

# Impact of innovative formson the chemical composition and rheological properties of jameed

## Abstract

Jameed is a fermented dried dairy product in the form of stone hard balls or other shapes. The aim of this study was to introduce a new jameed forms. Nine treatments of jameed were made from sheep buttermilk, goat and cow skim milk. Sheep buttermilk jameed took a spherical shape whereas goat or cow skim milk jameed was formed as a ball, triangle, square and cylinder. Utilization of square and cylinder molds in jameed manufacturing lowered total solids, fat and protein values. Square and cylinder forms jameed possessed the lowest total viable bacterial count, lactic acid bacteria and proteolytic bacteria. Using of triangle or square molds increased jameed wettability levels. The spherical and cylindrical shapes had the minimum values of hardness, cohesiveness, gumminess and chewiness whereas the triangle and square forms possessed the maximum levels. The scanning electron microscopy showed that in triangle jameed some compact protein masses with coarse structure contained little spaces were observed. In square and cylinder jameed, protein network possessed rigid plates structure, little aggregates and more gaps scattered in matrix.

**Keywords:** jameed, ball, triangle, square and cylinder molds

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**Abbreviations:** TVBC, total viable bacterial count; LAB, lactic acid bacteria; SEM, scanning electron microscopy; LSD, least significant difference; TS, total solids; SNF, solids-not-fat; WSN, water soluble nitrogen

## Introduction

Fermentation has being used in foods for thousands of years according to archaeological evidence. From time to time fermentation started to use for longer shelf life, and higher nutritional values. Today this technique is being commonly used in vegetables, fruits, cereals, meat, milk and fish and the fermented products are consumed around the world.<sup>1</sup>

Jameed is a dried fermented milk product that is widely used in Jordan, Palestine, Syria, Egypt, Northern Saudi Arabia and the western part of Iraq. Jameed (dried round balls) is one of the fermented milk products that are utilized after reconstitution in preparation of popular dishes in place of fresh yoghurt in the Middle East countries such as Jordan, Syria, Iraq and Egypt.<sup>2</sup>

Jameed is manufactured mainly from churned buttermilk during the surplus milk season (spring) as a means of preserving the milk but it can be made from cow and camel milk. It plays a large role in the nutritional well-being of the local population during periods of the year when fresh milk is not available. This product is reconstituted by soaking with water after crushing or grinding, and consumed as a yoghurt drink or in the form of a hot soup when cooked with meat.<sup>3</sup>

On the other hand, different shapes and forms affect the amount of moisture a cheese will retain, and the amount of time a cheese has to reach its peak. While in their forms, curds can also be pressed to release the whey.<sup>4</sup> Molds are used to form and consolidate curds, giving a finished cheese its desired shape. If a recipe calls for weight to be added to the curds, a press will apply uniform pressure.

Traditionally, jameed is manufactured in ball shape. The aim of this study was to break this rule, to introduce a new jameed may be more attractive and to facility pouring off moisture. Jameed was prepared in triangle, square and cylinder forms. The impact of these forms on the chemical composition, rheological and microbial properties of jameed was investigated.

## Materials and methods

### Materials

Fresh sheep, goat and cow milks were obtained from El-Serv Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Egypt. A commercial classic yoghurt starter containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (1:1) (Chr. Hansen's Lab A/S Copenhagen, Denmark) was used. Starter cultures were in freeze-dried direct-to-vat set form and stored at -18°C until used.

### Methods

**Jameed manufacture:** Nine treatments of Jameed were made from sheep buttermilk and from goat and cow skim milk according to the traditional method described by Quasem et al.<sup>5</sup> Jameed paste was manually shaped into balls whereas triangles, squares and cylinder forms were made by pressing the paste in the molds using hydraulic compressor for 1h. The weight and square area of all jameed forms were equal to minimize the differences between various treatments. Jameed treatments were as follows:

- Treatment A: Jameed made from sheep buttermilk with ball form
- Treatment B: Jameed made from goat skim milk with ball form
- Treatment C: Jameed made from goat skim milk with triangle form
- Treatment D: Jameed made from goat skim milk with square form

- v. Treatment E: Jameed made from goat skim milk with cylinder form
- vi. Treatment F: Jameed made from cow skim milk with ball form
- vii. Treatment G: Jameed made from cow skim milk with triangle form
- viii. Treatment H: Jameed made from cow skim milk with square form

- ix. Treatment I: Jameed made from cow skim milk with cylinder form

Figure 1 illustrates jameed manufacturing. The shaped jameed samples were placed on trays lined with cheesecloth and dried in the shade for 24h then direct sun until to constant weight (~15days). The dried jameed treatments were packaged in polyethylene bags and stored at room temperature 6months. Samples were analyzed when fresh and after 15, 30, 60, 90, 120, 150 and 180days of storage period.

