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RESEARCH ARTICLE

Compositional analysis of Chami cheese made from bovine milk in UAE

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ABSTRACT

Samples of nine home-made, commercial Chami cheese samples were analyzed for chemical composition, texture, and rheology. The samples showed large variations in moisture, protein, fat, ash, mineral contents, and pH values. Fat content, fatty acid composition, and differential scanning calorimetry analyses suggested addition of extra fat in some samples either butter or vegetable oil. The sodium content in the 9 cheese samples varied from 223-2411 mg/kg with three samples having very high contents 1756, 2024, and 2411 mg/kg indicative of added salt. The sample with the low moisture content (60.9%) was the hardest among the cheeses. Rheological examination showed the Chami cheese samples of more elastic than viscous behavior.

Keywords: Chami; Cheese; Chemical Composition; Texture; Rheology

INTRODUCTION

Traditional foods represent an important part of the Emirati culture, identity, and heritage. The diet of Emirati citizens includes many imported foods but traditional foods that are either prepared at home or purchased from restaurants still contribute a significant proportion of the diet of the local people (Habib et al., 2011). However, production of almost all traditional cheeses occurs to meet the local demand and those cheeses are not very well known in other regions. One of the appreciated Emirati foods is Chami, which is a traditionally fermented white cheese characterized by weak gel structure resembling in freshness cottage cheese that has been drained (Nessrien, 2013) and similar to Petit Suisse cheese in consistency (Pereira, 2016). The soft cheese like Chami should not have moisture level more than 55% whereas the milk fat should not be under the amount of 30%. The fat is adjusted by adding salt and nitrogen which can improve its spreadability. The soft cheese can also contain gelling and emulsifying locust gum bean for the thickening mechanisms. It can contain fat like 30.3-33.6% whereas the desired amount of the protein can be 8-10%. The soft cheese is hugely dependent on the lactate amount that needs to be 2-3% for perfect chemical bonding to procure consumable character (Kondyli et al., 2012). Chami has an improved shelf life and sensory properties due to the development of characteristic sweet taste with slight acidic and diacetyl flavor (Nessrien et al., 2013). Chami cheese is consumed generally with other food item (rice, date fruit, bread) during breakfast or consumed in dried form as Kami or Igt. There are many traditional kinds of cheese like the Chami in different countries such as Feta, Karish, Jammed, Koumiss, Jaben, Amasi, and Wara cheeses.

Chami cheese is prepared at homes and is commercialized by women. The quality of the cheese is primarily determined by the level of freshness of the milk used and also by external processing factors such as exposure to heat, air, and light. The preparation method and storage may change the quality of the prepared cheese leading to degradation and/or formation of undesirable flavors and tastes (Claudia et al., 2015). The producers of Chami cheese usually develop their own recipes to ensure a good shelf-life and sensory quality with regard to texture and taste. Therefore, some variability of the composition and quality of the home-produced Chami cheese is expected. There are not any studies reported on physico-chemical and compositional properties of chami cheese. Faced with extinction of some traditional cheeses and changes in milk production and

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cheese manufacture, a real need exists for the knowledge of characterization of texture and fat profile of traditional cheeses. Therefore, this study aimed to analyze commercial Chami samples and evaluate the variability in their chemical, textural, and rheological properties.

MATERIAL AND METHODS

Chami cheese samples and chemicals

Nine different commercial Chami samples procured from Abu Dhabi, Al Ain, Sharjah, and Fujairah were used in this study. Fig. 1 shows the photograph and procedure for preparation of chami cheese. The samples were immediately analyzed for texture and rheology and were frozen at -20 °C for the other analyses. Boron trifluoride for fatty acid methylation, fatty acid standards for gas chromatography analysis, potassium hydroxide for saponification, sodium hydroxide and phenolphthalein for titration, and all other reagents of analytical grade were purchased from Sigma (St Louis, CA, USA).

Physicochemical analysis

Chami cheese samples were homogenized in a mortar and pestle and analyzed for their proximate composition (fat content, total protein content, moisture and ash) using reference methods (AOAC, 2000). The pH of homogenized Chami samples was measured using pH meter (OHAUS Model®Starter 3100, Cole-Parmer Canada, Montreal, Canada).

