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Production and Evaluation of Soft Cheese Fortified with Ginger Extract as a Functional Dairy Food

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Key words: functional soft cheese, ginger extract, pickled and un-pickled soft cheese

Soft cheese fortified with ginger extract as a functional dairy food was evaluated. Buffalo's milk retentate was divided into three equal portions. One batch had no ginger extract as a control. The latter batches were fortified with extract at the rate of 1.5 or 3.0 g/kg. All batches were salted with 4% NaCl/water phase. The resultant cheese samples were divided into 2 parts; one was separately picked in salted permeate (4%), while the other was stored without pickling at 5±2°C for 6 weeks. The results revealed that cheese pickling increased the cheese proteolysis and lipolysis, and decreased pH and TVFAs. Fortification with ginger extract enhanced cheese proteolysis and TFVAs, while reduced pH value and oxidative rancidity of cheese. Physically, un-pickled soft cheese was more springy, harder, darker and more yellowish compared with pickled cheese samples. Ginger extract caused an increase in cohesiveness, whiteness and yellowish colour degree, and decrease in hardness of both pickled and un-pickled soft cheese. Ginger extract--fortified cheese enhances the growth of *L. lactis* ssp. *lactis* and *L. lactis* ssp. *cremoris* compared with control cheese. However, ginger extract exhibited the highest growth for *Lactococcus* strains in pickled cheese. Yeast and mould were detected only in cheese control sample after 2 weeks. Ginger extract--fortified cheese gained the highest scores for flavour, texture and overall acceptability in both pickled and un-pickled cheese, which became more acceptable to panelists than control cheese over storage.

INTRODUCTION

Since prehistorically time, herbs and spices have been used not just as food flavourings, but also for their medicinal properties, as well as for their preservative action that is derived from their antimicrobial and antioxidant constituents [Zheng & Wang, 2001; Bandyopadhyay *et al.*, 2007]. Among herbs and spices, ginger (rhizome of *Zingiber officinale* Roscoe, which belongs to the Zingiberaceae family) is well known in our daily diet. The use of ginger was recorded in early Sanskrit and Chinese texts as well as documented in ancient Greek, Roman and Arabic medical literature [Bone, 1997].

There are many varieties of ginger that have evolved naturally. All contain an essential oil and a resin, collectively called an oleoresin. The exact composition of either depends on the variety of ginger, the method of drying, extraction and storage [Bone, 1997]. The main constituents of ginger are gingerols, shogaols, zingerone and paradol. Also, 6-gingerol and 6-shogaol are the major gingerols and shogaols present in the rhizome [Langner *et al.,* 1998]. All of these compounds have antioxidant and anti-inflammatory, anticancer, antiemetic effect and can protect heart from blood clotting [Langner *et al.,* 1998; Craig, 1999; Mendi *et al.,* 2009]. Bandyopadhyay *et al.* [2007] found that ginger rhizome extract exhibited the highest antioxidant activity and had an activity comparable to commercial antioxidants such as TBHQ, BHA & BHT.

The essential oil, which is a mixture of monoterpenic and sesquiterpenic compounds, contains the volatile compounds responsible for the characteristic ginger flavour [Zancan *et al.,* 2002]. Ginger can also enhance shelf-life because of its antimicrobial nature [Adesokan *et al.,* 2010]. Ginger extract rich in gingerols and shogaols inhibited the growth of *M. avium*, *M. tuberculosis, E. coli* and *S. aureus* [Adeniran *et al.*, 2010], fungi [Ficker *et al.,* 2003] and can be used to protect immune-depressed patients, such as HIV positive [Hiserodt *et al.,* 1998].

From time immemorial, it has been observed that herb extracts were used for preserving poultry, meat, beef, fish, lard, soybean, *etc*. [Jamora & Rhee, 2002], but their use in dairy products has been scarce. Soft cheese is the most commonly consumed in Egypt. It is produced by different procedures, *i.e.* traditional methods and ultrafiltration (UF), and stored at low temperature with or without brine. UF technology has many advantages in cheese making such as increasing cheese yield and nutritive values, decreasing the production cost and solving the environmental problems related to whey disposal [Coker *et al.,* 2005; Mehaia, 2006]. On the other hand, UF-soft cheese was characterised by slow flavour, which was attributed to the concentration of proteinase and peptidase inhibitors by UF [El-Soda, 1997]. Therefore, the objective of this investigation was to produce and evaluate the physico--chemical, microbial and sensory properties of UF-soft cheese fortified with ginger extract as a functional dairy food.

