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PROPERTIES OF FUNCTIONAL SOFT CHEESE FORTIFIED WITH GINGER EXTRACT.

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ABSTRACT

UF soft cheese fortified with ginger extract as a functional dairy food was evaluated. Buffalo's milk retentate was divided into three equal portions. Five and 10 gm fresh ginger rhizome was extracted and added separately to 100 gm milk retentate. The latter batch had no ginger extract as a control. All groups were salted with 4 % NaCl/water phase. The resultant cheese samples were divided into 2 parts; one was separately pickled in salted permeate (4%), while the other was kept without pickling. All cheese samples were stored at 5±2°C for 6 weeks. The results revealed that, cheese pickling increased the proteolysis and acid value, while decreased pH and total volatile fatty acids (T.V.F.A.). Fortification with ginger extract enhanced cheese proteolysis and (T.V.F.A.), while reduced pH value and peroxide values (P.V.) of cheese samples. In general, un-pickled soft cheese was more springiness, firmer, darker and more yellowish compared with pickled cheese samples. Fortification with ginger extract caused an increase in cohesiveness, whiteness and yellowish colour degree and decrease in firmness of both pickled and un-pickled soft cheese. Ginger extract-fortified cheese enhance the growth of *L. lactis* ssp. *lactis* and *L. lactis* ssp. *cremoris,* which more pronounced in pickled samples. Mould and Yeast were detected only in control cheese samples after 2 weeks. Ginger extract fortified cheese gained the highest scores for flavour, texture and overall acceptability in both pickled and un-pickled cheese samples, which became more acceptable over storage.

INTRODUCTION

Since prehistorically time, herbs and spices have used not just as food flavorings, but also for its medicinal properties, as well as for their preservative action that is derived from their antimicrobial and antioxidant constituents (Zheng & Wang, 2001 and Bandyopadhyay *et al.,* 2006). Among herbs and spices, ginger (rizhome 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 being documented in ancient Greek, Roman and Arabic medical literature (Bone, 1998).

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, 1998). The main constituents of ginger are the 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 and Mendi *et al.,* 2009). Bandyopadhyay *et al.,* (2006) 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 sesqiterpenic compounds, contains the volatile compounds responsible for the characteristic ginger flavour (Zancan *et al.,* 2002). Ginger can also enhance shelf-life because of their 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 there use in dairy products is scarce. Soft cheese is the most and common largely consumed in Egypt, which produced by different procedures. UF soft cheese is nowadays the most favourite and acceptable one for its nutritive values (Coker *et al.,* 2005). Therefore, the objective of this investigation was to evaluate the physicochemical, microbial and sensory properties of UF soft cheese made with ginger extract as a functional dairy food.

MATERIALS AND METHODS

Materials:

Milk retentate was obtained from Animal Production Institute, Ministry of Agriculture, Egypt. Fresh ginger rhizome was purchased from the local market, 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.

Methods:

Ginger Extract:

Fresh ginger rhizome was washed, peeled, finely crushed 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 xg for 30 min and this step was repeated twice. The supernatant was collected and evaporated in a rotary vacuum evaporator (ROTAVAPOR R110, Buchi, Switzerland) at 50°C according to Penna *et al.,* 2003.

Starter Activation:

Starter cultures were activated in maintenance broths (M 17) at 30ºC for 24 hr. After activation they were centrifuged (15000 rpm/5 min at 4°C) in order to obtain pellet. Pellet was inoculated at30ºC for 24hr in 10% pasteurized skim milk powder.

Cheese Manufacture:

Buffalo's milk retentate was divided into three equal portions. Five and 10 gm fresh ginger rhizome was extracted and added separately to 100 gm buffalo's milk retentate. The latter batch had no ginger extract as control. All milk retentate batches were heated to 75°C and then cooled to 38°C. The milk retentate in each batch was inoculated with starter culture at rate 1% (10^6 cfu/ml)) and held for 30 min. Salt (4% in water phase) were 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. The resultant cheese samples were divided into 2 parts; one was separately picked in (4%) salted permeate while the other was kept without pickling. All cheese samples were stored at 5±2°C for 6 weeks. The treatment abbreviations were:

C_1: un-pickled control cheese without ginger extract.

T_1: un-pickled cheese fortified with ginger extract produced from 5 gm ginger rhizome/100gm cheese.

T_2: un-pickled cheese fortified with ginger extract produced from 10 gm ginger rhizome/100gmcheese.