Mineral analysis was performed using the inductively coupled optical emission spectrometer that runs axial and radial view analysis (ICP-OES model 710-Es, Varian/Agilent, Santa Clara, CA, USA). A microwave accelerated reaction system (model Mars 5, CEM Corporation, Matthews, North Carolina, USA) was used to digest the samples by adding 10 ml of concentration nitric acid (70% HNO_3) and 2 ml hydrochloric acid (37% HCl) in a closed vessel. Once dissolved, the solutions could cool and made up to 50 ml in a volumetric flask. After cooling, the vessel contents were filtered before analysis by ICP-OES.

For the analysis of fatty acid composition, fatty acid methyl esters (FAME) were prepared by saponifying samples of the fat (10mg) with 0.5 N alcoholic potassium hydroxide (1 ml) in sealed vials at 100°C for 10 minutes, cooling, and methylation with BF_3 reagent (2 ml) by heating again at 100°C for 10-15 minutes. The FAMEs

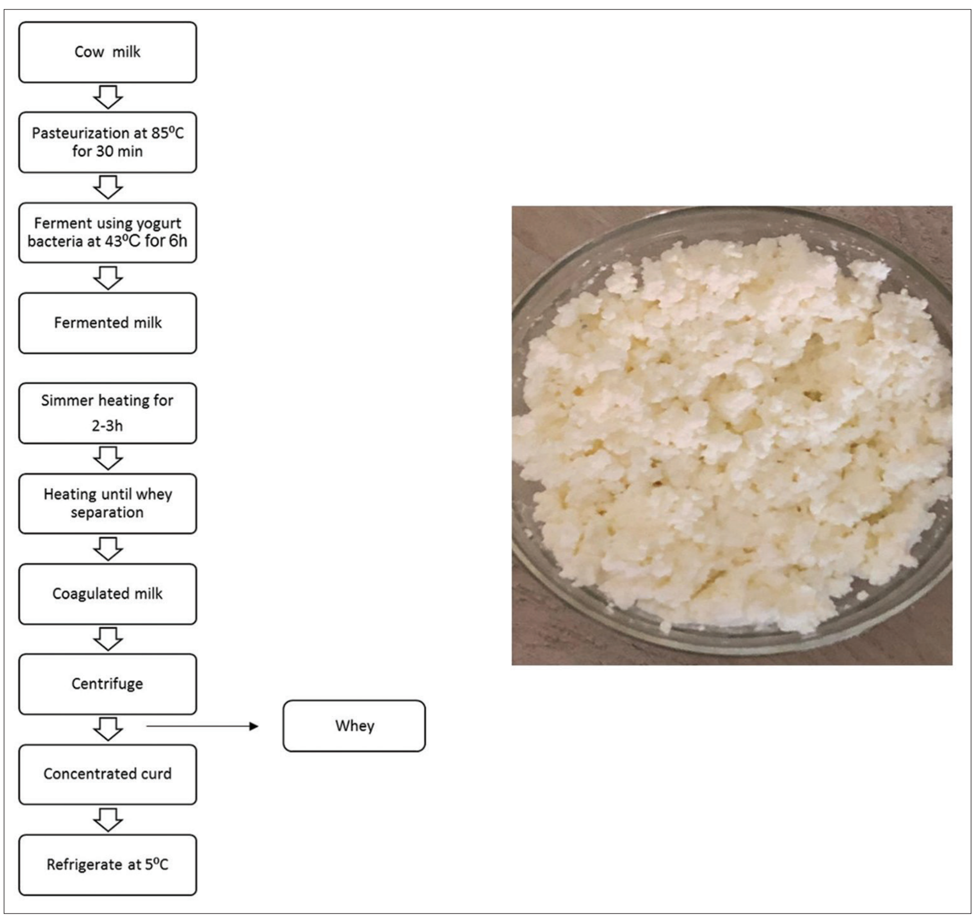

Fig 1. General procedure and photograph of Chami from cow milk.

were extracted twice in heptane (1 ml) and the extract was washed twice with water (1 ml) and dried using anhydrous Na_2SO_4. The extract was concentrated to 0.5 ml and transferred to a clean GC vial for injection into the gas chromatograph (6500GC System, YL instrument, Anyang, South Korea). The injected volume was 1 μl, and the injector was set at 240°C in a split mode (1:10). Separations were performed on CP 7488 Varian capillary column (50 m, 0.25 mm i.d., 0.2 μm film thickness, USA) programmed as follows: 80°C (2 min), 5 °C/min, 190 °C (5 min), 2 °C/min, 210 °C (5 min), 10 °C/min, and 240 °C (5 min). Helium was used as a carrier gas at a flow rate of 1.5 ml/min. Peaks were detected using flame ionization detector set at 300 °C.