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MATERIALS AND METHODS

Materials

Buffalo's milk retentate was obtained from Animal Production Institute, Ministry of Agriculture, Egypt. Fresh ginger rhizome was purchased from the local market at Cairo, Egypt. Calf rennet powder (HALA) and starter cultures (*Lactococcus lactis* ssp. *lactis* and *Lactococcus lactis* ssp. *cremoris*) were obtained from Chr. Hansen's Lab., A/S Copenhagen, Denmark.

Ginger extract

Fresh ginger rhizome was washed for any contaminates, peeled, crushed finely and ground to paste in mortar. The ginger paste was then soaked in 70% ethanol (1: 4) and kept for 3 days at 5±2°C. The extract was centrifuged at 5000 ×*g* for 30 min and this was repeated twice. The supernatant was collected and evaporated in a rotary vacuum evaporator (ROTAVAPOR R110, Buchi, Switzerland) at 50°C [Penna *et al.,* 2003].

Starter activation

Starter cultures were activated in maintenance broths (M 17) at 30ºC for 24 h. After activation they were centrifuged (15,000 ×*g* for 5 min at 4°C) in order to obtain pellet. Pellet was inoculated in 11% pasteurised skim milk powder for 24 h at 30ºC.

Cheese making

Buffalo's milk retentate was divided into three equal portions. One batch had no ginger extract as a control. The latter batches were fortified with ginger extract at the rate of 1.5 or 3.0 g/kg retentate. UF-soft cheese was made according to the method described by Renner & Abd El-Salam [1991]. All milk retentate batches were heated to 75°C, cooled to 38°C, inoculated with starter culture containing about 10^8 cfu/mL at the rate of 1% (4 x 10^6 cfu/g cheese) and held for 30 min. Salt (4% in water phase) was added to milk retentate and appropriate amount of rennet was added to achieve coagulation in 40 min. Milk retentate dispensed into plastic bags (500 mL), and held at 38°C until a uniform coagulum was formed. A part from resultant cheese was separately pickled in salted permeate (4% NaCl) and the other stored without permeate to create six treatments as shown in Table 1. All cheese samples were stored at 5±2°C for 6 weeks.

TABLE 1. Abbreviations of soft cheese treatments fortified with or without ginger extract.

Abbreviations	Treatments
C_1	Un-pickled soft cheese without ginger extract as a control 1.
T_1	Un-pickled soft cheese fortified with 1.5 g ginger extract / kg cheese.
T_2	Un-pickled soft cheese fortified with 3.0 g ginger extract / kg cheese.
C_2	Pickled soft cheese without ginger extract as a control 2.
T_3	Pickled soft cheese fortified with 1.5 g ginger extract / kg cheese.
T_4	Pickled soft cheese fortified with 3.0 g ginger extract / kg cheese.

Microbiological analysis

Ten g sample was taken from cheeses at the age of 0, 7, 15, 35 and 42 days, then homogenised in sterile 90 mL of 0.1% peptone water. Serial 8 fold dilutions in sterile 0.1% peptone water were prepared for bacterial analysis. M 17 agar was used for the enumeration of *Lactococcus* strains. Plates were incubated at 30°C for 24 h. Potato Dextrose Agar was used for yeast and mould enumeration. Plates were incubated at 25°C for 5 days, according to Marshall [1992]. Violet Red Bile Agar was used for the enumeration of coliforms. Plates were incubated at 37°C for 24 h, according to Marshall [1992].

Chemical analysis

Total solids, fat and total nitrogen (TN) contents of soft cheese samples were determined according to AOAC [2007, methods, 926.08, 933.05 and 2001.14 respectively]. The protein content was obtained by multiplying the percentage of TN by 6.38. The pH value was measured using digital pH meter (HANNA, Instrument, Portugal) with glass electrode. The water soluble nitrogen (WSN/TN) was estimated as described by Innocente [1997]. The spectrophotometric method of Vakaleris & Price [1959] was used for measuring tyrosine and tryptophane contents in cheese samples. Tyrosine, tryptophan and the WSN/TN were used as an index of proteolysis.