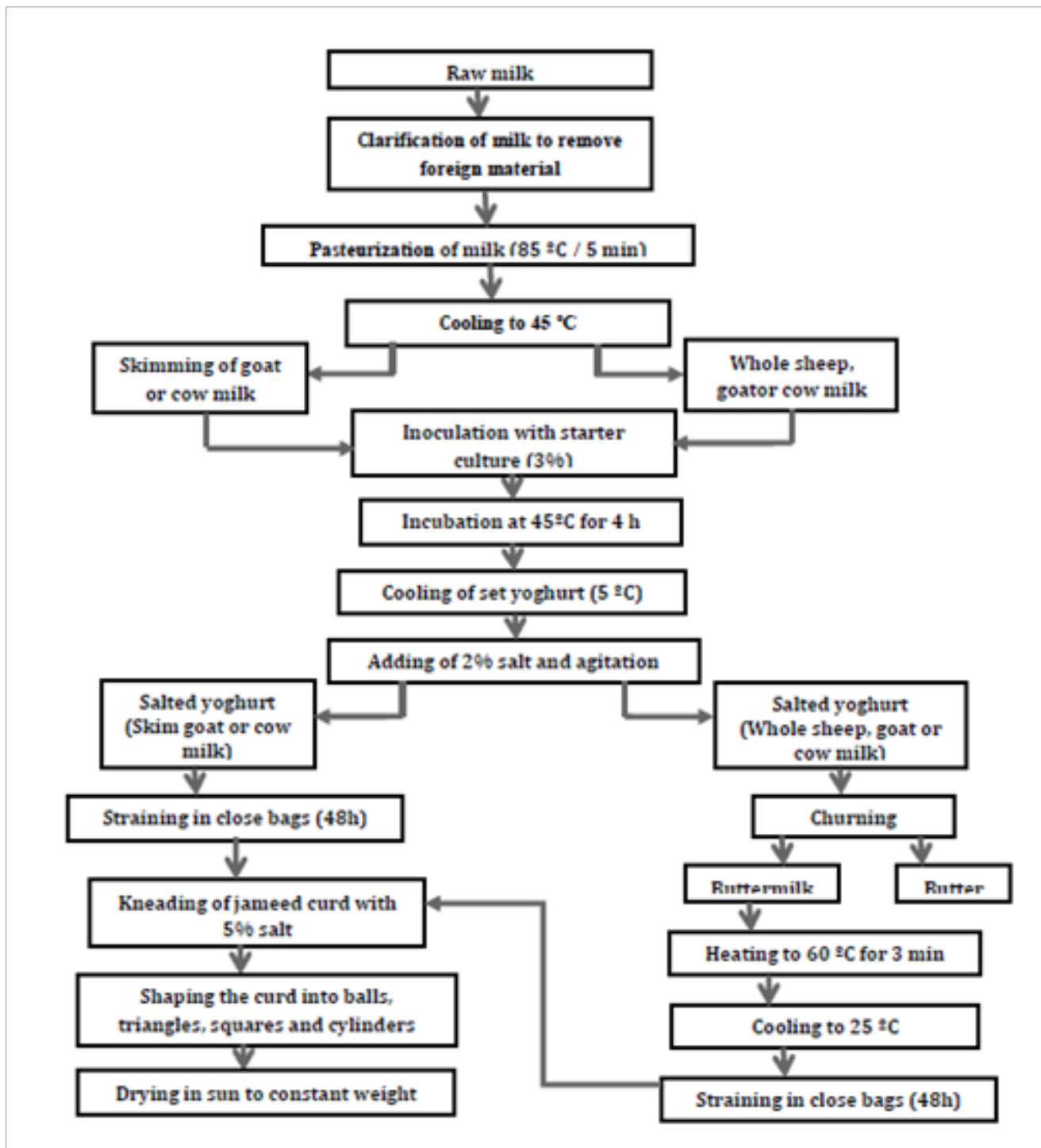


Figure 1 The processing steps for jameed.

## Methods of analysis

### Chemical analyses

Total solids, fat, total nitrogen and ash contents of samples were determined according to AOAC.<sup>6</sup> Titratable acidity in terms of % lactic acid was measured by titrating 10g of sample mixed with 10ml of boiling distilled water against 0.1 N NaOH using a 0.5% phenolphthalein indicator to an end point of faint pink color.<sup>7</sup> pH of the sample was measured at 17 to 20°C using a pH meter (Corning pH/ion analyzer 350, Corning, NY). Water soluble nitrogen (WSN) and non-protein-nitrogen of jameed were estimated according to Ling.<sup>8</sup> The Volhard's method as described by Richardson<sup>9</sup> was used to determine the salt content of jameed. Salt in moisture percentage of the cheese was estimated as follow: (Salt percentagex100)/(Moisture percentage+Salt percentage)

### Microbiological analyses

Jameed samples were analyzed for total viable bacterial count (TVBC), lactic acid bacteria (LAB), coliform, proteolytic bacteria, yeast-moulds counts according to the methods described by the American Public Health Association.<sup>10</sup>

### Wettability (diffusability) test

A cube weighing ca. 45g of jameed was cut using a hand saw from a whole jameed ball; 315ml water were added to the piece placed in 500ml cup and soaked for 24h.<sup>5</sup> The excess free water was carefully decanting weighed to calculate the soaked amount as follows:

$$\text{Absorbed water (\%)} = 315\text{ml water} - X / \text{Weight of cubs (g)} \times 100$$

Where X, the weight of excess water (g).

### Syneresis (whey separation) test

The soaked cube (45g) was mixed with (315ml water) for two minutes using electrical hand mixer (Hinari, model FM2, China) with the whipping accessory. The dispersed jameed was transferred to a 100ml graduated cylinder and the clear zone was measured after 1h and 24h.<sup>5</sup> Syneresis (whey separation) was calculated, as follow:

$$\text{Syneresis (\%)} = X / Y \times 100$$

Where; X, The height of the clear zone. Y, Total height of jameed dispersion.

### Textural measurements

Force and torque measurements of jameed treatments stored for sixmonths were measured using a Texturometer model Mecmesin Emperor TMLite 1.17(USA). Mechanical primary characteristics

of hardness, springiness, gumminess and cohesiveness and also the secondary characteristic of chewiness (hardness x cohesiveness x springiness) were determined from the deformation Emperor TMLite Graph. Because jameed samples were very hard, they were soaked in distilled water for 6h at room temperature before measurements.

### Scanning electron microscopy (SEM) examination

Jameed samples were prepared for SEM according to the method of Brooker & Wells.<sup>11</sup> The specimens were viewed in a scanning electron microscope (JXA-840A Electron Probe Micro analyzer-JEOL-Japan) after dehydrated using Critical Point Dried instrument and coating with gold using S150A Sputter Coater-Edwards England.

### Statistical analysis

The obtained results were statistically analyzed using a software package<sup>12</sup> based on analysis of variance. When F-test was significant, least significant difference (LSD) was calculated according to Duncan<sup>13</sup> for the comparison between means. The data are expressed as the mean of three experiments.

## Results and discussion

### Chemical composition of milk used in jameed manufacture

Because of fermentation process, sheep buttermilk had the highest acidity content and the lowest pH values (Table 1). On the contrary, total solids (TS) and solids-not-fat (SNF) contents were higher in goat and cow skim milk than that of sheep buttermilk. Because fat globules of goat's milk don't easily separated by separator as occur in cow's milk, fat concentration of goat skim milk was the highest as compared with those found in sheep buttermilk or cow skim milk. Sheep buttermilk is richer in protein than goat or cow skim milk.

### Chemical composition of jameed during storage period

During the storage period, titratable acidity values of various jameed treatments tended to increase while pH values tended to decrease (Table 2). The highest increasing rates or the lowest decreasing levels were observed through sun drying stage (15day) and in the first fifteen of storage. These results may be due to acid production in jameed during storage as a result of lactose fermentation. Sheep buttermilk jameed had higher acidity ratios than jameed prepared from goat or cow skim milk. Also, the highest values of the acidity development rates during storage were higher in the former than those of the latters. Goat skim milk jameed possessed slightly higher acidity values than cow skim milk jameed.

**Table 1** Chemical composition of milk used in jameed manufacture

Treatments	Acidity%	pH values	TS%	Fat %	Total protein%	SNF%
Sheep buttermilk	0.99 <sup>a</sup>	5.92 <sup>b</sup>	7.81 <sup>b</sup>	0.7 <sup>a</sup>	5.10 <sup>a</sup>	6.50 <sup>b</sup>
Goat skim milk	0.16 <sup>b</sup>	6.61 <sup>a</sup>	9.88 <sup>a</sup>	0.9 <sup>a</sup>	3.12 <sup>b</sup>	8.98 <sup>a</sup>
Cow skim milk	0.18 <sup>b</sup>	6.58 <sup>a</sup>	9.40 <sup>a</sup>	0.3 <sup>b</sup>	3.01 <sup>b</sup>	9.10 <sup>a</sup>

<sup>abcde</sup> Letters indicate significant differences between milk treatments