Differential scanning calorimetry (DSC)

The glass-transition temperature (T_g) and thermal behavior of homogenized Chami samples were measured using differential scanning calorimetry (TA Instruments Q100, New Castle, UK). A heat-cool-heat temperature programming protocol was adopted with the first heating at 5 °C/min followed by cooling at −30°C/min and final heating at 5°C/min to 70°C as the expected thermal events (glass transition temperature and a melting point of fat lie within this range temperature (Hjalmarsson, 2015).

Texture profile analysis

Instrumental texture profile analysis (TPA) parameters were determined using a Brookfield Texture Analyzer CT3 (Middleboro, MA, USA) utilizing two cycles of compression-decompression. The load cell of measurement was up to 50 kg weight. The Chami sample was filled in cup size 25 g. The instrument was set to zero before each measurement and compression mode was used for the textural analysis. The TPA parameters were determined from force-time curves depending on the following attributes: peak force of the first compression cycle 1 (N); peak force of the second compression cycle 2 (N); adhesive forces; resilience, springiness, fracturability (N), cohesiveness, chewiness, and gumminess (Hjalmarsson, 2015).

Rheological properties

Rheological measurements were performed using a DHR-2 hybrid rheometer (TA Instruments Ltd., Discovery, New Castle, DE, USA). A representative portion of each sample was carefully removed and put on the bottom plate of the rheometer. The top plate was slowly down until space was 1 mm and excess sample was removed from the edges of the plate. The oscillatory trails frequency sweep test was carried out with a frequency ranging between 0.01 and 10 Hz, at the same deformation (1%) within a linear viscoelastic region of less than 2%. The storage modulus (G') and the loss modulus (G") were recorded as a function of frequency. The temperature was set at 10 ºC during the tests. The tan delta were calculated by taking the ratio between G´´ and G´(Bayarri et al., 2009).

Statistical analysis

All the experiments were independently performed two to three times. All data were expressed as a mean value. The differences in physicochemical properties of commercial Chami samples were analyzed using one-way ANOVA test.

RESULTS AND DISCUSSIONS

Physicochemical parameters

Values of moisture, protein, fat, ash, pH of nine homemade Chami ranged between 60.9-84.1%, 8.2-14.6%, 0.5-7.8%, 5.1-8.0%, respectively, as shown in Table 1. The moisture values are comparable to other traditional soft cheeses like feta cheese having moisture contents of 60% and cottage cheese having about 80% moisture (Nessrien et al., 2013). In addition, protein values were in accordance with Dhuol et al. (2013) and Kondyli et al. (2012) who reported 11.2-21.4% protein in soft cheeses and the fat content was reported as 0.4-5.3 % in cottage cheese by Nessrien et al. (2013). The ash content was also comparable to other soft cheeses, for example cream cheese (7%) (Nessrienet al., 2013) and cottage cheese (8.0%) (Nessrien et al., 2013). The pH of Chami cheese samples were in the similar range of 4.2-4.5 as reported by Benkerroum and Tamime (2004).

The DSC thermograms show differences in the sizes of their fat melting peaks of three Chami samples (2, 5 and 9), as presented in Fig. 2,. These Chami samples showed a distinctive peak at (0°C) which represents the melting point of ice water in the samples. The two samples showed characteristic peaks that can be associated with the melting temperature of fat. However, it can be noticed the peak sizes in sample 5 is relatively

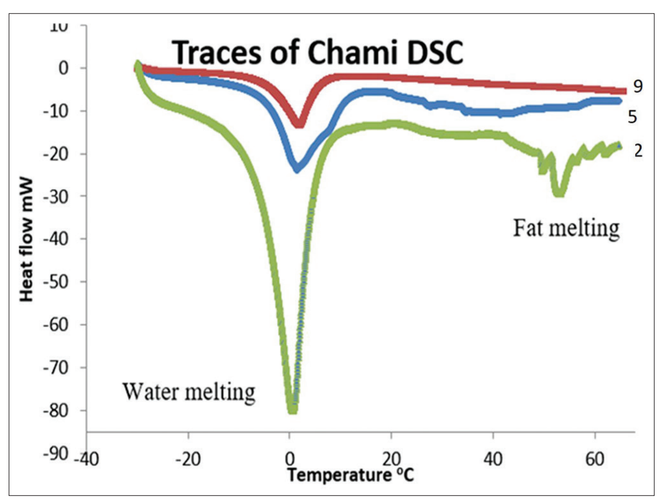

Fig 2. Differential scanning calorimetry (DSC) of Chami samples: red (samples 9), blue (sample 6), and green (sample 2).