C_2: pickled control cheese without ginger extract.

T_3: pickled cheese fortified with ginger extract produced from 5 gm ginger rhizome/100gm cheese.

T_4: pickled cheese fortified with ginger extract produced from 10 gm ginger rhizome/100gm cheese.

Chemical Analysis:

Total Solids (T.S.) and Total Nitrogen (T.N.) contents of soft cheese samples were determined according to AOAC (2000). Fat content was determined by the Gerber method **(**Ling, 1963). The pH value was measured using digital pH meter (HANNA, Instrument, Portugal) with glass electrode. The soluble nitrogen (S.N.) was estimated as described by Innocente (1997). The spectrophotmetric method of Vakaleris & Price (1959) was used for measuring tyrosine and tryptophan contents in cheese samples. The lipids were extracted from cheese samples using a method described by Kristensena *et al.* (2001). Acid value (A.V.) and Peroxide value (P.V.) of extracted lipids were determined according to the method described by Egan *et al.* (1981). Total volatile fatty acids (T.V.F.A.) value was determined according to the method described by Kosikowski (1982), values were expressed as ml of 0.1N NaOH/100g cheese.

Microbiological Analysis:

10 gm cheese samples were taken at the age of 0, 7, 15, 35 and 42 days, then homogenized 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 hr. Potato Dextrose Agar was used for mould and yeast 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 hr, according to Marshall (1992).

Texture Profile Analysis:

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 of 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.

Color Parameters:

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

L: value represents darkness from black (0) to white (100).
a: value represents color ranging from red (+) to green (-).
b: value represents yellow (+) to blue (-).

Sensory Evaluation:

Sensory evaluation (texture, flavor, and overall acceptability) of cheese samples was performed after one and six weeks of storage. A nine point hedonic scale (9, like extremely and 1, dislike extremely) was used according to Stone & Sidel (1993)**.**

Statistical Analysis:

Statistical analysis was performed using the GLM procedure with SAS (2004) software. Duncan's multiple comparison procedure was used to compare the means. A probability of P≤0.05 was used to establish statistical significance.

RESULTS AND DISCUSSION

Chemical Properties

As shown in Table (1), pickled cheese samples had the lower pH values, T.S., T.P. and fat contents than un-pickled cheese samples. After one week, addition of ginger extract caused insignificant decrease in pH value (P>0.05) compared with control cheese samples. The decrease was proportional to the addition ratio. However, the decreasing in pH values was significantly after 6week (P≤0.05). Tyrosine, tryptophan and the ratio of S.N. /T.N. were used as an index of proteolysis. To regard of proteolytic activity, the pickled cheese samples had the highest percentage S.N./T.N., Tyrosine, Tryptophan (Table 2). Ginger extract caused an increase in S.N. /T.N., Tyrosine and Tryptophan contents of all cheese samples, which indicate its great proteolytic activity (Table 2). The increasing was statistically insignificant, except tryptophan content where the increase was significant (P≤0.05). The degree of proteolysis in all soft cheeses increased during ripening, but it was more pronounced in ginger extract fortified cheese than the control (P≤0.05), which can be attributed to the proteolytic activity of ginger extract. Thompson *et al* (1973) isolated proteolytic enzyme called "zingibain" from *Zingiber officinale* roscoe (ginger rhizome), the ginger protease is a thiol proteinase.

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Regarding to (T.V.F.A.) contents (Table 3), ginger extract also increased (T.V.F.A.) contents of pickled and un-pickled cheese samples (P≤0.05). The increasing in (T.V.F.A.), it was more pronounced in un-pickled soft cheese, as well as at higher fortification, it can be attributed that ginger extract contain high content of essential oil, which is a mixture of monoterpenic and sesqiterpenic compounds, and contains the volatile compounds responsible for the characteristic ginger flavour (Zancan *et al.,* 2002). However, no significant differences were observed in Acid Values (A.V.) and Peroxide Value (P.V.) between all treatments, which increased with storage periods (P≤0.05). The increasing rate in acid value of ginger extract added cheese was higher, while in (P.V.) was lower than control cheese samples. Langner *et al.* (1998) reported that the rhizome of ginger contains curcumin in addition to dozen of phenol compounds known as gingirols and diarylheptanoids, which have antioxidant effect.