**Table 2** Effect of jameed form on some physicochemical properties

perties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
Acidity%	A	2.05	3.48	4.11	4.46	4.78	5.01	5.25	5.36	4.32 <sup>a</sup>
	B	1.82	2.78	3.27	3.58	3.88	4.07	4.3	4.4	3.48 <sup>ab</sup>
	C	1.82	2.8	3.26	3.6	3.87	4.05	4.29	4.41	3.51 <sup>ab</sup>
	D	1.82	2.77	3.24	3.57	3.86	4.06	4.28	4.39	3.50 <sup>ab</sup>
	E	1.82	2.75	3.23	3.56	3.85	4.05	4.27	4.37	3.49 <sup>ab</sup>
	F	1.72	2.6	3.1	3.38	3.62	3.83	3.96	4.08	3.25 <sup>b</sup>
	G	1.72	2.59	3.1	3.37	3.63	3.82	3.95	4.07	3.28 <sup>b</sup>
	H	1.72	2.58	3.09	3.35	3.6	3.82	3.95	4.06	3.33 <sup>ab</sup>
	I	1.72	2.56	3.06	3.33	3.6	3.81	3.94	4.05	3.25 <sup>b</sup>
	Means	1.82 <sup>D</sup>	2.76 <sup>C</sup>	3.32 <sup>CB</sup>	3.57 <sup>CAB</sup>	3.84 <sup>AB</sup>	4.04 <sup>AB</sup>	4.23 <sup>A<sup>B</sup></sup>	4.34 <sup>A</sup>	
pH values	A	4.98	4.43	4.19	3.91	3.7	3.55	3.41	3.36	3.94 <sup>a</sup>
	B	5.32	4.61	4.45	4.32	4.11	4.05	3.96	3.87	4.37 <sup>a</sup>
	C	5.32	4.6	4.44	4.3	4.14	4.07	3.97	3.86	4.33 <sup>a</sup>
	D	5.32	4.63	4.47	4.33	4.13	4.07	3.97	3.89	4.35 <sup>a</sup>
	E	5.32	4.65	4.47	4.34	4.14	4.08	3.98	3.91	3.61 <sup>a</sup>
	F	5.41	4.71	4.49	4.38	4.32	4.23	4.18	4.06	4.50 <sup>a</sup>
	G	5.41	4.73	4.5	4.4	4.3	4.24	4.17	4.08	4.48 <sup>a</sup>
	H	5.41	4.72	4.51	4.39	4.35	4.25	4.2	4.08	4.49 <sup>a</sup>
	I	5.41	4.74	4.53	4.41	4.36	4.26	4.21	4.11	4.50 <sup>a</sup>
	Means	5.30 <sup>A</sup>	4.67 <sup>AB</sup>	4.46 <sup>AB</sup>	4.32 <sup>B</sup>	4.18 <sup>B</sup>	4.10 <sup>B</sup>	4.02 <sup>B</sup>	3.92 <sup>B</sup>	
TS%	A	48.67	82	84.95	86.12	87.08	87.87	88.58	89.06	81.79 <sup>a</sup>
	B	31.89	75.79	78.14	79.1	81.11	82.15	82.21	82.95	82.04 <sup>a</sup>
	C	31.89	76.15	78.12	79.25	80.92	82.1	82.32	82.8	74.20 <sup>b</sup>
	D	31.89	72.67	75.55	76.64	78.19	79.74	80.01	80.79	71.81 <sup>c</sup>
	E	31.89	71.23	74.3	75.34	76.37	77.41	77.84	78.24	70.39 <sup>d</sup>
	F	34.14	76.24	79.12	80.26	81.33	82.46	82.97	83.78	82.44 <sup>a</sup>
	G	34.14	77.1	78.95	80.02	81.1	82.5	82.88	83.64	75.04 <sup>b</sup>
	H	34.14	73.45	76.68	78.72	79.79	80.82	81.12	81.69	73.93 <sup>b</sup>
	I	34.14	72.7	75.81	77.84	78.86	79.87	80.25	80.74	72.53 <sup>c</sup>
	Means	42.88 <sup>F</sup>	76.54 <sup>E</sup>	79.04 <sup>D</sup>	80.35 <sup>C</sup>	81.35 <sup>CB</sup>	82.17 <sup>AB</sup>	82.63 <sup>A</sup>	83.1 <sup>A</sup>	
Fat %	A	3.85	10.4	10.64	10.87	11.05	11.14	11.23	11.35	10.06 <sup>ab</sup>
	B	4.19	11.36	11.57	11.71	11.84	11.98	12.2	12.35	10.92 <sup>a</sup>
	C	4.19	11.27	11.73	11.8	11.93	12.17	12.25	12.42	10.97 <sup>a</sup>
	D	4.19	10.65	10.87	10.94	11.16	11.29	11.37	11.49	10.25 <sup>ab</sup>
	E	4.19	9.65	9.87	9.97	10.12	10.34	10.41	10.62	9.40 <sup>b</sup>
	F	3.17	9.9	9.95	10.19	10.31	10.4	10.49	10.6	9.88 <sup>b</sup>
	G	3.17	9.83	9.9	10.15	10.37	10.61	10.7	10.85	9.45 <sup>b</sup>
	H	3.17	8.19	8.33	8.56	8.79	8.92	9.03	9.24	8.03 <sup>c</sup>
	I	3.17	7	7.13	7.34	7.55	7.7	7.86	7.98	6.97 <sup>d</sup>
	Means	4.40 <sup>A</sup>	9.78 <sup>A</sup>	9.97 <sup>A</sup>	10.14 <sup>A</sup>	10.32 <sup>A</sup>	10.47 <sup>A</sup>	10.57 <sup>A</sup>	10.7 <sup>A</sup>	

<sup>abcde</sup> Letters indicate significant differences between jameed treatments<sup>ABCD</sup> Letters indicate significant differences between storage times

Very slight decreasing in acidity values was noted as a result of change jameed shape from ball to triangle, square and cylinder. The lowest acidity levels were detected in cylindrical form jameed.

Total solids values of goat skim milk jameed were similar to those of jameed made from cow skim milk but were lower than sheep buttermilk jameed. Goat skim milk jameed had the highest fat values followed by sheep buttermilk and cow skim milk jameed. Generally, TS and fat contents of different jameed treatments gradually increased within storage period. The highest rates of increases were found at the end of solar drying stage (after 15days).

As it is showed in Table 2, molds shape had a significant effect

( $p < 0.05$ ) on TS and fat contents of jameed. Utilization of square and cylinder molds in jameed manufacturing significantly ( $p < 0.05$ ) lowered TS and fat values. The low levels were clearer in cylindrical shape jameed. On the other side, TS and fat concentrations in both ball and triangle forms jameed were close to each other.

Total protein, ash, salt and salt in moisture values of sheep buttermilk jameed were higher than goat and cow skim milk one (Table 3). Using cow skim milk in jameed production increased total protein whereas decreased ash contents as compared with jameed made from goat skim milk. No clear differences were observed in salt and salt in moisture contents between jameed made from goat or cow skim milk.