Table 1: Proximate and mineral composition of the studied Chami cheese samples

Sample	Proximate components (%)				pH	Minerals (mg/Kg)							
	Moisture	Protein	Fat	Ash		Na	K	Ca	Mg	Fe	Zn	P	S
1	83.3	8.5	1.0	5.2	4.3	389	1008	1213	100	2	5	1530	1081
2	60.9	14.6	7.8	6.7	4.3	2411	988	944	86	2	1.8	1603	1291
3	81.1	10.0	0.8	6.6	4.0	668	864	1218	94	2	5	1426	910
4	81.7	8.2	1.0	6.5	3.7	223	695	812	76	2	7	1297	1009
5	72.8	12.5	2.1	8.0	4.5	263	816	959	87	1	7	1578	1214
6	80.9	11.3	1.0	5.1	3.6	2024	671	970	92	2	5	2018	1437
7	79.3	7.5	6.8	3.4	4.1	385	833	833	84	2	4	985	541
8	76.9	12.7	0.5	7.2	4.0	1756	736	736	83	1	4	1096	604
9	84.1	8.9	0.5	5.2	4.4	234	736	736	83	2	9	1481	1175
Range	60.9-84.1	8.2-14.6	0.5-7.8	5.1-8.0	3.6-4.5	223-2411	736-1008	736-1218	76-100	1-2	1.8-9	985-2018	541-1291
Mean	77.8	10.4	2.4	6.0	4.1	928	816	936	87.2	1.8	5.3	1446	1029
SD	7.2	2.4	2.8	1.4	0.3	877	121	182	7.1	0.4	2.1	303	301

smaller than the peaks of sample 2. This revelation agrees with the findings in the proximate composition analysis which showed that no. Sample 5 contained 2.1 % of fat while the sample 2 had 7.8% of fat (Table 1). In addition, the fat in sample 2 Chami melts at high temperatures of 45°C and 50°C for different fractions while sample 5 and 9 sample had low melting temperature of the fat i.e. between 25°C and 38°C. Although, there was no difference between the three cheese samples in the fatty acid composition (Table 2) suggesting that the difference in DSC results was mainly due to differences in total milk fat content, i.e. in the use of skimmed versus whole fat milk.

Table 1 shows the average values (mg/kg) of different minerals namely calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), phosphorous (P), sulfur (S), iron (Fe), manganese (Mn), and zinc (Zn). The sodium content in the 9 cheese samples varied from 223-2411 ppm with three samples having very high contents: (1756), (2024), (2410) suggesting addition of salt while preparing these cheese samples to influence taste, texture, and shelf-life of the cheese. Moreover, Dhuol and Hamid (2014) reported similar values for sodium (Na) and potassium (K) contents in case of soft white cheese. In addition, the pH values also impact the mineral content as it causes the movement of minerals from center to the external layer of cheese block or vice-versa (Kwak, 2011).

Texture profile analysis (TPA)

Results of TPA of nine Chami samples are given in Table 3. Sample 2 reported highest hardness cycles 1 and 2, fracturability, gumminess, and chewiness values while sample 4 had the least. The low hardness values in samples 1, 3, 4, 6,7, 8,9 can be explained by their higher moisture contents in these compared to other samples (Table 1). Hardness cycles 1 is positively correlated to hardness cycle 2, fracturability, gumminess, and chewiness but

Table 2: Fatty acids composition of three selected Chami cheeses (relative %)