The lipids were extracted from cheese samples using a method described by Kristensen *et al.* [2001]. Acid value of extracted lipids was determined according to AOAC [2007, method, 969.17]. Peroxide value (PV) of extracted lipids was determined according to the method described by Egan *et al.* [1981]. Total volatile fatty acids (TVFAs) value was determined according to the method described by Kosikowski [1982]. Values were expressed as mL of 0.1N NaOH/100 g cheese.

Texture measurements

Instron, model 4302 Materials Testing Machine (Serial No. H5202, England) equipped with a 10 kg load cell was used to perform the Texture Profile Analysis (TPA) of the cheese samples. A plunger with a diameter 8 mm was attached to the moving crosshead. The crosshead speed was set at 10 mm/min in both upward and downward directions. The cheese sample was placed on a flat holding plate at 25°C and the plunger inserted 20 mm below the cheese surface. Each sample was compressed twice by the compression load cell [Kaminarides & Stachtiaris, 2000]. Parameters such as firmness, cohesiveness and springiness were measured.

Colour parameters

Hunter L, a and b parameters of cheese samples were measured using a spectro-colorimeter (Tristimulus Color Machine) with the CIE lab colour scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode.

Sensory evaluation

Nine expert judges (males and females) were selected from staff member of Dairy Science Department, National Research Center, Egypt, to evaluate the texture, flavour and overall acceptability of the cheese samples. They scored the sample on the basis of nine-point hedonic scale, ranging from like extremely = 9 through like or dislike = 5 to dislike extremely = 1 as described by Piggott [1984]. Cheese samples were cut into cubes (1.5 x 1.5 x 1.5 cm) and covered with plastic wrap to prevent dehydration. The cubes were coded with three-digit random numbers. Cheese samples were held for at least 1 h at 20°C to equilibrate. Each judge was given three cubes of cheese per samples. Water and non-salted crackers were provided to clean their palates between tasting.

Statistical analysis

Data were expressed as means ± SE. Statistical analysis was performed using the GLM procedure with SAS [2004] software. Analysis of variance (ANOVA) and Duncan's multiple comparison procedure were used to compare the means. A probability of $p<0.05$ was used to establish statistical significance.

RESULTS AND DISCUSSION

Microbiological properties

Figure 1a and 1b exhibits the changes in counts ($\log_{10}$ cfu/g) of *Lactococcus* strains (*Lactococcus lactis* ssp. *lactis* and *Lactococcus lactis* ssp. *Cremoris*) in both ginger extract-fortified pickled and un-pickled soft cheese during refrigerated storage. In general, the viability of *Lactococcus* strains in both ginger extract-fortified pickled and un-pickled cheese was significantly ($p<0.05$) higher than in the control cheeses, the difference being significant only at week 5 and 6. The increase in counts during storage could be attributed to the ginger protease capable of degrading protein, which could have provided the essential growth factors in the form of peptides and amino acids to improve the growth of the *Lactococcus* strains in the cheese. These results are in accordance with those reported by Adesokan *et al.* [2010] and Adeniran *et al.* [2010]. However, in un-pickled cheese, the counts of *Lactococcus* strains in T_2 were higher than those in T_1 from week 1, while in pickled cheese, the counts of *Lactococcus* strains in T_3 were higher than those in T_4 from week 2. Over storage, counts of *Lactococcus* strains increased until week 2 in cheese controls, while the increase in ginger extract-fortified cheese was more pronounced until week 5. These results explain ginger extract improved viability of the *Lactococcus* strains during storage of soft cheese. The counts of *Lactococcus* strains may be correlated with protein proteolysis ($r=0.35^*$). Regardless of the ginger extract fortification, the count of *Lactococcus* strains of pickled cheese was higher ($p<0.05$) than un-pickled cheese (Figure 2), which may be correlated with the moisture content of cheese.

Moulds and yeasts began to appear at week 2 in control cheese (data not shown), however, they were not observed in ginger extract-fortified cheese throughout the storage period. Ginger is known to contain several compounds such as gingerol, gingerdiol and shogaol, which possess antimicrobial activity against food spoilage organisms. Ficker *et al.* [2003] investigated antifungal activity of some plant extracts, including ginger and concluded that the ginger extract was one of the most powerful against a wide variety of fungi. Coliforms were not detected in all cheese treatments either when fresh or during the storage period. This may be due to the high hygienic condition during the preparation and the development in the acidity in cheese during storage period.