**Table 3** Effect of jameed form on some chemical properties

Properties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
Total protein %	A	29.55	51.13	53.05	53.16	53.31	53.61	53.7	53.81	50.17 <sup>b</sup>
	B	14.95	43.91	47.01	47.34	47.45	47.66	47.78	47.92	51.66 <sup>a</sup>
	C	14.95	43.45	47.55	47.78	47.87	47.91	47.96	48.07	43.19 <sup>d</sup>
	D	14.95	40.54	45.1	45.35	45.44	45.5	45.6	45.72	41.03 <sup>e</sup>
	E	14.95	38.7	44.83	45.2	45.31	45.37	45.47	45.64	40.68 <sup>e</sup>
	F	17.24	47.11	49.23	49.54	49.69	49.87	49.99	50.28	52.19 <sup>a</sup>
	G	17.24	47.32	49.38	49.43	49.52	49.67	49.85	49.97	45.30 <sup>c</sup>
	H	17.24	45	48.12	48.17	48.29	48.4	48.51	48.63	44.05 <sup>d</sup>
	I	17.24	44.65	46.94	47	47.15	47.29	47.42	47.55	43.16 <sup>d</sup>
	Means	23.87 <sup>C</sup>	46.0 <sup>B</sup>	48.95 <sup>A</sup>	49.14 <sup>A</sup>	49.26 <sup>A</sup>	49.38 <sup>A</sup>	49.49 <sup>A</sup>	49.60 <sup>A</sup>	
Ash %	A	11.5	14.87	14.95	15.38	15.59	15.81	16.04	16.14	15.04 <sup>a</sup>
	B	10.14	13.57	13.81	13.97	14.31	14.47	14.6	14.74	14.41 <sup>ab</sup>
	C	10.14	13.78	13.97	14.11	14.21	14.3	14.38	14.53	13.74 <sup>bc</sup>
	D	10.14	12.53	12.81	12.96	13.47	13.6	13.82	14.01	12.92 <sup>dce</sup>
	E	10.14	12.12	12.56	12.87	13.24	13.38	13.51	13.66	12.69 <sup>e</sup>
	F	9.97	13.3	13.57	13.69	13.94	14.27	14.49	14.64	14.40 <sup>ab</sup>
	G	9.97	13.8	13.99	14.1	14.26	14.34	14.51	14.67	13.71 <sup>dcb</sup>
	H	9.97	12.71	12.89	13.12	13.28	13.41	13.6	13.78	12.85 <sup>dce</sup>
	I	9.97	12.68	12.71	12.97	13.1	13.25	13.43	13.69	12.73 <sup>de</sup>
	Means	10.73 <sup>C</sup>	13.4 <sup>B</sup>	13.64 <sup>B</sup>	13.84 <sup>AB</sup>	14.05 <sup>AB</sup>	14.18 <sup>AB</sup>	14.36 <sup>AB</sup>	14.58 <sup>A</sup>	
Salt %	A	7.02	10.23	10.58	10.62	10.78	10.87	10.95	11.07	10.27 <sup>ab</sup>
	B	6.4	9.72	10.11	10.25	10.39	10.45	10.51	10.57	10.98 <sup>a</sup>
	C	6.4	9.93	10.57	10.65	10.78	10.85	10.9	10.98	10.13 <sup>ab</sup>
	D	6.4	9.28	10.33	10.46	10.59	10.62	10.74	10.89	9.91 <sup>b</sup>
	E	6.4	9	10.1	10.23	10.35	10.49	10.58	10.73	9.74 <sup>b</sup>
	F	5.88	9.61	9.7	10.07	10.12	10.2	10.33	10.42	11.08 <sup>a</sup>
	G	5.88	9.19	9.42	10.05	10.3	10.43	10.56	10.67	9.56 <sup>b</sup>
	H	5.88	9.5	9.59	10.1	10.26	10.39	10.47	10.53	9.59 <sup>b</sup>
	I	5.88	9.05	9.15	10.2	10.34	10.47	10.6	10.73	9.55 <sup>b</sup>
	Means	6.83 <sup>C</sup>	9.77 <sup>B</sup>	10.22 <sup>AB</sup>	10.55 <sup>AB</sup>	10.70 <sup>AB</sup>	10.80 <sup>A</sup>	10.88 <sup>A</sup>	10.98 <sup>A</sup>	

Table continued...

Properties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
Salt in moisture %	A	12.03	36.23	41.27	43.34	45.48	47.26	48.94	50.29	40.61 <sup>a</sup>
	B	8.59	28.65	31.62	33.01	35.48	36.93	37.14	38.27	39.18 <sup>b</sup>
	C	8.59	29.4	33.74	34.2	36.1	37.74	37.89	38.96	32.04 <sup>c</sup>
	D	8.59	25.34	30.66	30.93	32.69	34.39	34.95	36.18	29.22 <sup>d</sup>
	E	8.59	23.83	29.05	29.32	35.45	31.71	32.32	33.03	27.91 <sup>e</sup>
	F	8.2	28.8	31.72	33.79	35.41	36.78	37.75	39.11	39.96 <sup>ab</sup>
	G	8.2	28.63	30.92	33.46	35.27	37.34	38.15	39.47	31.43 <sup>c</sup>
	H	8.2	26.35	31.07	32.19	33.67	35.14	35.67	36.51	29.85 <sup>d</sup>
	I	8.2	27.23	29.22	31.52	32.84	34.22	34.93	35.78	29.24 <sup>d</sup>
	Means	11.63 <sup>G</sup>	30.20 <sup>E</sup>	34.02 <sup>E</sup>	35.52 <sup>D</sup>	37.53 <sup>C</sup>	38.33 <sup>CB</sup>	38.99 <sup>AB</sup>	39.93 <sup>A</sup>	

<sup>ABCD</sup> Letters indicate significant differences between storage times

<sup>abcde</sup> Letters indicate significant differences between jameed treatments

The influence of mold shape on total protein and ash contents of jameed was similar to that on TS and fat. Square and cylinder jameed contained the lowest total protein and ash levels. The values of these components were similar in ball or triangle jameed. Salt levels of ball, triangle, and square and cylinder jameed were comparable. However, salt in moisture values of square and cylinder jameed were lower than that made in ball and triangle molds. Through storage period, total protein, ash salt and salt in moisture contents gradually increased in all jameed samples.

Results of chemical composition of jameed in our study were slightly lower than those reported by Abu-Lehia<sup>14</sup> and within ranges found by Tawalbeh<sup>15</sup> and Jumah et al.,<sup>16</sup> Abu-Lehia<sup>14</sup> reported that jameed from goat milk contains 9.1% moisture, 19.6% fat, 50.0% total protein, 13.0% ash and 8.1% carbohydrate. Tawalbeh<sup>15</sup> reported that jameed from sheep and goat, respectively, contain 4.7 and 5.6% acidity, 11.0 and 10.8% salt, 91.5 and 91.1% total solids, 19.7 and 31.7% fat, 51.4 and 39.3% protein, 3.1 and 3.8% non-protein nitrogen, 2.1 and 1.2% lactose, and 13.2 and 12.3% ash. Jumah et al.,<sup>16</sup> reported that the chemical composition of spray-dried jameed was in the range of 7.9-28.3% moisture, 16.9-19.6% fat and 40.2-63.4% protein.

### Changes in some nitrogen fractions of jameed

Type of milk used in jameed manufacture greatly affected the water soluble nitrogen (WSN), WSN/TN, non-protein-nitrogen, NPN/TN contents (Table 4). Jameed made from goat or cow skim milk possessed lower WSN and NPN levels than those of jameed made from sheep buttermilk. Values of WSN/TN and NPN/TN took the same trend through storage period but the opposite was occurred for jameed paste (fresh). Increasing of protein content in sheep buttermilk and consequently in jameed and also increasing bacterial counts (Table 5) may be the reasons which caused rising of WSN and NPN levels in sheep buttermilk jameed as compared with goat and cow skim milk jameed.

Levels of WSN and NPN of jameed shaped as square and cylinder were lower than those of ball and triangle jameed. On the contrary, WSN/TN and NPN/TN values were higher in the formers than the latters.

Irrespective of milk type or jameed form, WSN, WSN/TN, NPN and NPN/TN values gradually increased with the advanced of storage stage in different jameed treatments. Of course this attributed to the proteolytic bacteria activity.