Fatty acids	Cheese Sample Number		
	2	5	9
C6:0	0.8	0.1	0.2
C8:0	0.7	0.9	0.1
C10:0	1.9	2.1	2.0
C12:0	2.5	2.7	2.9
C14:0	10	9.4	10
C14:1	0.9	0.7	0.5
C15:0	1.1	1.0	1.1
C16:0	35.1	34.5	36.2
C16:1	2.0	1.5	1.3
C17:0	0.8	0.9	0.5
C18:0	10.3	10.6	10.1
C18:1	23.2	24.7	24.6
C18:2	8.0	8.0	5.6
C20:0	0.6	0.5	0.3
C18:3	0.5	0.2	0.3
C21:0	N.D.	0.3	0.9
Others	2.5	3.0	2.8

N.D. =Not detected

negatively correlated with springiness ($P<0.05$) (Table 4). The suitable chewiness provides a rich mouthfeel and enhances the joy of tasting cheese (Zheng, 2016). Textural attributes such as hardness, chewiness, gumminess are also positively influenced by protein content (Simoes et al., 2013) and fat content (Brighenti et al., 2008). Higher adhesiveness in samples 1, 3 and 4 can be explained by their higher fat content, which softens the cheese. Adhesiveness can be explained as the work required to pull cheeses away from the surfaces and higher adhesiveness values may be attributed to interactions between protein and water (Pastorino et al., 2003). No differences were found in resilience and cohesiveness of the nine Chami samples. Fat content, especially saturated fatty acids, negatively correlate with resilience because the presence of fat in cheese leads to deformation of the product and reduction of its resilience. In addition, high NaCl content

Table 3: Texture parameters of Chami samples

Sample	Hardness Cycle 1 (g)	Adhesiveness (mJ)	Resilience	Fracturability (g)	Hardness Cycle 2 (g)	Cohesiveness	Springiness	Gumminess (g)	Chewiness (mJ)
1	328	3.2	0.1	245	215	0.4	8.1	142	11.8
2	777	0.1	0.2	777	683	0.5	5.9	420	25.0
3	423	1.8	0.1	391	174	0.5	5.1	193	12.1
4	133	0.9	0.1	33	117	0.6	7.4	77	5.7
5	632	0.1	0.3	632	572	0.6	6.3	383	25.0
6	409	0.1	0.2	340	368	0.6	6.5	246	16.0
7	510	0.3	0.2	438	466	0.6	6.3	304	18.8
8	373	0.1	0.3	305	341	0.6	6.4	229	14.4
9	458	0.1	0.2	458	407	0.5	4.1	220	12.0
Range	133-777	0.1-3.2	0.1-0.3	33-777	117-683	0.4-0.6	4.1-8.1	77-420	5.7-25.0
Mean	449	0.74	0.18	402	371	0.5	6.2	246	15.6
SD	183	1.1	0.08	216	186	0.07	1.2	109	6.4

Table 4 : Pearson's correlation analysis of texture profile of Chami samples

Variables	Hardness Cycle 1	Adhesiveness	Resilience	Fracturability	Hardness Cycle 2	Cohesiveness	Springiness	Gumminess	Chewiness
Hardness Cycle 1	**1**								
Adhesiveness	-0.364	**1**							
Resilience	0.411	**-0.881**	**1**						
Fracturability	**0.996**	-0.380	0.423	**1**					
Hardness Cycle 2	**0.970**	-0.505	0.541	**0.963**	**1**				
Cohesiveness	-0.213	-0.578	0.594	-0.237	-0.055	**1**			
Springiness	**-0.638**	0.514	-0.370	**-0.674**	-0.563	0.266	**1**		
Gumminess	**0.981**	-0.484	0.555	**0.975**	**0.983**	-0.031	-0.594	**1**	
Chewiness	**0.968**	-0.412	0.530	**0.958**	**0.968**	-0.019	-0.504	0.991	**1**

increases the possibility of Ca^{2+} replacement and reduces the firmness and resilience of cheese. Cohesiveness showed a weak negative correlation with gumminess and chewiness attributes in agreement with previous findings (Zheng, 2016).

Principal component analysis of the texture profile of Chami cheese shows that two principal components (PCs) explained 88.7% of the variation in texture parameters; PC1 (65.8%), and PC2 (22.9%) (Fig. 3). Hardness cycles 1 and 2, cohesiveness, chewiness, fracturability, and resilience were separated from adhesiveness and springiness along PC1 while PC2 separates cohesiveness, resilience, and springiness from the rest of the parameters. The 9 samples showed variation in texture descriptors with samples showing cohesiveness/resilience (samples 5 and 7), hardness, chewiness, gumminess, and fracturability (samples 2), adhesiveness (samples 1, 3, and 9), or springiness (samples 4, 6, 8).

