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EFFECT OF UTILIZATION PARTIAL DRYING BY HOT AIR ON THE CHEMICAL COMPOSITION, RHEOLOGICAL AND MICROBIAL PROPERTIES OF JAMEED

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ABSTRACT

Eleven treatments of jameed were made from sheep butter milk and from goat and cow skim milk. After shaping the jameed paste into balls, control balls (made from sheep butter milk and from goat and cow skim milk) were sun dried for 15 days whereas other balls of goat and cow skim milk jameed were partially dried using hot air at 45ºC/12h, 60ºC/10h, 75ºC/8h and 90ºC/6h then jameed drying process was completed in sun till moisture content of jameed reached to ~20%. Utilization of partially drying after shaping of jameed paste reduced the time of solar drying period. During storage, acidity ratios of sun dried jameed were higher whereas total solids, fat, total protein, ash, salt, water soluble nitrogen and non-protein-nitrogen contents were lower than those of partial dried treatments. Manufacturing of jameed by traditional method (solar drying) increased the numbers of the total viable bacterial count, lactic acid bacteria and proteolytic bacteria as compared with partially dried jameed. Using of high temperatures in partial draying of jameed increased wettability while decreased syneresis values. Also, jameed samples treated with higher temperature of partial drying had the highest levels hardness, cohesiveness, gumminess and chewiness and the lowest levels of springiness. The micrograph images of partially dried jameed treatments showed that protein matrices characterized by little aggregates, plates structure, more open protein network and high fusion. These properties were more obvious with higher temperature heat treatments and in goat skim milk jameed.

1. Introduction

Jameed is a milk product widely used in rural and desert areas in some Arabian countries, such as Jordan, Syria, Northern Saudi Arabia and the western part of Iraq, and it forms a major component of the family diet. This product is also known as *Marees* or *Afig* (Yagil, 1982). Jameed is a dried fermented milk product (a hard cheese-like product), usually prepared from sheep buttermilk. However, buttermilk from other sources such as goat, cow and camel (Yagil, 1982) can also be utilized for preparation of jameed. Normally, jameed is reconstituted by dissolving in seven times its weight of water before consumption.

Drying methods of jameed include a reduction in moisture content to decrease or inhibit growth of pathogenic microorganisms. Salt is added in order to increase the shelf life. Numerous factors associated with environmental and manufacturing conditions play an important role in the shelf life and safety of drying jameed, including high salt content, low water activity, high level of lactic acid and low pH value (less than 4.0). The presence of lactic acid and salt in jameed reduces and inhibits the growth of pathogenic microorganisms (Alu'datt et al., 2015). The sun drying technique was usually used in jameed drying. It improves the quality of jameed, such as aroma, color, flavor and texture, due to the growth of microorganisms such as mold and bacteria on jameed through the drying technique. Nevertheless, undesirable chemical, physical and biological changes in functional properties may happen during the process of drying jameed. In addition to the traditional sun-drying, other methods can be used. Freeze drying results in 8.9% less moisture in the end product compared to sun drying (Al Omari et al., 2008), and was preferred by consumers (Mazahreh et al., 2008). Therefore, the aim of this work was to investigate the possibility of acceleration of jameed drying process by using hot air and study effect of this technic on the chemical composition, rheological and microbial properties of produced jameed.

2. Materials and Methods

2.1. Milk and Starter Culture

Fresh sheep's, goat's and cow's milks were obtained from El-Serw Animal Production Research Station, Animal Production Research Institute, Agricultural Research Center, Egypt. A commercial classic yoghurt starter containing *Streptococcus thermophillus* 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.

2.2. Jameed manufacture

Eleven treatments of Jameed were made from sheep buttermilk (control) and from goat and cow skim milk according to the traditional method described by Quasem et al., (2009). After shaping the jameed paste into balls, control balls were sun dried for 15 days whereas balls of goat and cow skim milk jameed were placed on trays and partially dried using hot air in electricity oven at different temperatures and times, then jameed drying process was completed in sun till moisture content of jameed reached to ~20%. Generally, jameed samples were as follow:

-Treatment A: Jameed made from sheep butter milk (control) with sun drying (traditional method).

-Treatment B: Jameed made from goat skim milk with sun drying (traditional method).

-Treatment C: Jameed made from goat skim milk and dried at 45ºC/12h.

-Treatment D: Jameed made from goat skim milk and dried at 60ºC/10h.

-Treatment E: Jameed made from goat skim milk and dried at 75ºC/8h.

-Treatment F: Jameed made from goat skim milk and dried at 90ºC/6h.

-Treatment G: Jameed made from cow skim milk with sun drying (traditional method).

-Treatment H: Jameed made from cow skim milk and dried at 45ºC/12h.

-Treatment I: Jameed made from cow skim milk and dried at 60ºC/10h.

-Treatment J: Jameed made from cow skim milk and dried at 75ºC/8h.

-Treatment K: Jameed made from cow skim milk and dried at 90ºC/6h.

-The dried jameed balls were packaged in cloth bags which were put in plastic containers and stored at room temperature for six months. Samples were analyzed when fresh (jameed curd) and after 15, 30, 60, 90, 120, 150 and 180 days of storage period.

2.3. Chemical analyses

Jameed yield was calculated by two means as follows:

Yield-1 (%) = Weight of jameed at the end of storage /Weight of milk used to make jameed x 100 (1)

Yield-2 (%) = Weight of jameed at the end of storage /Weight of jameed paste (before drying) x 100 (2)

Total solids, fat, total nitrogen and ash contents of samples were determined according to (AOAC, 2000). 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 (Parmar, 2003). pH of the sample was measured at 17 to 20°C using a pH meter (Corning pH/ion analyzer 350, Corning, NY) after calibration with standard buffers (pH 4.0 and 7.0). Water soluble nitrogen (WSN) and non-protein-nitrogen of jameed were estimated according to Ling (1963). The Volhard's method as described by Richardson (1985) was used to determine the salt content of jameed. Salt in moisture percentage of the cheese was estimated as follow:

(Salt percentage x 100) / (Moisture percentage + Salt percentage) (3)

2.4. Microbiological Analyses

Jameed samples were analyzed for total viable bacterial count (TVBC), lactic acid bacteria (LAB), coliform, proteolytic bacteria, moulds and yeast counts according to the methods described by the American Public Health Association (1992).

2.5. Rheological Properties

Force and torque measurements of jameed treatments stored for six months were measured using a Texturometer model Mecmesin Emperor ^{TM}Lite 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 ^{TM}Lite Graph. Because jameed samples were very hard, they were soaked in distilled water for 6h at room temperature before measurements.

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2.6. Wettability (Diffusability) test

A cube weighing ca. 45 g of jameed was cut using a hand saw from a whole jameed ball; 315 ml water were added to the piece placed in 500 ml cup and soaked for 24 h (Quasem et al., 2009). The excess free water was carefully decanting weighed to calculate the soaked amount as follows:

Absorbed water (%) = 315 ml water-X /Weight of cubs (g) x 100 (4)

where; X: the weight of excess water (g).