### Changes in microbial counts of jameed during storage

Coli form bacteria were not detected over the storage period in various samples. These outcomes confirm the hygienic conditions of the manufacture. The counts of total viable bacterial count (TVBC) significantly ( $P < 0.05$ ) increased in jameed made from sheep buttermilk (treatment A) comparing with that made from goat and cow skim milk (treatments B and F respectively) (Table 5). Cow skim milk jameed had the lowest TVBC among various samples. The very antithesis, the highest loss of survival levels of TVBC during storage period were detected in cow milk jameed followed by goat skim milk and sheep buttermilk jameed. Values of loss of survival for samples A, B, and F were 85.07, 87.93 and 90.00% respectively. On the other hand, lowering of nutrients such as fat, protein and ash in square and cylinder forms jameed caused decreasing of TVBC. Ball and triangle shapes nearly contained the same TVBC.

Also the counts of lactic acid bacteria increased in sheep buttermilk jameed and decreased in that prepared from cow skim milk. Their numbers in goat skim milk jameed were at an intermediate position. Add to that, goat skim milk jameed had lower levels of survival loss during storage than cow skim milk jameed but were higher than those of sheep buttermilk jameed. Like decreasing of TVBC in square and cylinder jameed, also lactic acid bacteria numbers reduced. The cylindrical jameed possessed the lowest counts between various samples. On the whole, lactic acid bacteria represented the majority of TVBC in all jameed treatments.

Regarding the counts of proteolytic bacteria in different jameed treatments, sheep buttermilk jameed scored the highest counts followed by jameed prepared from goat skim milk and in the end of the order jameed made from cow skim milk. Shape of molds used in jameed production also affected the proteolytic bacteria numbers. The cylindrical jameed had the lowest counts while the spherical jameed had the highest.

**Table 4** Effect of jameed form on nitrogen fractions

Properties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
WSN%	A	0.468	1.401	1.435	1.463	1.478	1.492	1.51	1.521	1.346 <sup>a</sup>
	B	0.45	1.187	1.194	1.222	1.237	1.245	1.26	1.272	1.260 <sup>a</sup>
	C	0.45	1.189	1.192	1.225	1.239	1.248	1.261	1.275	1.130 <sup>a</sup>
	D	0.45	1.174	1.186	1.214	1.23	1.242	1.257	1.268	1.128 <sup>a</sup>
	E	0.45	1.17	1.181	1.209	1.228	1.238	1.254	1.264	1.124 <sup>a</sup>
	F	0.441	1.159	1.177	1.193	1.206	1.217	1.23	1.242	1.238 <sup>a</sup>
	G	0.441	1.162	1.178	1.194	1.205	1.218	1.233	1.24	1.109 <sup>a</sup>
	H	0.441	1.157	1.171	1.186	1.198	1.211	1.226	1.235	1.103 <sup>a</sup>
	I	0.441	1.154	1.168	1.181	1.195	1.207	1.222	1.23	1.099 <sup>a</sup>
	Means	0.544 <sup>A</sup>	1.213 <sup>A</sup>	1.229 <sup>A</sup>	1.252 <sup>A</sup>	1.265 <sup>A</sup>	1.277 <sup>A</sup>	1.291 <sup>A</sup>	1.300 <sup>A</sup>	
WSN/TN%	A	10.1	17.49	17.26	17.56	17.7	17.76	17.95	18.04	16.73 <sup>cb</sup>
	B	19.23	17.25	16.2	16.44	16.55	16.67	16.82	16.94	15.50 <sup>de</sup>
	C	19.23	17.43	16	16.38	16.52	16.62	16.76	16.89	16.98 <sup>cab</sup>
	D	19.23	18.49	16.78	17.1	17.28	17.42	17.64	17.68	17.70 <sup>ab</sup>
	E	19.23	19.27	16.82	17.08	17.3	17.41	17.59	17.68	17.80 <sup>a</sup>
	F	16.33	15.7	15.24	15.37	15.48	15.56	15.7	15.76	15.08 <sup>e</sup>
	G	16.33	15.66	15.22	15.41	15.4	15.55	15.79	15.84	15.65 <sup>de</sup>
	H	16.33	16.41	15.53	15.7	15.84	15.96	16.13	16.21	16.01 <sup>cde</sup>
	I	16.33	16.48	15.87	16.02	16.17	16.29	16.45	16.51	16.73 <sup>cd</sup>
	Means	15.77 <sup>B</sup>	16.91 <sup>A</sup>	16.03 <sup>AB</sup>	16.27 <sup>AB</sup>	16.40 <sup>AB</sup>	16.50 <sup>AB</sup>	16.67 <sup>AB</sup>	16.74 <sup>A</sup>	
NPN %	A	0.089	0.271	0.28	0.29	0.298	0.31	0.317	0.325	0.272 <sup>a</sup>
	B	0.078	0.24	0.249	0.256	0.261	0.269	0.273	0.278	0.256 <sup>a</sup>
	C	0.078	0.244	0.248	0.257	0.26	0.27	0.274	0.279	0.239 <sup>a</sup>
	D	0.078	0.237	0.244	0.251	0.255	0.267	0.269	0.275	0.234 <sup>a</sup>
	E	0.078	0.235	0.241	0.25	0.252	0.265	0.267	0.271	0.232 <sup>a</sup>
	F	0.077	0.25	0.259	0.266	0.273	0.279	0.285	0.293	0.245 <sup>a</sup>
	G	0.077	0.253	0.26	0.268	0.274	0.278	0.286	0.292	0.249 <sup>a</sup>
	H	0.077	0.245	0.255	0.261	0.27	0.274	0.282	0.288	0.244 <sup>a</sup>
	I	0.077	0.241	0.252	0.259	0.266	0.27	0.28	0.285	0.241 <sup>a</sup>
	Means	0.092 <sup>B</sup>	0.245 <sup>A</sup>	0.255 <sup>A</sup>	0.262 <sup>A</sup>	0.268 <sup>A</sup>	0.276 <sup>A</sup>	0.281 <sup>A</sup>	0.287 <sup>A</sup>	
NPN/TN %	A	1.92	3.38	3.36	3.48	3.56	3.69	3.76	3.85	3.38 <sup>a</sup>
	B	3.33	3.49	3.38	3.45	3.51	3.6	3.64	3.7	3.13 <sup>a</sup>
	C	3.33	3.58	3.33	3.44	3.47	3.6	3.64	3.7	3.51 <sup>a</sup>
	D	3.33	3.73	3.45	3.54	3.58	3.74	3.76	3.84	3.69 <sup>a</sup>
	E	3.33	3.87	3.43	3.53	3.55	3.73	3.74	3.79	3.62 <sup>a</sup>
	F	2.59	3.39	3.35	3.42	3.5	3.57	3.64	3.72	2.75 <sup>a</sup>
	G	2.85	3.41	3.36	3.46	3.53	3.57	3.66	3.73	3.44 <sup>a</sup>
	H	2.85	3.48	3.38	3.46	3.57	3.61	3.71	3.78	3.48 <sup>a</sup>
	I	2.85	3.44	3.42	3.51	3.6	3.64	3.77	3.83	3.51 <sup>a</sup>
	Means	2.71 <sup>B</sup>	3.45 <sup>AB</sup>	3.29 <sup>AB</sup>	3.37 <sup>AB</sup>	3.44 <sup>AB</sup>	3.53 <sup>AB</sup>	3.65 <sup>A</sup>	3.66 <sup>A</sup>	