Rheological analysis

The rheological analysis was performed to assess the viscoelastic properties of Chami samples (Table 5). Frequency sweep test was conducted from 0.01 to

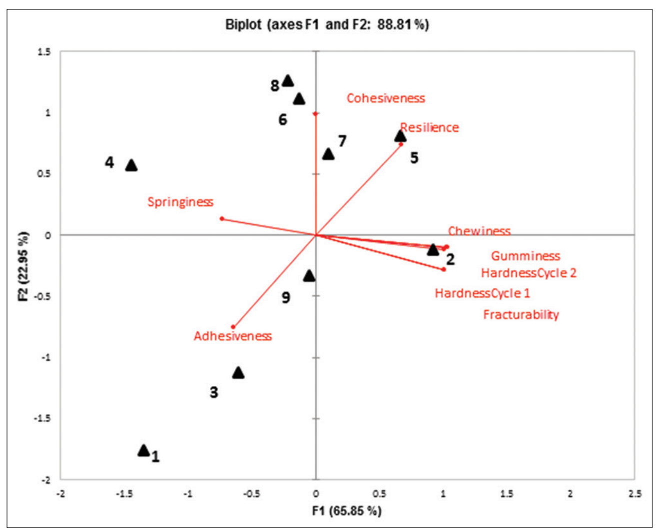

Fig 3. Principle component analysis of Chami cheese texture.

10 Hz at a fixed strain of 1%. The values of storage modulus (elastic; G´), loss modulus (viscous; G´´), apparent viscosity (η), and tan delta (δ) were in range of 33-300 KPa, 8.5-100 KPa, 5-55 Pa.s and 0.22-0.30, respectively. The Elastic Modulus G´ was higher than loss modulus G´´ for all Chami samples implying that all Chami samples had more elastic structure than viscous.

Table 5: Viscoelastic properties of Chami at a fixed frequency of 1 Hz

Chami	Elastic modulus G× (kPa)	Viscous modulus G×× (kPa)	Apparent viscosity η (kPa.s)	tan delta (δ)
1	40	9.7	5	0.24
2	300	90	40	0.3
3	100	30	19	0.3
4	33	8.5	7	0.25
5	300	100	51	0.3
6	89	20	15	0.22
7	250	71	40	0.28
8	250	60	30	0.24
9	301	101	55	0.3
Range	33-300	8.5-100	5-55	0.22-0.30
Mean	185	54.4	29.1	0.27
SD	117	38.2	18.6	0.03

Viscoelasticity is the main feature for cheese structure (Lucey et al., 2003). The predominance of caseins in cheese matrix and cross-linkages between cheese proteins may be attributed to the elastic properties of cheese structure (Hassan et al., 2005). These results are in accordance with those reported by Ma et al. (1997) and Raphaelides et al. (2006). The tan delta is a measure that relates the viscous and elastic properties of a viscoelastic material (Bayarri et al., 2009). Since, tan delta values of all Chami cheeses are less than 1 indicating elastic behavior (solid-like) of the cheeses.

CONCLUSIONS

Chami is a traditional fermented soft cheese product in UAE, prepared by whey separation by either centrifuging or shaking, boiling, and dictation followed by final concentration of curd by sieving over a cloth. Nine Chami cheeses studied had comparable chemical compositions except for 3 samples found with high salt and 2 samples with high fat contents. Strong positive correlations were observed between hardness cycle 1 with hardness cycle 2, fracturability, gumminess, and chewiness but negatively correlations with springiness. The PCA showed that there is variation in texture descriptors with some samples showing cohesiveness/resilience (samples 5 and 7), hardness, chewiness, gumminess, and fracturability (2), adhesiveness (samples 1, 3, and 9), and springiness (sample 4, 6, 8). In addition, rheological studies showed that all Chami samples had more elastic structure than viscous.

Authors' Contributions

Aysha O. A. Al Katheeri: Investigation; Bhawna Sobti: Writing-Manuscript Draft, Sami Ghnimi: Supervision, Reviewing and Editing Manuscript Afaf Kamal-Eldina: Supervision, Reviewing and Editing Manuscript

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