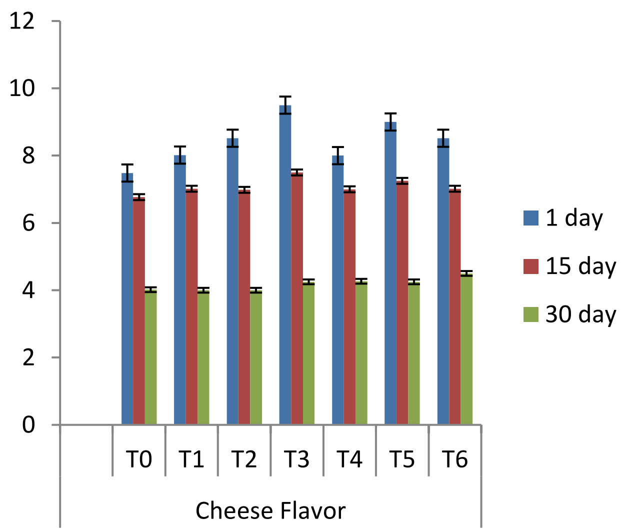

Figure 1. Effect of storage days and treatments on the flavor of soft cheese samples.

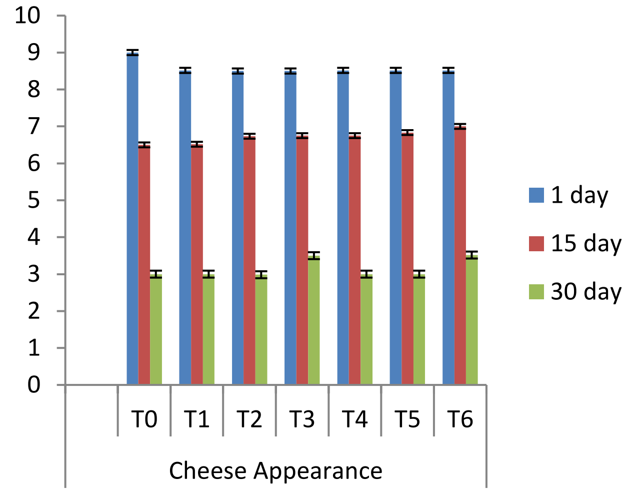

Figure 2. Effect of storage days and treatments on the appearance of soft cheese samples.

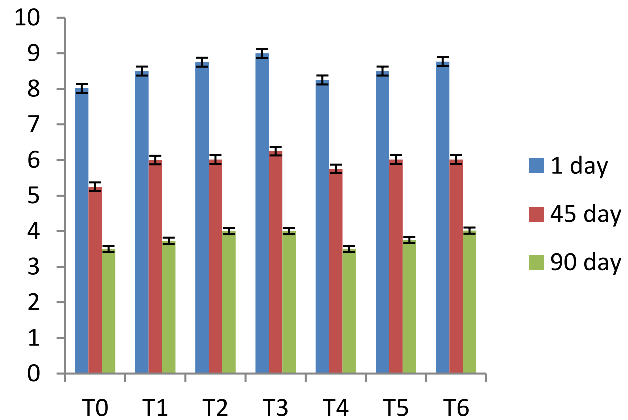

Figure 3. Effect of storage days and treatments on the texture of soft cheese samples.

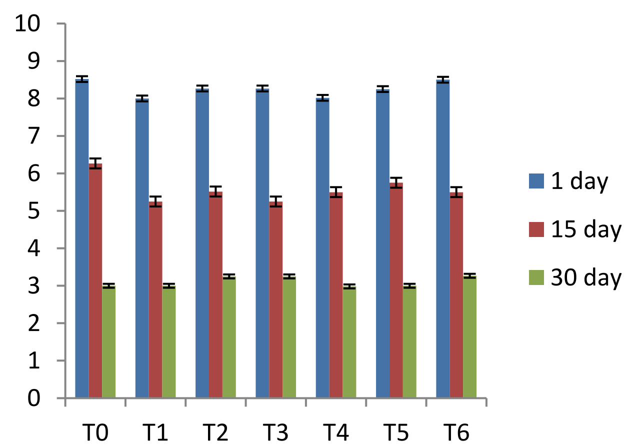

Figure 4. Effect of storage days and treatments on the overall acceptability of soft cheese samples.