<sup>abcde</sup> Letters indicate significant differences between jameed treatments<sup>ABCD</sup> Letters indicate significant differences between storage times

**Table 5** Effect of jameed form on some microbial groups

Properties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
TVBC (x 103)	A	67	35	29	22	18	15	13	10	26.13 <sup>a</sup>
	B	58	25	20	15	14	13	9	7	20.13 <sup>b</sup>
	C	58	23	19	17	13	11	8	5	19.25 <sup>b</sup>
	D	58	21	16	12	11	8	5	3	16.75 <sup>c</sup>
	E	58	19	15	10	9	6	4	1	15.25 <sup>d</sup>
	F	50	18	17	15	10	8	6	5	16.13 <sup>cd</sup>
	G	50	16	18	14	9	7	5	3	15.25 <sup>d</sup>
	H	50	15	15	11	8	6	4	1	13.75 <sup>e</sup>
	I	50	13	12	9	6	3	1	0.09	11.76 <sup>f</sup>
	Means	55.44 <sup>A</sup>	20.56 <sup>B</sup>	17.89 <sup>C</sup>	13.89 <sup>D</sup>	10.89 <sup>E</sup>	8.56 <sup>F</sup>	6.11 <sup>G</sup>	3.90 <sup>H</sup>	
Lactic acid bacteria (x 103)	A	55	28	21	16	13	10	9	8	20.00 <sup>a</sup>
	B	44	20	15	10	9	8	6	3	14.38 <sup>b</sup>
	C	44	21	14	9	7	6	4	2	13.38 <sup>c</sup>
	D	44	19	12	8	5	3	1	0.7	11.59 <sup>de</sup>
	E	44	15	11	6	3	1	0.9	0.5	10.24 <sup>f</sup>
	F	38	16	13	10	9	5	3	0.6	11.83 <sup>d</sup>
	G	38	15	13	9	6	4	1	0.7	10.84 <sup>fe</sup>
	H	38	12	9	6	4	1	0.9	0.5	8.93 <sup>g</sup>
	I	38	9	7	4	1	0.8	0.6	0.3	7.59 <sup>h</sup>
	Means	42.56 <sup>A</sup>	17.22 <sup>B</sup>	12.83 <sup>C</sup>	8.67 <sup>D</sup>	6.33 <sup>E</sup>	4.31 <sup>F</sup>	2.93 <sup>G</sup>	1.81 <sup>H</sup>	
Proteolytic bacteria (x 103)	A	6	0.9	0.7	0.3	0.1	0.08	0.05	0.05	1.023 <sup>a</sup>
	B	4	0.6	0.4	0.07	0.06	0.04	0.03	0.01	0.651 <sup>b</sup>
	C	4	0.7	0.4	0.06	0.04	0.03	0.01	0.009	0.657 <sup>b</sup>
	D	4	0.5	0.3	0.01	0.009	0.008	0.006	0.004	0.604 <sup>b</sup>
	E	4	0.4	0.2	0.01	0.008	0.006	0.005	0.003	0.580 <sup>b</sup>
	F	3	0.2	0.09	0.08	0.05	0.04	0.03	0.01	0.438 <sup>b</sup>
	G	3	0.2	0.08	0.06	0.04	0.03	0.02	0.009	0.430 <sup>b</sup>
	H	3	0.1	0.07	0.009	0.008	0.007	0.004	0.002	0.400 <sup>b</sup>
	I	3	0.09	0.05	0.008	0.007	0.005	0.003	0.001	0.395 <sup>b</sup>
	Means	3.78 <sup>A</sup>	0.41 <sup>B</sup>	0.25 <sup>BC</sup>	0.07 <sup>C</sup>	0.34 <sup>C</sup>	0.027 <sup>C</sup>	0.017 <sup>C</sup>	0.01 <sup>C</sup>	
Moulds & Yeast (x 103)	A	0	0	0	0	0.3	0.4	0.7	0.9	0.288 <sup>a</sup>
	B	0	0	0	0	0.1	0.3	0.6	0.8	0.225 <sup>b</sup>
	C	0	0	0	0	0.1	0.4	0.5	0.8	0.225 <sup>b</sup>
	D	0	0	0	0	0	0.2	0.4	0.6	0.150 <sup>c</sup>
	E	0	0	0	0	0	0.1	0.2	0.4	0.088 <sup>ed</sup>
	F	0	0	0	0	0.09	0.2	0.3	0.5	0.136 <sup>cd</sup>
	G	0	0	0	0	0.08	0.1	0.4	0.5	0.135 <sup>cd</sup>
	H	0	0	0	0	0	0.09	0.1	0.3	0.061 <sup>e</sup>
	I	0	0	0	0	0	0.08	0.09	0.1	0.033 <sup>e</sup>
	Means	0 <sup>E</sup>	0 <sup>E</sup>	0 <sup>E</sup>	0 <sup>E</sup>	0.07 <sup>D</sup>	0.21 <sup>C</sup>	0.37 <sup>B</sup>	0.54 <sup>A</sup>	

abcde Letters indicate significant differences between jameed treatments

ABCD Letters indicate significant differences between storage times

In different jameed samples, there were significant ( $p < 0.05$ ) lowering in TVBC, lactic acid bacteria and proteolytic bacteria during storage. The main metabolic products of carbohydrate fermentation by bacteria activity are organic acids substantiated by a drop in pH of the surrounding environment. This statement was approved in different cheese varieties by the studies of many authors. Shehata et al.,<sup>17</sup> found that yeast-moulds, proteolytic, psychrophilic and viable spore forming bacterial counts significantly decreased along the ripening period of Ras cheese. Andrade et al.,<sup>18</sup> reported that the dynamic of starter LAB during Cheddar ripening showed that lactococci, represented by *Lc. lactis*, *Lc. cremoris* and *Lc. diacetylactis*, have a gradual decline, resulting in 2 log reduction after 6month. *Lb. casei* increased significantly during the firstmonth and showed a slight decrease after 6month. Conversely, *Lb. bulgaricus* population showed a rapid increase after inoculation, followed by a drastic reduction, indicative of autolytic activity, during the firstmonth.

At the ninetydays of storage, yeast-moulds appeared in samples A,

B, C, F and G. After that, they were detected in all jameed treatments. On the whole, findings of yeast-moulds showed the exactly same trend of TVBC, lactic acid bacteria and proteolytic bacteria. Sheep buttermilk jameed had the greatest and cow skim milk jameed possessed the lowest. Ball and triangle jameed contained higher counts than jameed formed in square and cylinder shapes.

### Changes in solubility of jameed during storage

To make jameed edible, it should be first reconstituted in warm water. Wettability and syneresis properties are good indicators for the validity of jameed to reconstitution. Data in Table 6 show the impact of change jameed form on the wettability and syneresis during storage.

As can be seen from Table 6, results of wettability revealed that utilization of sheep buttermilk in jameed manufacture increased its value. The wettability levels of goat skim milk jameed were higher than jameed prepared from cow skim milk.