2.7. Syneresis (whey separation) test

The soaked cube (45 g) was mixed with (315 ml water) for two minutes using electrical hand mixer (Hinari, model FM2, China) with the whipping accessory. The dispersed jameed was transferred to a 100 ml graduated cylinder and the clear zone was measured after 1h and 24h (Quasem et al., 2009). Syneresis (whey separation) was calculated, as follow:

$$\text{Syneresis (\%)} = X / Y \times 100 \qquad (5)$$

where; X: The height of the clear zone. Y: Total height of jameed dispersion.

2.8. Scanning Electron Microscopy (SEM) Examination

Jameed samples were prepared for SEM according to the method of Brooker and Wells (1984). The specimens were viewed in a scanning electron microscope (JXA-840A Electron Probe Microanalyzer-JEOL-Japan) after dehydrated using Critical Point Dried instrument and coating with gold using S150A Sputter Coater-Edwards England.

2.9. Statistical Analysis

The obtained results were statistically analyzed using a software package (SAS, 1991) based on analysis of variance. When F-test was significant, least significant difference (LSD) was calculated according to Duncan (1955) for the comparison between means. The data presented, in the tables, are the mean (± standard deviation) of 3 experiments.

3. Results and Discussion

3.1. Chemical composition of milk used in jameed manufacture

Data in Table 1 show the differences in chemical properties of milk used in jameed manufacturing. Because of fermentation process, sheep butter milk had the highest acidity content and the lowest pH values. On the contrary, total solids (TS) and solids-not-fat (SNF) levels were higher in goat and cow skim milk than that of sheep butter milk. Because fat globules of goat's milk don't easily separate by separator as occurred 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 butter milk is richer in protein than goat or cow skim milk.

Table 1. Chemical composition of milk used in jameed manufacture

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

^{abcde} Letters indicate significant differences between milk treatments

Table 2. Moisture content of jameed samples during solar drying process

Treatments	Solar drying process (days)							
	Fresh	3	5	7	9	11	13	15
A	51.33^c	43.72^c	37.37^c	32.68^b	28.89^b	24.16^b	21.56^b	18.00^b
B	68.11^a	56.68^a	49.14^a	42.02^a	37.16^a	31.56^a	27.47^a	24.21^a
C	33.20^d	30.08^d	27.90^d	25.42^{cd}	23.25^c	21.30^c	19.04^c	-
D	31.00^e	28.33^e	25.00^e	22.08^d	20.10^e	-	-	-
E	28.77^f	26.07^f	24.98^e	21.15^{de}	19.37^e	-	-	-
F	27.00^g	25.73^{fg}	22.06^f	20.07^e	-	-	-	-
G	65.86^b	54.12^b	47.88^b	41.67^a	36.53^a	31.23^a	26.76^a	23.76^a
H	32.60^{de}	30.66^d	28.05^d	26.34^c	22.74^d	19.58^d	-	-
I	30.03^{ef}	27.80^e	24.77^e	21.03^{de}	19.94^e	-	-	-
J	27.64^{fg}	25.33^{fg}	23.96^{ef}	20.69^e	-	-	-	-
K	26.33^g	24.05^g	22.11^f	20.08^e	-	-	-	-

^{abcde} Letters indicate significant differences between milk treatments

Table 3. Effect of using partial drying on jameed yield

Treatments	Yield-1	Yield-2
A	16.03^{a}	54.66^{a}
B	7.57^{b}	39.33^{b}
C	7.22^{b}	37.69^{c}
D	7.19^{b}	37.56^{c}
E	7.18^{b}	37.50^{c}
F	7.14^{b}	37.29^{c}
G	6.80^{d}	40.84^{b}
H	6.61^{c}	39.58^{b}
I	6.60^{c}	39.47^{b}
J	6.57^{c}	39.33^{b}
K	6.55^{c}	39.17^{b}

^{abcde} Letters indicate significant differences between milk treatments

Table 4. Effect of using partial drying on some physicochemical properties of jameed

Properties	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	4.31^{a}
	B	1.82	2.78	3.27	3.58	3.88	4.07	4.30	4.40	3.51^{ab}
	C	1.91	2.75	3.24	3.55	3.81	4.03	4.22	4.33	3.48^{ab}
	D	1.83	2.61	3.05	3.32	3.54	3.77	3.98	4.08	2.98^{b}
	E	1.71	2.42	2.77	3.01	3.21	3.40	3.59	3.70	2.82^{b}
	F	1.66	2.27	2.60	2.84	3.04	3.25	3.42	3.54	3.25^{b}
	G	1.72	2.60	3.10	3.38	3.62	3.83	3.96	4.08	3.29^{b}
	H	1.78	2.58	3.07	3.34	3.57	3.73	3.92	4.02	3.03^{b}
	I	1.73	2.47	2.84	3.08	3.30	3.45	3.62	3.71	2.92^{b}
	J	1.68	2.39	2.71	2.97	3.18	3.35	3.51	3.60	2.78^{b}
	K	1.60	2.25	2.52	2.75	2.97	3.16	3.31	3.42	2.75^{b}
	Means	1.77^{D}	2.60^{CD}	3.02^{CB}	3.25^{CAB}	3.48^{CAB}	3.68^{AB}	3.87^{AB}	3.97^{A}	
pH values	A	4.98	4.43	4.19	3.91	3.70	3.55	3.41	3.36	3.94^{a}
	B	5.32	4.61	4.45	4.32	4.11	4.05	3.96	3.87	4.34^{a}
	C	5.23	4.64	4.49	4.36	4.18	4.11	4.01	3.92	4.37^{a}
	D	5.29	4.73	4.57	4.42	4.30	4.23	4.14	4.01	4.46^{a}
	E	5.41	4.84	4.68	4.59	4.47	4.39	4.31	4.25	4.62^{a}
	F	5.47	4.91	4.76	4.64	4.55	4.49	4.40	4.30	4.69^{a}
	G	5.41	4.71	4.49	4.38	4.32	4.23	4.18	4.06	3.94^{a}
	H	5.33	4.77	4.55	4.41	4.36	4.29	4.23	4.11	4.50^{a}
	I	5.39	4.81	4.62	4.55	4.44	4.36	4.28	4.24	4.59^{a}
	J	5.45	4.88	4.67	4.60	4.50	4.41	4.36	4.31	4.65^{a}
	K	5.53	4.95	4.77	4.69	4.60	4.54	4.45	4.40	4.74^{a}
	Means	5.34^{A}	4.77^{AB}	4.59^{AB}	4.46^{AB}	4.34^{B}	4.26^{B}	4.18^{B}	4.10^{B}	
TS %	A	48.67	82.00	84.95	86.12	87.08	87.87	88.58	89.06	81.79^{e}
	B	31.89	75.79	78.14	79.10	81.11	82.15	82.21	82.95	74.17^{f}
	C	66.80	81.75	83.24	84.30	84.74	84.90	85.17	85.44	82.04^{de}
	D	69.00	81.94	83.60	84.57	84.87	85.06	85.24	85.75	82.50^{dce}
	E	71.23	82.55	83.95	84.85	85.23	85.41	85.68	85.89	83.09^{cb}
	F	73.00	83.02	84.19	85.34	85.62	85.95	86.11	86.36	83.69^{ab}
	G	34.14	76.24	79.12	80.26	81.33	82.46	82.97	83.78	75.04^{f}
	H	67.40	81.82	83.79	84.90	85.11	85.31	85.47	85.69	82.43^{dce}
	I	69.97	82.88	83.96	85.14	85.31	85.49	85.72	85.94	83.00^{dcb}
	J	72.36	83.38	84.08	85.25	85.56	85.74	85.97	86.23	83.57^{ab}
	K	73.67	83.82	84.79	85.72	85.91	86.15	86.34	86.59	84.12^{a}
	Means	68.01^{E}	82.57^{D}	84.06^{C}	85.13^{B}	85.49^{AB}	85.76^{AB}	86.03^{AB}	86.27^{A}	