Table 3: Total Volatile Fatty Acids, Acid value and Peroxide Value of pickled and un-pickled UF soft cheese fortified with ginger extract during storage.

Treatments	T.V.F.A. (%)		A.V.		P.V. (ml.eq./Kg)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese						
C_1	$1.67^{D}\pm0.12$	$1.18^{E}\pm0.04$	$0.50^{D}\pm0.04$	$0.69^{C}\pm0.01$	$0.60^{C}\pm0.04$	$1.10^{A}\pm0.02$
T_1	$2.75^{B}\pm0.13$	$1.53^{D}\pm0.06$	$0.51^{D}\pm0.03$	$0.74^{BC}\pm0.03$	$0.45^{C}\pm0.03$	$0.84^{B}\pm0.04$
T_2	$3.40^{A}\pm0.16$	$1.61^{D}\pm0.07$	$0.51^{D}\pm0.06$	$0.84^{AB}\pm0.03$	$0.47^{C}\pm0.04$	$0.83^{B}\pm0.06$
Pickled UF soft cheese						
C_2	$1.48^{D}\pm0.05$	$1.44^{D}\pm0.02$	$0.50^{D}\pm0.03$	$0.75^{BC}\pm0.03$	$0.56^{C}\pm0.08$	$1.18^{A}\pm0.07$
T_3	$1.66^{D}\pm0.07$	$1.49^{D}\pm0.02$	$0.51^{D}\pm0.02$	$0.83^{AB}\pm0.04$	$0.54^{C}\pm0.06$	$0.87^{B}\pm0.07$
T_4	$2.04^{D}\pm0.08$	$1.60^{D}\pm0.06$	$0.52^{D}\pm0.03$	$0.93^{A}\pm0.05$	$0.54^{C}\pm0.07$	$0.85^{B}\pm0.09$

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

Microbiological Properties

As shown in Figure 1 (a & b), the viability of *Lactococcus* strains in both ginger extract-fortified pickled and un-pickled samples were significantly (p≤0.05) higher than the control cheese. The higher viability was found in low level pickled (T_3) and high level un-pickled (T_2) respectively. T_2 and T_3 showed 1.1 and 1.3 $\log_{10}$ cycles increase in cell population, respectively. Regardless of the ginger extract fortification, the viability of *Lactococcus* strains of pickled cheese samples was higher (p≤0.05) than un-pickled cheese (Fig 2). Over storage, viability of *Lactococcus* strains increased until 2 weeks in control cheese, while the increasing in ginger extract-fortified cheese samples was more pronounced until 5 weeks. The viability of *Lactococcus* strains may be correlated with protein proteolysis ($r = 0.35^{*}$). These results are in agreement with those reported by Adesokan *et al.* (2010).

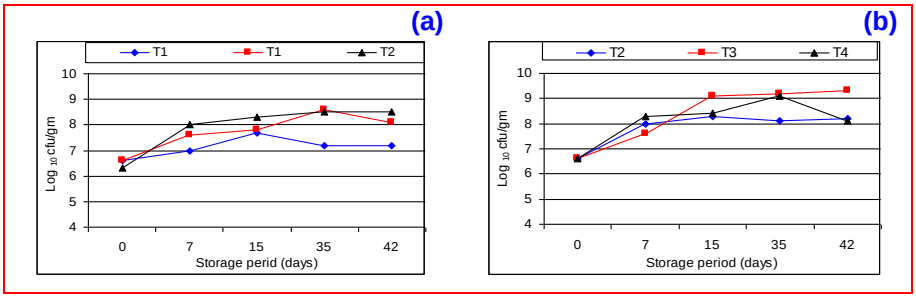

Figure 1: The viability of *Lactococcus* strains of ginger extract-fortified un-pickled (a) and pickled (b) UF-soft cheese during storage.

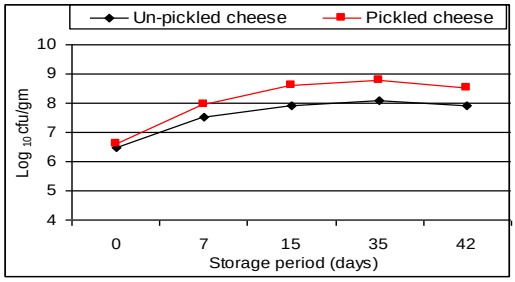

Figure 2: The viability of *Lactococcus* strains of pickled and un-pickled UF-soft cheese during storage.