**Table 6** Effect of jameed form on wet ability and syneresis

Properties	Treatments	Storage period (days)							Means
		15	30	60	90	120	150	180	
Wettability (%)	A	210.85	220.73	225.22	227.12	228.79	230.91	233.34	225.28 <sup>a</sup>
	B	196.48	201.36	210.89	215.78	218.33	219.14	221.97	211.99 <sup>a</sup>
	C	207.56	216.08	220.33	223.06	226.32	228.11	230.44	221.70 <sup>a</sup>
	D	202.23	212.45	215.78	218.04	223.67	224.98	226.09	217.53 <sup>a</sup>
	E	195.07	202.88	211.05	214.98	219.67	221.57	222.55	212.54 <sup>a</sup>
	F	191.85	202.88	210.04	212.87	217.23	218.2	219.09	210.31 <sup>a</sup>
	G	205.67	217.02	219.02	222.02	227	227.78	230.54	221.29 <sup>a</sup>
	H	203	210.62	216.9	219.06	223.15	225.21	227.08	217.86 <sup>a</sup>
	I	192.33	203.85	210	211.33	218.35	219.45	221.94	211.04 <sup>a</sup>
	Means	200.56 <sup>A</sup>	209.71 <sup>A</sup>	215.47 <sup>A</sup>	218.25 <sup>A</sup>	222.50 <sup>A</sup>	223.93 <sup>A</sup>	225.89 <sup>A</sup>	
Syneresis% (after 1h of mixing with water)	A	39.84	47.87	48.03	51.97	54.67	55.84	57.22	50.78 <sup>h</sup>
	B	42.74	47.87	50.45	53.14	56.49	57.66	58.49	52.40 <sup>e</sup>
	C	50.9	56.55	62.45	66.9	68.03	69.84	70.1	63.54 <sup>b</sup>
	D	46	52.33	58.98	62.02	63.12	65.24	67.1	59.40 <sup>d</sup>
	E	43.98	48.09	51.12	53.43	56.9	58.09	59.17	52.97 <sup>ef</sup>
	F	44.31	50.8	52.01	55.13	57.24	57.99	59.24	53.82 <sup>ef</sup>
	G	54.36	60.07	64.11	68.95	71.17	72.89	74.22	66.54 <sup>a</sup>
	H	49.98	55.09	60.44	64.08	66.66	68.46	70.19	62.13 <sup>c</sup>
	I	44.66	51.38	53.22	55.89	57.56	58.74	60.17	54.52 <sup>e</sup>
	Means	46.31 <sup>G</sup>	52.23 <sup>F</sup>	55.76 <sup>E</sup>	59.06 <sup>D</sup>	61.32 <sup>C</sup>	62.75 <sup>B</sup>	63.99 <sup>A</sup>	

Table continued...

Properties	Treatments	Storage period (days)							Means
		15	30	60	90	120	150	180	
Syneresis% (after 24h of mixing with water)	A	42.42	50	50.11	54.65	57.14	60.12	63.16	54.09 <sup>d</sup>
	B	44.43	51.62	52.3	54.31	57.27	60.14	63.38	55.50 <sup>d</sup>
	C	53.33	61.07	63.19	67.65	69.73	71.25	72.35	65.51 <sup>ab</sup>
	D	48.4	56.67	59.08	63.56	64.02	66.23	68.7	61.03 <sup>c</sup>
	E	44.33	52.05	53.98	55.87	57.96	59.75	70.04	56.23 <sup>d</sup>
	F	47.15	53.25	54.23	56.97	59.41	61.2	64.24	55.92 <sup>d</sup>
	G	56.81	63.88	65.56	69.37	73.05	74.12	75.55	68.33 <sup>a</sup>
	H	50.51	56.88	61.7	65.48	67.13	69.67	71.9	63.32 <sup>cb</sup>
	I	46.94	54.07	54.77	57.05	58.7	60.41	62.13	56.30 <sup>d</sup>
	Means	48.89 <sup>E</sup>	55.55 <sup>D</sup>	56.65 <sup>D</sup>	60.55 <sup>C</sup>	62.71 <sup>CB</sup>	64.77 <sup>AB</sup>	67.99 <sup>A</sup>	

<sup>abcde</sup> Letters indicate significant differences between jameed treatments

<sup>ABCD</sup> Letters indicate significant differences between storage times

When comparing between the wettability values of various jameed forms, it is clear that using of triangle mold caused significant ( $p < 0.05$ ) increase in jameed wettability. With lesser degree than triangle mold, also square shape raised the jameed wettability within storage period. Both ball and cylinder jameed approximately had the same results of wettability.

Syneresis values of cow skim milk jameed were higher than those of goat skim milk one which were higher than jameed made from sheep buttermilk. On the other side, triangle jameed followed by square form scored the highest syneresis levels among different shapes. No clear differences were observed between results of syneresis of ball and cylinder jameed. In all jameed treatments, values of syneresis measured after 24h were higher than those measured after 1h of mixing with water. Both wettability and syneresis values of different jameed samples gradually increased during storage stage.

### Changes in textural characterizes of jameed at the end of storage

The force necessary to attain a given deformation with a maximum force bite when the sample is placed between molars is termed as hardness.<sup>19</sup> Cohesiveness is defined as the extent to which a sample can be deformed before it ruptures.<sup>20</sup> Gumminess is defined as the energy needed to disintegrate a semisolid food until it becomes ready for swallowing.<sup>19</sup> Chewiness is defined as the number of masticates required for a certain amount of sample in order to satisfactorily decrease the consistency for swallowing.<sup>19</sup>

Results of hardness, cohesiveness, springiness, gumminess and chewiness of jameed at the end of storage period are tabulated in Table 7. The values of textural mentioned properties significantly ( $p < 0.05$ ) affected by the type of milk used in jameed production. Utilization of sheep buttermilk yielded jameed with high values of hardness, cohesiveness, gumminess and chewiness and low levels of springiness. This may be due to high total solids content (Table 2). Cow skim milk jameed recognized to have hardness, cohesiveness and gumminess and chewiness levels higher than those of goat milk jameed while springiness values had the opposite trend.

In both goat and cow skim milk jameed; the spherical and cylindrical shapes had the minimum values of hardness, cohesiveness, gumminess and chewiness whereas the triangle and square forms possessed the maximum levels.

### Microstructure of jameed at the end of storage period

Scanning electron microscopy (SEM) was used in our study for more deeply understanding of the effect of jameed forms change on the structural properties. The microstructures of jameed samples at the end of storage period are shown in Figure 2.