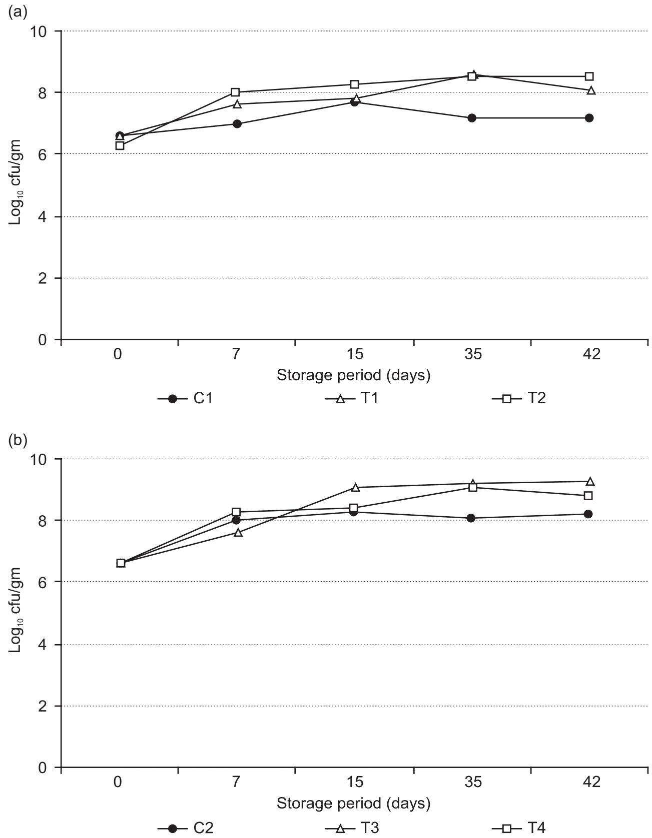

FIGURE 1. The counts of *Lactococcus* strains of ginger extract-fortified un-pickled (a) and pickled (b) soft cheese during storage period at 5±2°C.

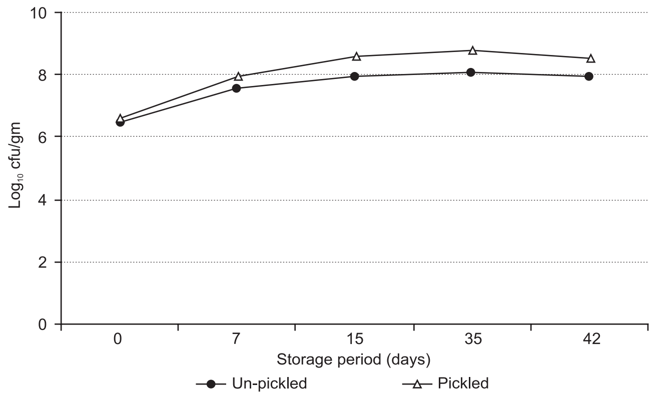

FIGURE 2. The counts of *Lactococcus* strains of pickled and un-pickled soft cheese during storage period at 5±2°C.

Chemical properties

As shown in Table 2, there was no significant difference in total solids, total protein and fat between the treatments although in the un-pickled soft cheese their contents were slightly higher than in the pickled cheese. Also, a slight increase was observed in total solids and fat contents ($p>0.05$) of un-pickled cheese with the increasing of ginger extract level as well as time of storage but remained stable in pickled

TABLE 2. Chemical properties of ginger extract-fortified pickled and un-pickled soft cheese during storage at 5±2°C.