On the other hand, moulds and yeasts began to appear after 15 days of storage only in control cheese. 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 samples during storage.

Texture Profile Analysis

Texture profile analysis of pickled and un-pickled cheese samples fortified with ginger extract during storage is presented in Table 4. After 1 week, pickled cheese samples were significantly firmer ($P \leq 0.05$) than un-pickled one. However, no significant differences ($P > 0.05$) were observed in cohesiveness and springiness between two type cheese samples. Fortification with ginger extract caused an increase in cohesiveness and a decreased in firmness ($P \leq 0.05$) of the resultant cheese, but had no significant effect on springiness. The gradual decrease in firmness was correlated with ginger level. Over storage, cheese firmness increased, while cohesiveness decreased ($P \leq 0.05$). Creamer & Olson (1982) illustrated that as proteolysis occurs, more “new” ionic peptides are created; 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.

Table 4: Texture attributes of ginger extract fortified pickled and un-pickled UF soft cheese during storage.

Treatments	Firmness (N)		Cohesiveness		Springiness (mm)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese						
C_1	1.57^{B}±0.05	1.85^{A}±0.06	0.56^{B}±0.02	0.41^{D}±0.02	0.84^{AB}±0.01	0.86^{A}±0.02
T_1	1.39^{DE}±0.07	1.67^{B}±0.03	0.66^{A}±0.03	٠,٤٢^{D}±0.03	0.86^{A}±0.03	0.87^{A}±0.02
T_2	1.26^{DE}±0.10	1.58^{B}±0.05	0.65^{A}±0.01	0.44^{D}±0.01	0.82^{AB}±0.03	0.84^{AB}±0.01
Pickled UF soft cheese						
C_2	1.41^{CD}±0.02	1.55^{BC}±0.02	0.54^{B}±0.01	0.45^{CD}±0.02	0.84^{A}±0.01	0.84^{AB}±0.01
T_3	1.11^{EF}±0.03	1.25^{F}±0.06	0.65^{A}±0.03	0.45^{CD}±0.03	0.84^{AB}±0.01	0.82^{AB}±0.01
T_4	1.04^{F}±0.03	1.05^{F}±0.05	0.68^{A}±0.040	0.51^{BC}±0.02	0.82^{AB}±0.02	0.76^{B}±0.01

Means (±SE, n=3) with the same capital letters are not significantly

Color Parameters

Data in Table (5) shows that un-pickled cheese samples were darker and more yellowish than pickled cheese. Ginger extract-fortified cheese caused an increase in whiteness and yellowish degree of cheese samples. The increase in whiteness and yellowish degree were proportional to the addition rate of ginger extract. Conversely, red color degree of soft cheese proportionally decreases with addition of ginger extract. As storage periods increased; yellowish and red color degree of soft cheese increased, while whiteness decreased.

Table 5: Color parameters of ginger extract fortified pickled and un-pickled UF soft cheese during storage.

Treatments	L		a		b	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese						
C_1	90.47	87.55	-1.04	-1.01	7.25	8.68
T_1	91.10	87.56	-1.11	-1.02	7.62	8.68
T_2	91.35	87.97	-1.25	-1.17	9.37	10.29
Pickled UF soft cheese						
C_2	91.37	88.98	-0.96	-0.98	6.99	7.13
T_3	91.56	89.65	-1.10	-1.12	7.22	8.73
T_4	93.01	89.11	-1.13	-1.29	8.56	10.89

L, darkness from black (0) to white (100); a, colour red (+) to green (-); b, colour yellow (+) to blue (-).

Sensory Evaluation

The sensory evaluation scores indicated that flavor, texture and overall acceptability of cheese samples increased with the level of ginger extract compared with control cheese (Table 6). Panellists' gave higher scores for ginger extract-fortified cheese (high level, T2 and T4), which was softer, smoother with pronounced flavour and overall acceptability ($P \leq 0.05$) than other treatments. This may attributed to ginger extract have attractive smell of gingerol and other volatile oil Bandyopadhyay *et al.*, 2006) as well as proteolytic activity of ginger protease. Cheese texture was positively correlated with S.N./T.N. content ($r = 0.35^{*}$). Over storage, sensory attributes of cheese samples increased with the time increased. 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. In addition, cheese pickling improved slightly sensory attributes compared with un-pickled cheese.

Table 6: Sensory attributes of ginger extract fortified pickled and un-pickled UF soft cheese during storage.