Fat %	A	3.85	10.40	10.64	10.87	11.05	11.14	11.23	11.35	10.06^{ced}
	B	4.19	11.36	11.57	11.71	11.84	11.98	12.20	12.35	10.90^{cadb}
	C	7.30	10.98	11.03	11.33	11.51	11.61	11.74	11.80	10.90^{cadb}
	D	7.43	11.05	11.28	11.45	11.50	11.65	11.78	11.84	11.00^{cab}
	E	7.50	11.14	11.42	11.50	11.56	11.70	11.84	11.91	11.07^{ab}
	F	7.71	11.19	11.51	11.58	11.64	11.72	11.90	12.01	11.16^{a}
	G	3.17	9.90	9.95	10.19	10.31	10.40	10.49	10.60	9.75^{e}
	H	6.35	10.05	10.25	10.32	10.40	10.49	10.56	10.62	9.88^{e}
	I	6.50	10.10	10.37	10.40	10.43	10.52	10.60	10.66	9.95^{ed}
	J	6.64	10.18	10.44	10.47	10.54	10.55	10.62	10.71	10.0^{ced}
	K	6.83	10.27	10.51	10.60	10.64	10.69	10.70	10.75	10.1^{cedb}
	Means	6.68^{B}	10.59^{A}	10.82^{A}	10.94^{A}	11.03^{A}	11.11^{A}	11.21^{A}	11.29^{A}	

^{abcde} Letters indicate significant differences between jameed treatments
^{ABCD} Letters indicate significant differences between storage times

Table 5. Effect of using partial drying on some chemical properties of jameed

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	53.70	53.81	50.17^{e}
	B	14.95	43.91	47.01	47.34	47.45	47.66	47.78	47.92	43.00^{g}
	C	43.78	51.36	52.50	52.90	53.05	53.15	53.25	53.32	51.66^{d}
	D	45.98	51.48	52.77	53.21	53.33	53.46	53.56	53.60	52.17^{cd}
	E	48.62	52.10	53.20	53.48	53.62	53.69	53.77	53.82	52.79^{cab}
	F	50.46	52.45	53.38	53.62	53.75	53.84	53.97	54.04	53.19^{ab}
	G	17.24	47.11	49.23	49.54	49.69	49.87	49.99	50.28	45.37^{f}
	H	44.89	52.11	53.10	53.23	53.37	53.53	53.61	53.67	52.19^{cab}
	I	48.30	52.61	53.36	53.54	53.67	53.74	53.80	53.88	52.79^{cab}
	J	50.11	52.24	53.57	53.70	53.84	53.96	54.11	54.18	53.21^{a}
	K	51.74	52.64	53.79	53.92	54.08	54.17	54.29	54.37	53.63^{a}
	Means	45.94^{C}	52.01^{B}	53.13^{A}	53.42^{A}	53.56^{A}	53.68^{A}	53.78^{A}	53.85^{A}	
Ash %	A	11.50	14.87	14.95	15.38	15.59	15.81	16.04	16.14	15.03^{a}
	B	10.14	13.57	13.81	13.97	14.31	14.47	14.60	14.74	13.70^{b}
	C	12.33	14.38	14.45	14.52	14.65	14.83	14.98	15.13	14.40^{a}
	D	12.37	14.49	14.52	14.61	14.80	14.97	15.17	15.29	14.52^{a}
	E	12.40	14.54	14.60	14.66	14.84	15.04	15.23	15.30	14.57^{a}
	F	12.50	14.62	14.68	14.72	14.93	15.16	15.31	15.42	14.67^{a}
	G	9.97	13.30	13.57	13.69	13.94	14.27	14.49	14.64	13.48^{b}
	H	12.38	14.40	14.44	14.50	14.66	14.73	14.97	15.14	14.40^{a}
	I	12.40	14.53	14.55	14.65	14.79	14.93	15.20	15.31	14.54^{a}
	J	12.45	14.58	14.65	14.70	14.87	15.06	15.30	15.37	14.62^{a}
	K	12.56	14.66	14.72	14.80	14.98	15.21	15.41	15.49	14.72^{a}
	Means	12.32^{B}	14.56^{A}	14.61^{A}	14.72^{A}	14.90^{A}	15.08^{A}	15.29^{A}	15.39^{A}	
Salt %	A	7.02	10.23	10.58	10.62	10.78	10.87	10.95	11.07	10.27^{b}
	B	6.40	9.72	10.11	10.25	10.39	10.45	10.51	10.57	9.80^{b}
	C	8.80	10.81	11.03	11.25	11.40	11.47	11.51	11.55	10.98^{ab}
	D	9.09	11.25	11.33	11.40	11.48	11.53	11.58	11.70	11.17^{ab}
	E	9.20	11.39	11.49	11.55	11.60	11.67	11.71	11.79	11.30^{a}
	F	9.35	11.57	11.69	11.75	11.79	11.84	11.87	11.94	11.47^{a}
	G	5.88	9.61	9.70	10.07	10.12	10.20	10.33	10.42	9.54^{b}
	H	8.84	10.94	11.18	11.40	11.48	11.57	11.62	11.68	11.08^{ab}
	I	9.13	11.37	11.49	11.59	11.65	11.70	11.73	11.81	11.31^{a}
	J	9.33	11.50	11.66	11.74	11.80	11.82	11.86	11.93	11.46^{a}
	K	9.55	11.71	11.87	11.91	11.95	11.98	12.04	12.14	11.64^{a}
	Means	8.92^{B}	11.19^{A}	11.36^{A}	11.46^{A}	11.54^{A}	11.60^{A}	11.65^{A}	11.73^{A}	
	A	12.03	36.23	41.27	43.34	45.48	47.26	48.94	50.29	40.60^{dc}
	B	8.59	28.65	31.62	33.01	35.48	36.93	37.14	38.27	31.21^{f}
	C	20.95	37.19	39.69	41.74	42.76	43.16	43.69	44.23	39.18^{e}