Treatments	pH		Total solids (%)		Total protein (%)		Fat (%)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese								
C_1	5.86^{A}±0.06	4.94^{B}±0.07	33.68^{AB}±0.37	34.10^{A}±0.29	12.47^{A}±0.28	12.77^{A}±0.26	13.33±^{A}0.17	13.48^{A}±0.08
T_1	5.80^{A}±0.07	4.78^{C}±0.09	33.85^{ABC}±0.17	34.17^{A}±0.31	12.58^{A}±0.26	12.73^{A}±0.26	13.41^{A}±0.29	13.58^{A}±0.22
T_2	5.76^{A}±0.09	4.75^{C}±0.06	33.97^{AB}±0.21	34.29^{A}±0.38	12.37^{A}±0.29	12.74^{A}±0.21	13.50^{A}±0.22	13.67^{A}±0.17
Pickled soft cheese								
C_2	5.76^{A}±0.08	4.87^{B}±0.07	33.11^{B}±0.09	33.59^{AB}±0.23	12.23^{AB}±0.34	12.11^{AB}±0.05	13.25^{A}±0.14	13.17^{A}±0.08
T_3	5.72^{A}±0.06	4.62^{C}±0.06	33.12^{B}±0.27	33.28^{AB}±0.16	12.04^{AB}±0.10	12.19^{AB}±0.08	13.27^{A}±0.22	13.17^{A}±0.18
T_4	5.66^{A}±0.03	4.63^{C}±0.10	33.24^{B}±0.36	33.16^{B}±0.43	12.30^{AB}±0.22	11.53^{B}±0.23	13.25^{A}±0.25	13.15^{A}±0.21

Means (±SE, n=3) with the same capital letters are not significantly different at $p<0.05$.

TABLE 3. Protein proteolysis of ginger extract-fortified pickled and un-pickled soft cheese during storage period at 5±2°C.

Treatments	WSN/TN (%)		Tyrosine (mg/100 g cheese)		Tryptophane (mg/100 g cheese)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese						
C_1	13.15^{E}±0.45	20.21^{D}±0.67	18.49^{F}±1.42	71.67^{D}±0.27	28.56^{E}±1.93	64.57^{C}±2.56
T_1	14.13^{E}±0.64	22.21^{D}±0.75	19.57^{F}±1.42	91.22^{C}±2.06	37.64^{D}±1.44	69.22^{C}±2.29
T_2	14.74^{E}±0.55	26.74^{BC}±1.51	23.29^{EF}±1.06	95.55^{BC}±3.21	40.42^{D}±1.55	77.55^{AB}±2.51
Pickled soft cheese						
C_2	14.07^{E}±0.30	23.75^{CD}±1.21	21.92^{EF}±2.04	92.76^{C} ±1.40	30.48^{E}±1.45	67.28^{C}±3.01
T_3	15.05^{E}±0.57	29.16^{B}±1.40	24.11^{EF}±0.80	100.13^{B}±0.84	41.33^{D}±0.94	75.55^{B}±1.81
T_4	16.77^{E}±0.92	32.98^{A}±2.72	25.04^{E}±0.58	109.67^{A}±1.74	41.90^{D}±1.02	83.27^{A}±2.79

Means (±SE, n=3) with the same capital letters are not significantly different at $p<0.05$. WSN/TN, water soluble nitrogen/total nitrogen.

TABLE 4. Acid value, peroxide value and total volatile fatty acids of ginger extract-fortified pickled and un-pickled soft cheese during storage period at 5±2°C.

Treatments	TVFAs*		Acid value		PV (mEq/kg)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese						
C_1	1.67^{D}±0.12	1.18^{E}±0.04	0.50^{D}±0.04	0.69^{C}±0.01	0.60^{C}±0.04	1.10^{A}±0.02
T_1	2.75^{B}±0.13	1.53^{D}±0.06	0.51^{D}±0.03	0.74^{BC}±0.03	0.45^{C}±0.03	0.84^{B}±0.04
T_2	3.40^{A}±0.16	1.61^{D}±0.07	0.51^{D}±0.06	0.84^{AB}±0.03	0.47^{C}±0.04	0.83^{B}±0.06
Pickled soft cheese						
C_2	1.48^{D}±0.05	1.44^{D}±0.02	0.50^{D}±0.03	0.75^{BC}±0.03	0.56^{C}±0.08	1.18^{A}±0.07
T_3	1.66^{D}±0.07	1.49^{D}±0.02	0.51^{D}±0.02	0.83^{AB}±0.04	0.54^{C}±0.06	0.87^{B}±0.07
T_4	2.04^{D}±0.08	1.60^{D}±0.06	0.52^{D}±0.03	0.93^{A}±0.05	0.54^{C}±0.07	0.85^{B}±0.09

Means (±SE, n=3) with the same capital letters are not significantly different at $p<0.05$. * mL of 0.1N NaOH/100 g cheese.

cheese. Ginger extract-fortified cheese caused an insignificant decrease in pH value ($p>0.05$) in both pickled and un-pickled soft cheeses at week 1, however, the decrease was significantly higher ($p<0.05$) than in the control cheese at week 6. The decrease in pH value attributed to ginger extract may enhance the growth of *Lactococcus* strains (Figure 1a and 1b). The pH value was negatively correlated with the total count of *Lactococcus* strains ($r=-0.67^{**}$). However, the difference in pH values between the fortification levels was not significant ($p>0.05$).