Treatments	Flavor		Texture		Overall acceptability	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese						
C_1	7.67^{CB}±0.17	7.11^{C}±0.35	7.11^{D}±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^{CD}±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 UF soft cheese						
C_2	7.44^{CB}±0.18	7.78^{CB}±0.15	7.33^{CD}±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=3) with the same capital letters are not significantly different at (p≤0.05).

CONCLUSION

The fortification with ginger extract can accelerate the ripening period of UF-soft cheese, caused an increase in cohesiveness and a decreased in firmness, which reflex more softness and smoothness along storage period. Regarding sensory properties, compared to control, the level of acceptance increased when UF-soft cheese was fortified with the heigh level of ginger extract. Ginger extract had an effective impact against mould and yeast in UF-soft cheese preservation. It could be saying that its application in dairy industry may be valuable, desirable and can easily be introduced in the Egyptian market.

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الخواص الوظيفية للجبن الطرى المدعم بمستخلص الزنجبيل

محمود عبد العزيز السيد ، فاتن لطفى سليط ، سحر حسن صلاح و هيام محمد عباس
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تهدف هذه الدراسة إلى تقييم بعض الخواص الوظيفية للجبن الطرى المصنع من لبن جاموسى مركز والمدعم بمستخلص درنات الزنجبيل. تم تقسيم اللبن الى ثلاثة أجزاء متساوية:-
استخدم مستخلص الزنجبيل الناتج من ٥جرام و١٠ جرام كلا على حدة/١٠٠جرام لبن مركزفى تصنيع المجموعتان قيد الاختبار. المجموعة الثالثة صنعت بدون اضافة للمقارنة ككنترول. تم تمليح المجموعات الثلاثة بنسبة ٤% ملح فى الوسط المائى.
كل مجموعة من المجموعات الثلاثة المصنعة قسمت الى جزئين، الجزء الأول تم تخزينة فى راشح اللبن المركز بنسبة ٤% ملح، أما الجزء الثانى فقد تم تخزينة بدون محلول ملحى. تم التخزين على حرارة الثلاجة ٥±٢°م/٦ أسابيع فى عبوات بلاستيكية سعة ٥٠٠مل.
أظهرت التحليلات النتائج التالية :

- أدي التدعيم بمستخلص الزنجبيل الي زيادة االتحلل البروتينى، رقم الحموضة، الأحماض الدهنية الكلية الطيارة، وانخفاض رقم الـ pH ، ورقم البيروكسيد.
- بصفة عامة الجبن المخزن بدون محلول ملحى كانت أكثر صلابة و مطاطية ويتدرج اللون من الغامق الى الأصفر مقارنة بالجبن المخزن فى محلول ملحى.
- أدى التدعيم بمستخلص الجبن الى زيادة فى خاصية قوى الترابط بين جزيئات المادة، تدرج فى اللون من الأبيض الى الأبيض المائل للصفرار ، أيضا الى نقص فى الصلابة لكلا من الجبن المخزن والغير مخزن فى محلول ملحى.أيضا الجبن المخزن فى محلول ملحى و المدعم بمستخلص الزنجبيل حدث به زيادة فى نموبكتريا *L. lactis* ssp. *lactis* and *L. lactis* ssp. *cremoris*. ظهرت نموات فطرية وخميرة فى الأسبوع الثانى من التخزين فى عينات الكنترول على عكس الجبن المدعم بالمستخلص حيث لم يظهر به أى نموات حتى نهاية مدة التخزين.
- الجبن المدعم بمستخلص الزنجبيل حصل على أعلى نتائج فى التحكيم الحسى لكلا نوعى التخزين (بمحلول ملحى أو بدون محلول ملحى) خاصة ذات التركيز العالى من مستخلص الزنجبيل.

قام بتحكيم البحث

أ.د / محمد شلبى جمعة	**كلية الزراعة – جامعة المنصورة**
أ.د / محمود حمزه السنيطى	**المركز القومى للبحوث**

Table 1: Chemical Properties of ginger extract fortified pickled and un-pickled UF soft cheese.