Salt in moisture %	D	22.67	38.39	40.85	42.48	43.14	43.55	43.96	45.08	40.02[de]
	E	24.22	39.49	41.72	43.25	43.98	44.44	44.98	45.52	40.95[dc]
	F	25.72	40.52	42.50	44.49	45.05	45.73	46.07	45.72	41.98[b]
	G	8.20	28.80	31.72	33.79	35.41	36.78	37.75	39.11	31.44[f]
	H	21.33	37.56	40.82	43.01	43.53	44.05	44.43	44.94	39.96[de]
	I	23.31	39.90	41.73	43.92	44.22	44.63	45.09	45.65	41.05[bc]
	J	25.23	40.89	42.27	44.31	45.48	45.32	45.80	46.42	41.96[b]
	K	26.62	41.98	43.83	45.47	45.89	46.38	46.85	47.51	43.06[a]
	Means	22.45[G]	39.12[F]	41.63[E]	43.55[D]	44.38[CD]	44.94[CD]	45.53[AB]	46.15[A]	

[abcde] Letters indicate significant differences between jameed treatments
[ABCD] Letters indicate significant differences between storage times

Table 6. Effect of using partial drying on some nitrogen fractions of jameed

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	1.510	1.521	1.353[a]
	B	0.450	1.187	1.194	1.222	1.237	1.245	1.260	1.272	1.133[ab]
	C	0.884	1.263	1.284	1.308	1.319	1.330	1.342	1.350	1.264[a]
	D	0.871	1.255	1.275	1.294	1.304	1.315	1.324	1.331	1.246[a]
	E	0.865	1.247	1.269	1.284	1.291	1.301	1.311	1.320	1.242[a]
	F	0.858	1.240	1.255	1.270	1.277	1.284	1.293	1.301	1.227[a]
	G	0.441	1.159	1.177	1.193	1.206	1.217	1.230	1.242	1.108[b]
	H	0.867	1.249	1.266	1.284	1.297	1.305	1.314	1.320	1.238[a]
	I	0.855	1.241	1.259	1.272	1.280	1.284	1.291	1.301	1.236[a]
	J	0.847	1.235	1.250	1.263	1.268	1.271	1.280	1.286	1.214[a]
	K	0.842	1.224	1.237	1.250	1.257	1.260	1.266	1.272	1.213[a]
	Means	0.81[A]	1.27[A]	1.28[A]	1.29[A]	1.30[A]	1.31[A]	1.33[A]	1.33[A]	
WSN/TN %	A	10.10	17.49	17.26	17.56	17.70	17.76	17.95	18.04	16.73[a]
	B	19.23	17.25	16.20	16.44	16.55	16.67	16.82	16.94	17.01[a]
	C	12.88	15.68	15.62	15.77	15.87	15.96	16.09	16.16	15.50[b]
	D	12.09	15.57	15.41	15.51	15.61	15.71	15.78	15.84	15.19[bc]
	E	11.35	15.28	15.23	15.32	15.36	15.46	15.57	15.65	14.90[bc]
	F	10.86	15.08	15.01	15.11	15.16	15.23	15.30	15.36	14.66[bc]
	G	16.33	15.70	15.24	15.37	15.48	15.56	15.70	15.76	15.64[b]
	H	12.33	15.30	15.21	15.39	15.51	15.55	15.64	15.69	15.08[bc]
	I	11.29	15.06	15.05	15.16	15.21	15.32	15.31	15.41	14.72[bc]
	J	10.78	15.09	14.89	15.02	15.04	15.05	15.09	15.14	14.51[bc]
	K	10.39	14.83	14.67	14.79	14.84	14.84	14.89	14.92	14.27[c]
	Means	11.34[B]	15.37[A]	15.49[A]	15.51[A]	15.59[A]	15.65[A]	15.76[A]	15.80[A]	
NPN %	A	0.089	0.271	0.280	0.290	0.298	0.310	0.317	0.325	0.272[a]
	B	0.078	0.240	0.249	0.256	0.261	0.269	0.273	0.278	0.238[a]
	C	0.141	0.256	0.262	0.266	0.271	0.277	0.284	0.288	0.255[a]
	D	0.133	0.244	0.248	0.252	0.257	0.263	0.266	0.273	0.245[a]
	E	0.125	0.235	0.240	0.246	0.256	0.261	0.265	0.270	0.237[a]
	F	0.108	0.221	0.225	0.230	0.237	0.242	0.247	0.252	0.220[a]
	G	0.077	0.250	0.259	0.266	0.273	0.279	0.285	0.293	0.248[a]
	H	0.132	0.250	0.256	0.260	0.266	0.271	0.274	0.278	0.245[a]
	I	0.121	0.234	0.237	0.240	0.245	0.250	0.253	0.256	0.229[a]
	J	0.110	0.230	0.240	0.244	0.247	0.253	0.257	0.260	0.230[a]
	K	0.102	0.210	0.213	0.219	0.222	0.226	0.229	0.234	0.206[a]
	Means	0.11[B]	0.23[A]	0.24[A]	0.25[A]	0.26[A]	0.26[A]	0.27[A]	0.27[A]	
NPN/TN %	A	1.92	3.38	3.36	3.48	3.56	3.69	3.76	3.85	3.38[a]
	B	3.33	3.49	3.38	3.45	3.51	3.60	3.64	3.70	3.51[a]
	C	2.05	3.18	3.19	3.20	3.26	3.32	3.40	3.44	3.13[a]
	D	1.84	3.02	2.99	3.02	3.07	3.14	3.17	3.25	2.94[a]
	E	1.64	2.87	2.88	2.93	3.04	3.10	3.14	3.20	2.91[a]
	F	1.36	2.68	2.69	2.73	2.81	2.87	2.92	2.97	2.63[a]

	G	2.59	3.39	3.35	3.42	3.50	3.57	3.64	3.72	3.40^{a}
	H	1.87	3.06	2.70	2.75	2.83	2.88	2.94	2.99	2.75^{a}
	I	1.59	2.83	2.83	2.86	2.91	2.98	3.00	3.03	2.75^{a}
	J	1.40	2.81	2.86	2.90	2.93	2.99	3.03	3.06	2.75^{a}
	K	1.25	2.54	2.52	2.59	2.62	2.66	2.69	2.74	2.45^{a}
	Means	1.65^{B}	2.89^{A}	2.93^{A}	2.94^{A}	3.06^{A}	3.07^{A}	3.11^{A}	3.17^{A}	

^{abcde} Letters indicate significant differences between jameed treatments
^{ABCD} Letters indicate significant differences between storage times