Fortification with ginger extract affected protein proteolysis (WSN/TN ratio, tyrosine and tryptophane) of soft cheese (Table 3). Ginger extract-fortified cheese caused a slight increase in the in WSN/TN and tyrosine contents at day 7 ($p>0.05$) after which the increases were significant ($p<0.05$) for the week 6. However, the count of tryptophane in both pickled and un-pickled cheese was higher ($p<0.05$) than in control cheese from week 1 onwards. The increase in proteolysis could be attributed to the proteolytic activity of the starter culture [Kaminarides & Stachtiaris, 2000] as well as proteolytic enzyme in ginger extract. Thompson *et al.* [1973] isolated proteolytic enzyme called "zingibain" from *Zingiber officinale roscoe* (ginger rhizome). The ginger prote-

TABLE 5. Texture attributes of ginger extract-fortified pickled and un-pickled soft cheese during storage period at 5±2°C.

Treatments	Hardness (N)		Cohesiveness		Springiness (mm)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese						
C_1	$1.57^{B}\pm0.05$	$1.85^{A}\pm0.06$	$0.56^{B}\pm0.02$	$0.41^{D}\pm0.02$	$0.84^{AB}\pm0.01$	$0.86^{A}\pm0.02$
T_1	$1.39^{DE}\pm0.07$	$1.67^{B}\pm0.03$	$0.63^{A}\pm0.03$	$0.42^{D}\pm0.03$	$0.86^{A}\pm0.03$	$0.87^{A}\pm0.02$
T_2	$1.26^{DE}\pm0.10$	$1.58^{B}\pm0.05$	$0.67^{A}\pm0.01$	$0.44^{D}\pm0.01$	$0.82^{AB}\pm0.03$	$0.84^{AB}\pm0.01$
Pickled soft cheese						
C_2	$1.41^{CD}\pm0.02$	$1.55^{BC}\pm0.02$	$0.54^{B}\pm0.01$	$0.45^{CD}\pm0.02$	$0.84^{A}\pm0.01$	$0.84^{AB}\pm0.01$
T_3	$1.11^{EF}\pm0.03$	$1.25^{F}\pm0.06$	$0.65^{A}\pm0.03$	$0.45^{CD}\pm0.03$	$0.84^{AB}\pm0.01$	$0.82^{AB}\pm0.01$
T_4	$1.04^{F}\pm0.03$	$1.05^{F}\pm0.05$	$0.68^{A}\pm0.04$	$0.51^{BC}\pm0.02$	$0.82^{AB}\pm0.02$	$0.76^{B}\pm0.01$

Means (±SE, n=3) with the same capital letters are not significantly different at p<0.05.

TABLE 6. Colour parameters of ginger extract-fortified pickled and un-pickled soft cheese during storage period at 5±2°C.

Treatments	L		a		b	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese						
C_1	$90.47^{AB}\pm1.63$	$87.55^{B}\pm0.88$	$-1.04^{AB}\pm.05$	$-1.01^{AB}\pm0.03$	$7.25^{C}\pm0.46$	$8.68^{BC}\pm0.57$
T_1	$91.10^{AB}\pm1.49$	$87.56^{B}\pm1.67$	$-1.11^{BC}\pm0.07$	$-1.02^{AB}\pm0.03$	$7.62^{BC}\pm0.47$	$8.68^{BC}\pm0.68$
T_2	$91.35^{AB}\pm1.70$	$87.97^{B}\pm0.32$	$-1.25^{BC}\pm0.83$	$-1.17^{BC}\pm0.03$	$9.37^{AB}\pm0.56$	$10.29^{AB}\pm0.04$
Pickled soft cheese						
C_2	$91.37^{AB}\pm1.17$	$88.98^{AB}\pm0.91$	$-0.96^{A}\pm0.03$	$-0.98^{A}\pm0.05$	$6.59^{D}\pm0.58$	$7.13^{CD}\pm0.41$
T_3	$91.56^{AB}\pm0.74$	$89.65^{AB}\pm1.44$	$-1.10^{AB}\pm0.11$	$-1.12^{AB}\pm0.06$	$7.22^{CD}\pm0.47$	$8.73^{BC}\pm0.71$
T_4	$93.01^{A}\pm1.09$	$89.11^{AB}\pm1.73$	$-1.30^{C}\pm0.09$	$-1.29^{C}\pm0.08$	$8.56^{B}\pm0.64$	$10.89^{A}\pm0.84$