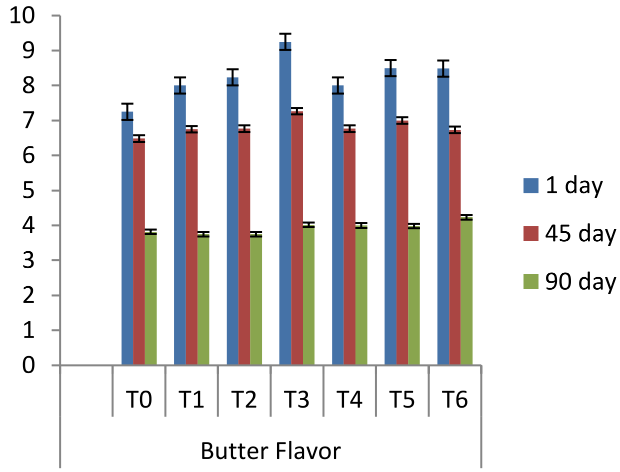

Figure 5. Effect of storage days and treatments on the flavor of butter samples.

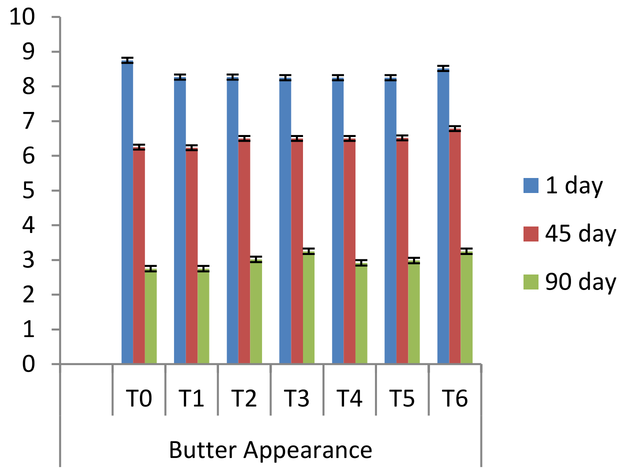

Figure 6. Effect of storage days and treatments on the appearance of butter samples.

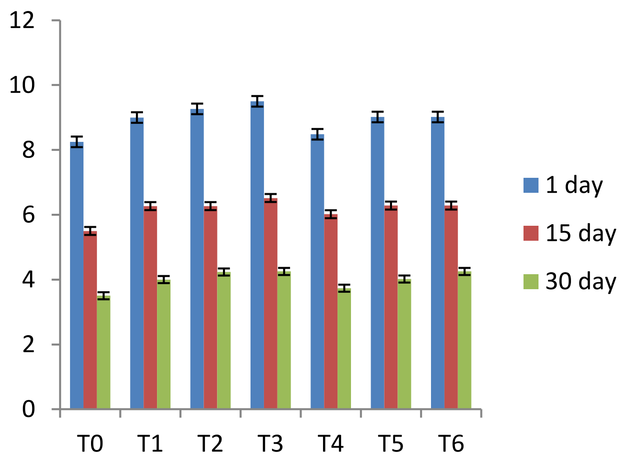

Figure 7. Effect of storage days and treatments on the texture of butter samples.

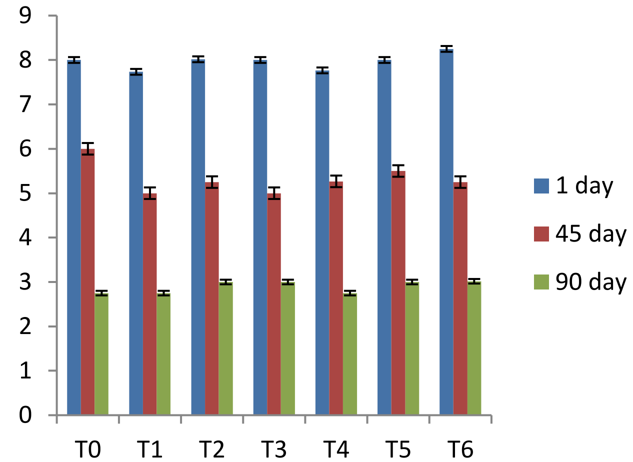

Figure 8. Effect of storage days and treatments on the overall acceptability of butter samples.

***Conclusion*:** So, the storage stability of SC and butter can effectively be enhanced by using active edible coating containing natural essential oil (EOs) with better sensory attributes. There was a positive correlation between the concentration of EOs in the edible coating and storage stability of SC and butter as the concentration of Eos was increased, the storage stability of the product was also increased. However, higher concentrations of EOs in the edible coating have negative impact on the sensory characteristics of SC and butter.

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