Table 7. Effect of using partial drying on some microbial groups of jameed

Properties	Treatments	Storage period (days)								Means
		Fresh	15	30	60	90	120	150	180	
TVBC (x 10^3)	A	67	35	29	22	18	15	13	10	26.12^{a}
	B	58	25	20	15	14	13	9	7	20.12^{b}
	C	63	31	25	18	14	10	7	5	21.62^{b}
	D	49	28	17	13	11	7	4	2	16.38^{d}
	E	27	15	12	10	8	5	2	0.8	9.98^{e}
	F	12	8	6	5	2	0.9	0.5	0.14	4.32^{g}
	G	50	18	17	15	10	8	6	5	16.12^{d}
	H	57	27	21	13	11	6	3	0.90	17.36^{c}
	I	37	21	11	5	3	0.9	0.6	0.3	9.85^{e}
	J	18	12	10	3	2	0.9	0.5	0.2	5.83^{f}
	K	10	7	3	0.9	0.6	0.4	0.1	0.08	2.76^{h}
	Means	37.7^{A}	20.4^{B}	14.89^{C}	9.98^{D}	7.73^{E}	5.12^{F}	3.41^{G}	2.15^{H}	
Lactic acid bacteria (x 10^3)	A	55	28	21	16	13	10	9	8	20.0^{a}
	B	44	20	15	10	9	8	6	3	14.4^{c}
	C	53	27	22	15	11	8	5	2	17.8^{b}
	D	32	23	15	10	9	6	3	0.9	12.3^{d}
	E	25	12	10	7	6	4	1	0.6	8.20^{e}
	F	9	6	5	3	0.9	0.6	0.3	0.08	3.11^{g}
	G	38	16	13	10	9	5	3	0.6	11.8^{d}
	H	49	23	17	10	8	4	2	0.7	14.2^{c}
	I	29	19	10	4	1	0.7	0.3	0.09	8.01^{e}
	J	14	10	8	0.8	0.6	0.6	0.1	0.08	4.27^{f}
	K	8	5	1	0.6	0.3	0.1	0.07	0.04	1.82^{h}
	Means	30.4^{A}	17.0^{B}	12.1^{C}	7.31^{D}	5.53^{E}	3.78^{F}	2.30^{G}	1.39^{H}	
Proteolytic bacteria (x 10^3)	A	6	0.9	0.7	0.3	0.10	0.08	0.05	0.05	1.06^{a}
	B	4	0.6	0.4	0.07	0.06	0.04	0.03	0.01	0.65^{cab}
	C	5	1	0.6	0.3	0.09	0.07	0.03	0.01	0.89^{a}
	D	4	0.8	0.4	0.1	0.06	0.04	0.01	0.007	0.68^{cab}
	E	2	0.5	0.2	0.08	0.04	0.01	0.008	0.007	0.36^{cdb}
	F	2	0.3	0.1	0.05	0.02	0.008	0.006	0.005	0.31^{cd}
	G	3	0.2	0.09	0.08	0.05	0.04	0.03	0.01	0.44^{cdb}
	H	4	1	0.5	0.2	0.07	0.03	0.009	0.005	0.73^{ab}
	I	2	0.6	0.3	0.1	0.04	0.03	0.008	0.006	0.39^{cdb}
	J	1	0.6	0.2	0.07	0.04	0.008	0.006	0.003	0.24^{d}
	K	1	0.4	0.09	0.05	0.01	0.006	0.004	0.002	0.19^{d}
	Means	3.00^{A}	0.68^{B}	0.34^{BC}	0.13^{C}	0.05^{C}	0.04^{C}	0.03^{C}	0.01^{C}	
Mould & Yeast (x10^3)	A	0	0	0	0	0.3	0.4	0.7	0.9	0.29^{a}
	B	0	0	0	0	0.1	0.3	0.6	0.8	0.22^{b}
	C	0	0	0	0	0.2	0.3	0.4	0.7	0.20^{b}
	D	0	0	0	0	0.2	0.2	0.4	0.5	0.16^{b}
	E	0	0	0	0	0	0.1	0.2	0.3	0.08^{c}
	F	0	0	0	0	0	0.1	0.1	0.2	0.05^{c}
	G	0	0	0	0	0.09	0.2	0.3	0.5	0.14^{b}
	H	0	0	0	0	0.1	0.3	0.4	0.6	0.18^{b}
	I	0	0	0	0	0.1	0.3	0.4	0.6	0.18^{b}

	J	0	0	0	0	0	0.1	0.2	0.3	0.08^{c}
	K	0	0	0	0	0	0.1	0.2	0.2	0.06^{c}
	Means	0.00^{E}	0.00^{E}	0.00^{E}	0.00^{E}	0.10^{D}	0.21^{C}	0.33^{B}	0.48^{A}	

^{abcde} Letters indicate significant differences between jameed treatments
^{ABCD} Letters indicate significant differences between storage times

Table 8. Effect of using partial drying on wettability and syneresis of jameed

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^{a}
	B	196.48	201.36	210.89	215.78	218.33	219.14	221.97	210.71^{cd}
	C	190.67	194.76	197.55	199.87	201.90	202.45	204.30	198.79^{e}
	D	203.98	209.12	211.96	214.45	215.33	216.85	218.17	212.83^{cb}
	E	213.00	219.33	222.09	223.89	225.89	227.01	228.55	222.82^{ab}
	F	220.71	226.65	228.33	229.56	230.98	231.87	233.49	227.31^{a}
	G	191.85	202.88	210.04	212.87	217.23	218.20	219.09	210.31^{cd}
	H	177.43	182.63	186.55	188.94	189.76	190.21	191.72	186.74^{f}
	I	180.88	188.89	194.09	197.55	200.62	201.98	203.30	195.33^{ef}
	J	188.67	195.33	199.07	204.77	206.03	207.74	208.48	201.44^{ed}
	K	197.43	203.63	208.55	213.95	214.72	215.64	216.88	210.11^{cd}
	Means	197.07^{C}	204.56^{BC}	208.16^{AB}	211.12^{AB}	212.67^{AB}	213.85^{AB}	215.31^{A}	
Syneresis % (after 1h of mixing with water)	A	39.84	47.87	48.03	51.97	54.67	55.84	57.22	50.78^{c}
	B	42.74	47.87	50.45	53.14	56.49	57.66	58.49	52.40^{c}
	C	44.48	50.04	51.00	55.80	59.93	61.12	63.66	55.00^{b}
	D	41.66	45.25	47.90	53.54	55.93	58.34	60.06	51.81^{c}
	E	37.24	43.33	46.94	52.24	54.72	55.98	58.97	49.20^{d}
	F	32.04	37.10	40.80	48.93	50.66	53.47	57.89	45.62^{e}
	G	44.31	50.80	52.01	55.13	57.24	57.99	59.24	53.82^{c}
	H	53.44	56.08	57.82	59.09	61.83	63.75	65.90	59.55^{a}
	I	51.34	54.89	56.70	59.13	60.97	62.15	63.40	58.36^{a}
	J	47.21	50.90	53.07	55.67	59.81	61.56	62.22	55.78^{b}
	K	42.09	45.88	46.03	51.87	56.42	57.96	59.33	51.36^{c}
	Means	43.26^{G}	47.81^{F}	49.81^{E}	54.14^{D}	56.54^{C}	58.96^{B}	60.85^{A}	
Syneresis % (after 24h of mixing with water)	A	42.42	50.00	50.11	54.65	57.14	60.12	63.16	54.08^{cab}
	B	44.43	51.62	52.30	54.31	57.27	60.14	63.38	54.79^{cab}
	C	46.90	51.30	53.79	57.88	60.30	62.54	64.11	56.68^{ab}
	D	44.89	48.00	52.23	56.68	58.32	60.21	63.80	54.80^{cab}
	E	40.13	45.87	50.81	53.92	56.10	58.37	60.22	52.20^{cb}
	F	34.30	40.79	44.88	49.30	52.11	54.37	59.89	47.95^{c}
	G	47.15	53.25	54.23	56.97	59.41	61.20	64.24	56.63^{ab}
	H	54.98	57.24	58.21	60.91	63.15	64.88	66.11	60.78^{a}
	I	52.03	55.18	57.00	59.56	60.99	63.56	65.46	59.11^{ab}
	J	50.78	53.54	55.84	56.06	59.98	62.74	63.88	57.55^{ab}
	K	44.75	50.48	51.97	53.34	57.70	59.21	61.00	53.97^{cab}
	Means	45.79^{D}	50.27^{CD}	52.69^{BCD}	55.76^{ABC}	58.42^{AB}	60.67^{A}	63.07^{A}	