Means (±SE, n=3) with the same capital letters are not significantly different at (p<0.05). L, darkness from black (0) to white (100); a, colour red (+) to green (-); b, colour yellow (+) to blue (-).

ase is a thiol proteinase. The effect of ginger extract on protein proteolysis was more pronounced (p<0.05) at week 6, and in ginger extract-fortified pickled cheese (p<0.05).

Ginger extract also, increased TVFAs content of both pickled and un-pickled cheese although, the increase in TVFAs was more pronounced (p<0.05) in un-pickled soft cheese (Table 4). This could be attributed to a ginger extract's high content of essential oil, which is a mixture of monoterpenic and sesquiterpenic compounds, and contains the volatile compounds responsible for the characteristic ginger flavour [Zancan *et al.,* 2002]. However, the TVFAs content of un-pickled cheese showed a significant reduction at week 6 (p<0.05), while the reduction was insignificant (p>0.05) in pickled cheese.

The PV of ginger extract-fortified cheese was lower (p>0.05) than control cheese, the difference being significant at week 6 (Table 4). Langner *et al.* [1998] reported that the rhizome of ginger contains curcumin in addition to dozen of phenolic compounds known as gingirols and diarylheptanoids, which have antioxidant effect. This is similar to the observation of Bandyopadhyay *et al.* [2007] who found that addition of solvent extract form of mint, beet and ginger showed the highest antioxidant level than any other form. Conversely, fortification with ginger extract caused a significant increase in acid value (p<0.05) only at week 6. However, the acid value of pickled cheese was slightly higher than that of the un-pickled one. The difference in PV and acid value between the fortification levels was not significant (p>0.05).

Texture attributes

Texture attributes of pickled and un-pickled cheese samples fortified with ginger extract during storage are presented in Table 5. After 1 week, fortification with ginger extract caused a gradual increase in cohesiveness and a gradual decrease in hardness (p<0.05) in both pickled and un-pickled soft cheeses (p<0.05), but had no significant effect on cheese springiness. The decrease in hardness of ginger extract-fortified cheese may be attributed to extended proteolysis (Table 3) that decreases the surface area occupied by the protein fraction in cheese microstructure, leading to a decrease of the force-bearing component in cheese texture [Khosrowshahi *et al.,* 2006]. Cheese hardness increased, while cheese cohesiveness decreased in un-pickled soft cheeses at week 6. According to Creamer & Olson [1982], as proteolysis occurs, more "new" ionic peptides are created; and as each "new" group is created, competition for available water increases; less water is available to solvate the protein chains and the resulting cheese is harder and less deformable. Also, the pH of cheese affects the texture of curd directly by influencing the solubility of the caseins; high pH cheeses are softer than more acid cheeses [Fathollahi *et al.,* 2010]. No significant changes were observed in texture attributes of pickled cheese throughout the storage period, which may be correlated with moisture content of cheese and extended proteolysis (Tables 2, 3). Fathollahi *et al.* [2010] found that proteolysis can contribute to textural softening during ripening of Iranian UF white cheese. However, some other works

TABLE 7. Sensory attributes of ginger extract-fortified pickled and un-pickled soft cheese during storage period at 5±2°C.