Treatments	pH		T.S. (%)		T.P. (%)		Fat (%)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese								
C_1	$5.86^{A}\pm0.06$	$4.92^{B}\pm0.07$	$33.68^{AB}\pm0.37$	$34.18^{A}\pm0.29$	$12.47^{A}\pm0.28$	$12.77^{A}\pm0.26$	$13.33\pm^{A}0.17$	$13.58^{A}\pm0.08$
T_1	$5.82^{A}\pm0.07$	$4.78^{BC}\pm0.09$	$33.85^{ABC}\pm0.17$	$34.17^{A}\pm0.31$	$12.58^{A}\pm0.26$	$12.73^{A}\pm0.26$	$13.41^{A}\pm0.29$	$13.58^{A}\pm0.22$
T_2	$5.76^{A}\pm0.09$	$4.75^{C}\pm0.06$	$33.97^{AB}\pm0.21$	$34.29^{A}\pm0.38$	$12.37^{A}\pm0.29$	$12.74^{A}\pm0.21$	$13.50^{A}\pm0.22$	$13.67^{A}\pm0.17$
Pickled UF soft cheese								
C_2	$5.76^{A}\pm0.08$	$4.88^{B}\pm0.07$	$33.11^{B}\pm0.09$	$33.59^{AB}\pm0.23$	$12.23^{AB}\pm0.34$	$12.11^{AB}\pm0.05$	$13.25^{A}\pm0.14$	$13.17^{A}\pm0.08$
T_3	$5.75^{A}\pm0.06$	$4.62^{C}\pm0.06$	$33.12^{B}\pm0.27$	$33.28^{AB}\pm0.16$	$12.04^{AB}\pm0.10$	$12.19^{AB}\pm0.08$	$13.27^{A}\pm0.22$	$13.17^{A}\pm0.18$
T_4	$5.66^{A}\pm0.03$	$4.63^{C}\pm0.10$	$33.24^{B}\pm0.36$	$33.16^{B}\pm0.43$	$12.30^{AB}\pm0.22$	$11.53^{B}\pm0.23$	$13.25^{A}\pm0.25$	$13.15^{A}\pm0.21$

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

TS, total solids; TP, total protein; C1, un-pickled cheese without ginger extract; T_1, un-pickled cheese fortified with ginger extract produced from 5 gm ginger rhizome/100gm cheese; T_2, un-pickled cheese fortified with ginger extract produced from 10 gm ginger rhizome/100gm cheese; C2, pickled cheese without ginger extract; T_3, pickled cheese fortified with ginger extract produced from 5 gm ginger rhizome/100gm cheese; T_4, pickled cheese fortified with ginger extract produced from 10 gm ginger rhizome/100gm cheese.

Table 2: Proteolysis of pickled and un-pickled UF-soft cheese fortified with ginger extract during storage.

Treatments	SN/TN Ratio		Tyrosine (mg/100gm)		Tryptophan (mg/100gm)	
	1 week	6 weeks	1 week	6 weeks	1 week	6 weeks
Un-pickled UF soft cheese						
C_1	$13.15^{E}\pm0.45$	$20.21^{D}\pm0.67$	$18.49^{F}\pm1.42$	$71.67^{D}\pm0.27$	$28.56^{E}\pm1.93$	$64.57^{C}\pm2.56$
T_1	$14.13^{E}\pm0.64$	$20.21^{D}\pm0.75$	$19.57^{FF}\pm1.42$	$91.22^{C}\pm2.06$	$37.64^{D}\pm1.44$	$69.22^{C}\pm2.29$
T_2	$14.74^{E}\pm0.55$	$26.74^{BC}\pm1.51$	$23.29^{EF}\pm1.06$	$95.55^{BC}\pm3.21$	$40.42^{D}\pm1.55$	$77.55^{AB}\pm2.51$
Pickled UF soft cheese						
C_2	$14.07^{E}\pm0.30$	$23.75^{CD}\pm1.21$	$21.92^{EF}\pm2.04$	$92.76^{C}\pm1.40$	$30.48^{E}\pm1.45$	$67.28^{C}\pm3.01$
T_3	$15.05^{E}\pm0.57$	$29.16^{B}\pm1.40$	$24.11^{EF}\pm0.80$	$100.13^{B}\pm0.84$	$41.33^{D}\pm0.94$	$75.55^{B}\pm1.81$
T_4	$16.77^{E}\pm0.92$	$32.98^{A}\pm2.72$	$25.04^{E}\pm0.58$	$109.67^{A}\pm1.74$	$41.90^{D}\pm1.02$	$83.27^{A}\pm2.79$

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

S.N./T.N., soluble nitrogen/total nitrogen.