^{abcde} Letters indicate significant differences between jameed treatments
^{ABCD} Letters indicate significant differences between storage times

Table 9. 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^{f}	0.309^{a}	1.497^{a}	6.846^{g}	4.573^{d}
B	14.72^{g}	0.153^{b}	0.757^{f}	3.266^{h}	6.410^{cd}
C	25.30^{e}	0.347^{a}	1.124^{b}	7.464^{gf}	4.809^{d}
D	33.00^{d}	0.389^{a}	0.875^{d}	10.256^{ef}	5.875^{cd}
E	37.40^{c}	0.420^{a}	0.824^{e}	14.421^{cd}	6.325^{cdb}
F	41.90^{ab}	0.522^{a}	0.523^{h}	17.621^{ab}	9.493^{ab}
G	15.66^{g}	0.172^{b}	0.628^{g}	4.371^{h}	6.860^{cd}
H	30.31^{d}	0.361^{a}	0.956^{c}	11.160^{ed}	5.470^{d}
I	37.45^{c}	0.410^{a}	0.830^{e}	14.338^{cd}	6.306^{cd}
J	39.60^{cb}	0.452^{a}	0.612^{g}	16.545^{cb}	8.963^{cab}
K	43.00^{a}	0.531^{a}	0.499^{h}	19.942^{a}	9.966^{a}

^{abcde} Letters indicate significant differences between jameed treatments

3.2. Changes in moisture content of jameed during solar drying process

After partially drying of jameed treatments at different temperatures and times in electricity oven, drying process was completed in sun till moisture content of jameed reached to ~20%. To determine the end of solar drying stage, the moisture contents were followed in jameed paste and after 3, 5, 7, 9, 11, 13 and 15 days of solar drying period. Results are shown in Table 2. Moisture values of jameed made from goat or cow skim milk and dried in sun (samples B and G respectively) were higher than jameed prepared from sheep butter milk with sun drying (sample A). As expected, moisture levels at the beginning and within drying period of samples A, B and G were higher than other treatments. Utilization of partially drying after shaping of jameed paste significantly ($P<0.05$) reduced moisture concentrations. The reduction rates were proportional with increasing of drying temperatures. Consequently, samples of goat skim milk jameed dried at 90ºC/6h (sample F) reached to ~20% moisture at the seventh day of drying period while samples dried at 75ºC/8h, 60ºC/10h and 45ºC/12h reached after 9, 9 and 13 days of drying respectively. The same trend but with faster levels was observed in cow skim milk jameed. Treatments dried at 90ºC/6h, 75ºC/8h, 60ºC/10h and 45ºC/12h (samples K, J, I, and H respectively) recoded 20% moisture after 7, 7, 9 and 11 days of drying stage. This main that the time of solar drying period reduced by 53.33, 53.33, 40.00 and 26.67% for the mentioned above samples respectively. Moisture levels were a little bit lower in cow skim milk jameed than that of goat skim milk one. Generally, the highest levels of moisture losing were noticed in the first five days of drying process.

3.3. Yield of jameed

Cheese yield is defined as the amount of cheese, expressed in kilograms, obtained from 100 kg of milk. It is a very important parameter: the higher the recovered percentage of solids, the greater is the amount of cheese obtained and therefore gains in economic terms (Abd El-Gawad and Ahmed, 2011). Data of the obtained yield (Table 3) show that very higher differences could be detected between jameed treatments made from sheep butter milk and goat or cow skim milk using solar drying (samples A, B and G respectively). The values of yield -1 or 2 of sample A were significantly ($P<0.05$) higher than those of samples B and G which may be due to the high total protein content of sheep butter milk. Hilali (2001) and Park et al., (2007) stated that proteins account for approximately 96% of the total N in sheep milk, with 4% being non-protein nitrogen (NPN). The level of NPN in goat milk is double that of sheep milk. This difference affects cheese yield which is higher in sheep milk.

The yield-1 values of partial draying jameed were similar to that of solar drying whereas levels of yield-2 were slightly higher in the latter than the former. Also, no remarkable changes were noted in jameed yield between various heat treatments of partial drying. Goat skim milk jameed possessed slightly higher yield-1 values than jameed manufactured from cow skim milk. An altogether opposite trend was observed for yield-2. Yield-1 values of samples B, C, D, G, H and I were 7.57, 7.22, 7.19, 6.80, 6.61 and 6.60% respectively. Respective values of yield-2 were 39.33, 37.69, 37.56, 40.84, 39.58 and 39.47% respectively.

3.4. Chemical composition of jameed during storage period

The changes in the titratable acidity (% lactic acid), pH, total solids (TS) and fat contents during storage of jameed are presented in Table 4. The values of titratable acidity gradually increased during storage of all samples of jameed. The greatest increasing levels were occurred in the first month of storage. The results of the pH values followed an opposite trend to that observed for titratable acidity measurements, i.e., as the acidity increased, the pH decreased. This may be due to fermentation of lactose, which produces lactic and acetic acid during fermentation and storage period. Because of higher acidity of sheep butter milk, it is normal that jameed prepared from it had the highest acidity values comparing with jameed made from goat or cow skim milk. Moreover, the rises rates in titratable acidity or drop in pH during storage were higher in control jameed (sheep butter milk) than that observed in goat or cow skim milk jameed. On the other hand, goat skim milk jameed contained slightly higher acidity values than cow skim milk jameed. The acidity values of treatments A, B, C, G and H after 15 days of storage were 3.48, 2.58, 2.75, 2.50 and 2.58% respectively.

In respect of the impact of partial drying on acidity and pH levels, it is shown from results of Table 4 that after finishing of partial drying (fresh samples) the acidity values of goat and cow skim milk jameed dried at 45ºC/12h and 60ºC/10h (samples C, D, H and I respectively) were slightly higher while dried at 75ºC/8h and 90ºC/6h (samples E, F, J and K respectively) were slightly lower than the acidity levels of fresh jameed paste made from goat and cow skim milk (samples B and G respectively). On the fifteenth day and during storage, acidity ratios of sun dried jameed were significantly ($P<0.05$) higher than those of partial dried treatments. With increasing of temperature and decreasing of time of heat treatments, acidity levels of jameed lowered while pH values increased. After 60 days of storage, acidity contents of cow skim milk jameed samples (H, I, J and K) dried at 45ºC/12h, 60ºC/10h, 75ºC/8h and 90ºC/6h were 3.57, 3.30, 3.18 and 2.97% respectively. These outcomes may be attributed to the influence of heat treatment of partial drying on bacterial activity in jameed. As it is well known, high temperatures inhibit bacterial growth and activity.