The protein network for the jameed made from sheep buttermilk tended to be qualitatively thicker (sample A) than the jameed made from goat and cow skim milk (samples B and F respectively). However, the protein matrix was coarser and more granular in treatments B and F than treatment A. The protein matrix of cow skim milk jameed observed with SEM has a relatively denser structure than

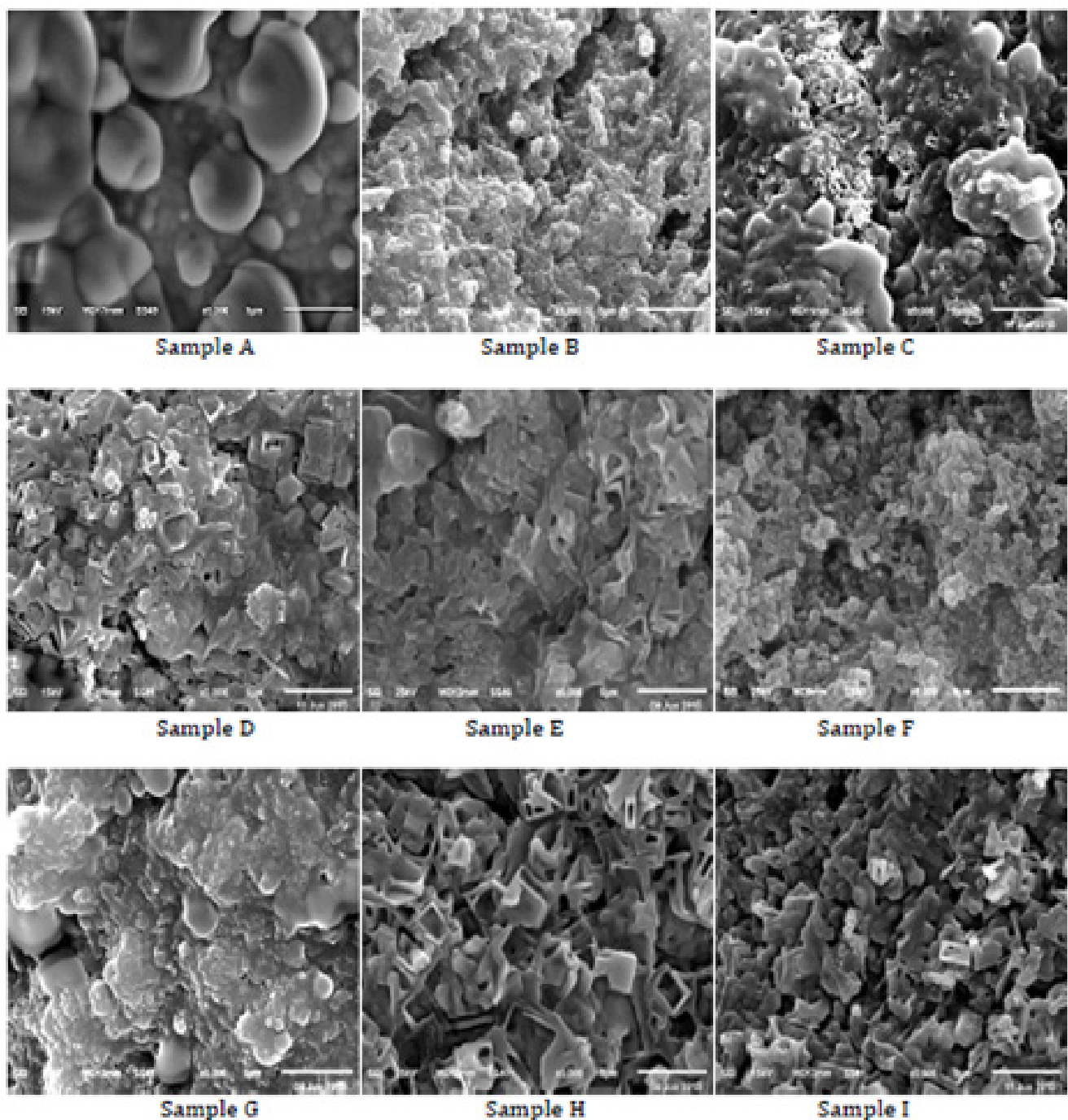
that of goat skim milk jameed. Also, scanning electron microscopic examination demonstrated that small gaps of different sizes, indicated by the black regions, were embedded in the protein network in both goat and cow skim milk jameed but they were more visible in goat skim milk one. These gaps contained the fat globules. The microscopic images correlated well with textural characteristics reported in Table 7. The hardest jameed (sample A) had less porous and more compact structure. Similar observations were reported by Mistry et al.,<sup>21</sup> that showed that in the firmest cheese, a very compact protein network was observed. Soodam et al.,<sup>22</sup> found that small gaps appear at the interface between the fat and protein phases by week 13 of ripening period of Cheddar cheese, which could arise from proteolysis of the

protein network leading to a weaker structure that behaves differently during microscopy sample preparations. That is, the interface of the protein and fat could be considered as the weakest point within the structure. As such, gaps are more likely to appear in the aged cheese at the fat-protein interface. Distinct variations were noted between the images of ball, triangle, square and cylinder jameed. As previously mentioned, the ball jameed (samples B and F) characterized with a coarse granular structure with relatively large pores whereas in triangle jameed some compact protein masses with coarse structure contained little spaces were observed. In square and cylinder jameed, protein network possessed rigid plates structure, little aggregates and more gaps scattered in matrix.

**Table 7** Textural properties of jameed at the end of storage period

Treatments	Hardness (N)	Cohesiveness (B/A area)	Springiness (mm)	Gumminess (N)	Chewiness (N/mm)
A	22.10 <sup>a</sup>	0.309 <sup>a</sup>	1.497 <sup>a</sup>	6.846 <sup>ab</sup>	4.573 <sup>b</sup>
B	14.72 <sup>de</sup>	0.153 <sup>a</sup>	0.757 <sup>b</sup>	3.266 <sup>c</sup>	6.410 <sup>ab</sup>
C	19.70 <sup>ab</sup>	0.243 <sup>a</sup>	0.553 <sup>b</sup>	7.464 <sup>ab</sup>	7.607 <sup>ab</sup>
D	17.80 <sup>dc</sup>	0.222 <sup>a</sup>	0.637 <sup>b</sup>	5.331 <sup>cab</sup>	7.314 <sup>ab</sup>
E	14.50 <sup>e</sup>	0.155 <sup>a</sup>	0.760 <sup>b</sup>	3.270 <sup>c</sup>	6.419 <sup>ab</sup>
F	15.66 <sup>dce</sup>	0.172 <sup>a</sup>	0.628 <sup>b</sup>	4.371 <sup>cb</sup>	6.860 <sup>ab</sup>
G	20.01 <sup>ab</sup>	0.276 <sup>a</sup>	0.534 <sup>b</sup>	8.335 <sup>a</sup>	8.052 <sup>a</sup>
H	18.15 <sup>cb</sup>	0.243 <sup>a</sup>	0.625 <sup>b</sup>	6.846 <sup>ab</sup>	7.568 <sup>ab</sup>
I	15.37 <sup>dce</sup>	0.173 <sup>a</sup>	0.630 <sup>b</sup>	4.376 <sup>cb</sup>	6.871 <sup>ab</sup>

<sup>abcde</sup> Letters indicate significant differences between jameed treatments



**Figure 2** Scanning electron micrographs of jameed at the end of storage period.

## Conclusion

Traditionally, jameed is manufactured and shaped as a ball. In this study jameed was made in various forms such as triangle, square and cylinder and stored for sixmonths at ambient temperature. From chemical, microbial and rheological measurements, jameed with good quality was successfully prepared using the above mentioned shapes. Utilization of triangle, square and cylinder molds in jameed production not only helps to obtain suitable quality but also reduce the production time. Hydraulic pressure can be applied with these molds. Consequently, moisture expulsion will be faster which decrease the

time of solar drying period and minimize jameed contamination and increase shelf life. On the contrary, it is impossible to use hydraulic pressure with spherical shape.

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## Conflict of interest

Author declares that there is no conflict of interest.

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