Treatments	Flavor		Texture		Overall acceptability	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled soft cheese						
C_1	7.67^{CB}±0.17	7.11^{C}±0.35	7.17^{C}±0.26	7.89^{CB}±0.11	7.33^{CB}±0.9	7.44^{CB}±0.18
T_1	7.67^{CB}±0.17	7.56^{CB}±0.29	7.33^{C}±0.28	8.22^{AB}±0.15	7.33^{CB}±0.29	7.67^{CB}±0.17
T_2	7.78^{CB}±0.22	8.00^{AB}±0.24	8.11^{AB}±0.39	8.33^{A}±0.24	7.78^{CB}±0.15	8.00^{AB}±0.24
Pickled soft cheese						
C_2	7.44^{CB}±0.18	7.78^{CB}±0.15	7.33^{C}±0.17	7.44^{CD}±0.29	7.22^{C}±0.28	7.44^{CB}±0.29
T_3	7.56^{CB}±0.29	8.44^{A}±0.18	7.78^{CB}±0.18	8.11^{AB}±0.11	7.33^{CB}±0.24	8.00^{AB}±0.09
T_4	7.67^{CB}±0.33	8.52^{A}±0.33	7.78^{CB}±0.17	8.56^{A}±0.18	7.44^{CB}±0.18	8.56^{A}±0.29

Means (±SE, n=9) with the same capital letters are not significantly different at p<0.05.

reported Ca solubilisation as a main factor of some cheese softening. Lucey *et al.* [2003] reported that various rheological parameters of Cheddar cheese were more highly correlated with the level of insoluble Ca than with the extent of primary proteolysis during ripening.

Colour parameters

Colour degrees were influenced by fortification with ginger extract for both pickled and un-pickled soft cheese (Table 6). All ginger extract-fortified cheese treatments exhibited a slight gradual increase ($p<0.05$) in whiteness and greenish degree at week 1 and 6, except T_4, where the increase in greenish degree was significant ($p<0.05$) at week 6. Yellowish degree of cheese was more affected by fortification level with ginger extract. T_2 showed a significant increase ($p<0.05$) in yellowish degree only at week 1, while T_4 showed a significant increase ($p<0.05$) at week 1 as well as week 6. Yellowish degree of cheese may be attributed to the curcumin in ginger extract [Bandyopadhyay *et al.*, 2007]. As storage periods increased; the yellowish degree of soft cheese increased, while whiteness decreased at the same rate within treatments. A similar observation was made by Khosrowshahi *et al.* [2006] in Iranian white cheese during ripening. According to Fresno *et al.* [2006], many biochemical modifications occur in the maturation process of cheeses. Van Boekel [1998] reported that modifications in lactose due to series of reactions result in brown pigmented products such as pyrazines and melanoidins, and small acid molecules are also formed during the Maillard reaction.

Sensory properties

On week 1, slight improvements were observed in sensory properties (flavour, texture and overall acceptability) of ginger extract-fortified cheese (Table 7), because of the attractive smell of gingerol and other volatile oil of ginger [Bandyopadhyay *et al.*, 2007]. Panelists gave higher scores to T_2, which had smooth texture with more acceptable flavour than other treatments. Over storage, the sensory attributes scores of ginger extract--fortified un-pickled cheese were not significantly improved ($p<0.05$). Sensory properties of pickled soft cheese were more affected by fortification with ginger extract and time of storage. T_4 had the highest score for sensory properties ($p<0.05$) at week 6. These results may be attributed to proteolytic activity of ginger protease, which can improve the flavour and texture through increased proteolysis. Vafopoulou *et al.* [1989] reported that proteolysis products and free fatty acids produced through lipolysis imparted the characteristic flavour of Feta cheese. Cheese texture was positively correlated with WSN/TN content ($r=0.35^{*}$). Also, He *et al.* [1998] reported that over storage or thermal processing, the gingerols may be modified to series of homologous compounds called shogaols, which are more pungent than the gingerols.

CONCLUSION

The fortification with ginger extract can accelerate the ripening period of soft cheese, caused an increase in cohesiveness and a decrease in firmness, which reflex more softness and smoothness along storage. Ginger extract-fortified cheese was characterised by enhanced growth of *Lactococcus* strains, flavour compounds and exhibited antioxidant activity. Regarding sensory properties, soft cheese became more acceptable by fortification with ginger extract and throughout storage, especially the pickled one. Ginger extract had an effective impact against mould and yeast in cheese preservation. It could be said that its application in dairy industry may be valuable and can easily be introduced in the Egyptian market.

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