It can easily be observed from Tables 4 and 5 that there is a substantial effect of the partial drying on TS, fat, total protein and ash contents of jameed especially in fresh treatments. After partial drying of jameed past, significant increases in TS, fat, total protein and ash contents were obtained as compared with control. As well the increases in these components more rose with increasing of temperature of heat treatment. Total solids contents of fresh A, B, C, G and H samples were 48.67, 31.89, 66.80, 34.14 and 67.40% respectively. Of course, this due to higher moisture evaporation at higher heat treatment temperature. At the end of solar drying period (after 15 days) and through storage, the findings radically varied. Jameed manufactured from sheep butter milk using solar drying possessed the highest levels of TS and ash whereas goat and cow skim milk jameed treatments dried by sun had the lowest. Generally, TS and ash values of goat skim milk jameed were close to their counterparts of jameed made from cow skim milk. Samples of goat skim milk jameed had the highest fat concentrations followed by sheep butter milk and cow skim milk jameed. Total protein values of sun dried jameed treatments prepared from goat and cow skim milk were lower than partial dried samples. Overall, total protein was the predominant content of TS in various jameed samples. Jameed has high ash content due to the salt added to jameed paste before shaping and drying.

Regardless of milk type or drying method applied, TS, fat, total protein and ash contents of different jameed treatments increased with the advancing of storage period. The largest percentages of increases were found at the end of sun drying period (after 15 days). Jism, (1997) stated that the chemical composition of jameed differs because of numerous factors, including the stage of milk production (i.e., lactation cycle), milk sources, animal feeds and processing method. From the viewpoint of quality, moisture content in jameed should not be more than 15% in order to reduce microbial spoilage and to stop any undesirable chemical and physical changes from taking place during storage **(**Krokida and Marinos-Kouris 2003 and Koç et al., 2008). Mazahreh et al., (2008) reported a fat content up to 31.7%, which indicate the low efficiency churning in traditional Jameed processing methods.

Data of salt and salt in moisture of jameed samples during drying and storage periods are tabulated in Table 5. With progressive of storage period, salt and salt in moisture ratios increased in different jameed treatments. Jameed made from goat and cow skim milk and partially dried by hot air had slightly higher salt contents than jameed manufactured from sheep butter milk or goat and cow skim milk with sun drying. As a result of moisture evaporation during partial drying, salt levels were slightly higher in jameed samples treated with this technic than control. Salt values of samples A, B, C, G and H at the end of storage period were 11.07, 10.57, 11.55, 10.42 and 11.68% respectively. Irrespective of drying method applied, salt and salt in moisture results were almost similar in both jameed treatments made from goat and cow skim milk.

3.5. Changes in some nitrogen fractions of jameed

In jameed paste (fresh), utilization of partial drying increased WSN and NPN levels than control (Table 6). This may be due to increasing of total solids and total protein. During storage period, results of WSN and NPN reflected while sheep butter milk jameed dried by sun had the highest levels followed by that prepared from goat and cow skim milk using partial drying while goat and cow skim milk jameed dried in sun had the lowest levels. On the other side, using of low temperature with prolongation of heat treatment time through partial drying of jameed paste significantly increased ($P<0.05$) WSN and NPN values. These results could be interpreted on the basis of stimulation of jameed paste bacteria by low temperature (45ºC/12h) thus more proteolysis was done. Inversely, high temperature (90ºC/6h) inhibited jameed bacteria thus decreased WSN and NPN contents. Values of WSN of samples C, D, E and F after 30 days of storage were 1.284, 1.275, 1.269 and 1.255% respectively. When comparing results of WSN and NPN between goat and cow skim milk jameed, it was clear that these contents were higher in the former than the latter. These results are in line with those reported by Ismail (2010), he reported that WSN/TN and NPN/TN values of Halloume cheese made from goat's milk were higher than that made from cow's milk.

3.6. Changes in microbial counts of jameed during storage

Using of various types of drying or milk impacted on the microbial numbers of fresh jameed and during storage period. It could be viewed form Table 7 that jameed made from sheep butter milk by traditional method (completely sun drying) had higher numbers of total viable bacterial count (TVBC) than jameed made from goat or cow skim milk and dried by sun or hot air. Conversely, loss of viability ratios of TVBC during storage period highly increased in partial dried jameed than control one. Values of loss of viability for samples A, B, C, G and H were 85.07, 87.93, 92.06, 90.00 and 98.42% respectively. As it is expected, raising of temperature in heat treatments of partial drying significantly (P<0.05) decreased TVBC of jameed. Numbers of TVBC is samples C, D, E and F after 90 days of storage were 14, 11, 8, and 2 x 10^3 CFU/g respectively. The TVBC increased in jameed made from goat skim milk as compared with that made from cow skim milk jameed.

Manufacturing of jameed by traditional method (samples A, B and G) significantly (P<0.05) increased the numbers of lactic acid bacteria in fresh product and within storage period. As TVBC reduced in jameed samples treated with partial drying, also lactic acid bacteria decreased in these samples. With increasing of temperature of partial drying, lowering levels increased. Using goat skim milk increased the counts of lactic acid bacteria than using cow skim milk in jameed production. In addition to this, goat skim milk jameed possessed lower levels of survival loss during storage than cow skim milk jameed.

It is quite apparent from the results reported in Table 7 that small numbers of proteolytic bacteria were found in fresh jameed samples and during storage period. Numbers of these bacteria exhibited the same behavior of TVBC and lactic acid bacteria regarding the effect of applied drying method, partial drying temperature and milk type. Supported to the effect of drying method of jameed on bacterial numbers, Al Omari et al., (2008) cleared that the bacteria counts of the freeze-dried samples are generally higher than solar dried ones. This may demonstrate the lethal effect of the prolonged heat (50ºC) on certain lactic acid bacteria in solar drying of this product.

In all jameed treatments, there were significant (p<0.05) reduction in TVBC, lactic acid bacteria and proteolytic bacteria through storage period which due to the accumulation of acids, reduction of moisture and increasing of salt contents.

After 90 days of storage, moulds and yeasts were detected in some jameed samples while at 120, 150 and 180 days, they found in all treatments. Their numbers increased in jameed made by traditional method and lowered by higher temperature of partial drying and increased in goat skim milk jameed than that prepared from cow skim milk. Because of high hygienic conditions of the manufacture, coliform bacteria were not detected in fresh jameed samples and during storage period.

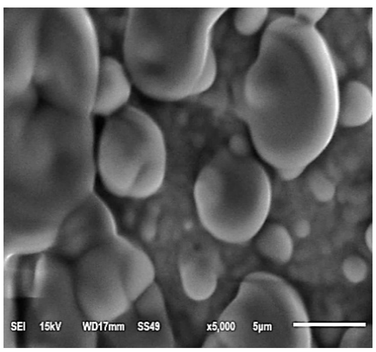
3.7. Changes in solubility of jameed during storage

An important criterion for quality assessment of jameed treatments is the solubility, so the wettability and syneresis are an important characteristic that determines the acceptability of the product for reconstitution. Results of Table 8 illustrate the influence of using partial drying and different types of milk on the wettability and syneresis of jameed during storage. From 15 till 180 days of storage, goat skim milk jameed partially dried at 90ºC/6h had the greatest wettability levels as compared with other treatments. Cow skim milk jameed partially dried using various heat treatments possessed the lowest wettability values whereas control jameed was at an intermediate position. In both goat and cow skim milk jameed, increasing of temperature and decreasing of time of heat treatments of partial drying significantly (p<0.05) increased the wettability levels. The wettability levels of samples A, F and K after 120 days of storage were 228.79, 230.98 and 214.72% respectively.

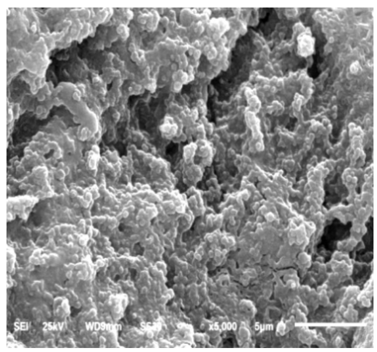
Quite the contrary, values of syneresis determined after 1 or 24 h of mixing with water were higher in cow skim milk jameed than those of goat skim milk and control jameed. Raising of temperature and lowering of time of heat treatments of partial drying significantly (p<0.05) reduced the values of syneresis. In different jameed treatments, syneresis levels increased after 24 hours of mixing with water. However wettability values always inversely proportional with syneresis, but both of them gradually increased during storage stage in various jameed treatments.

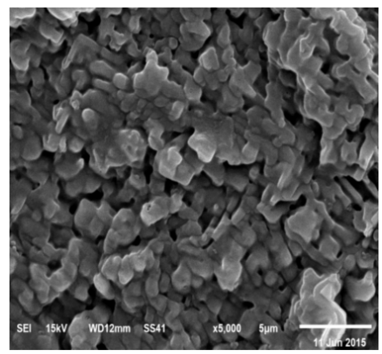
3.8. Changes in textural characterizes of jameed at the end of storage period

Rheological studies are widely used in food products to understand their texture and microstructure. Small strain dynamic rheological methods are nondestructive. They conduct within the linear viscoelastic region, and determine the elastic and viscous nature of cheese. Large strain rheological methods determine rheological properties that occur outside of the linear viscoelastic region and characterize the nonlinear and fracture properties of the material (Rahimi et al., 2013). Table 9 shows the textural properties of jameed after 180 days of storage. Using of partial drying in jameed manufacturing increased values of hardness, cohesiveness, gumminess and chewiness values and decreased values of springiness comparing with control which made using sun drying. Olson and Johnson (1990) indicated that relative amounts of water, protein, and fat were the dominant factors electing cheese hardness. Fat and moisture act as the filler in the casein matrix of cheese texture (Madadlou et al., 2005), giving it lubricity and softness.

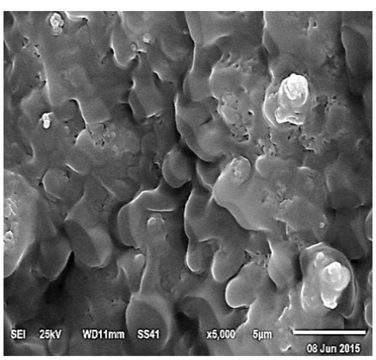


Sample A

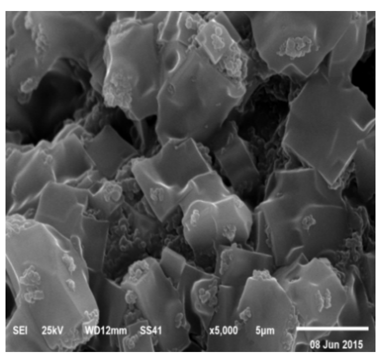

Sample B



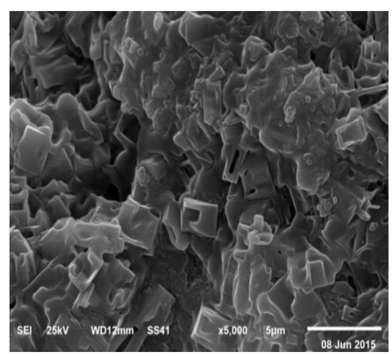
Sample C



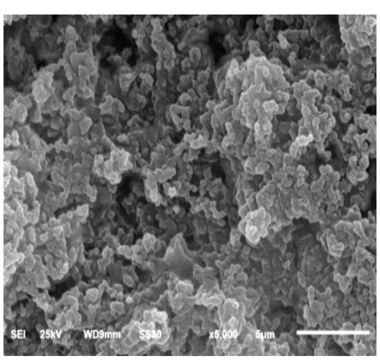
Sample D

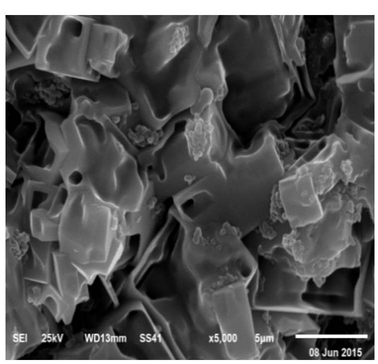


Sample E

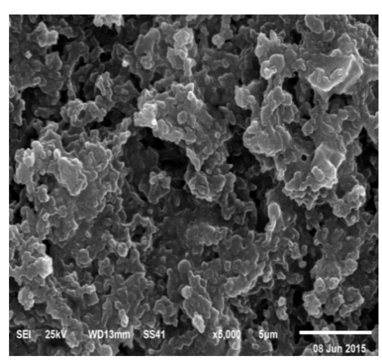


Sample F

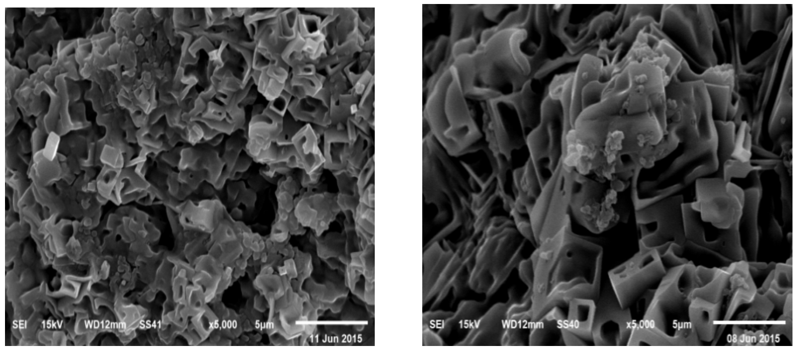

Sample G



Sample H



Sample I



Sample J Sample K

Figure 1. Scanning electron micrographs of jameed at the end of storage period

On the other hand, jameed samples treated with higher temperature of partial drying had the highest levels hardness, cohesiveness, gumminess and chewiness and the lowest levels of springiness. This may be due to increasing of TS, ash and salt at higher temperatures. These results are in agreement with those found by Kaminarides et al., (2006) who reported that with increasing the salt and ash contents in blend Halloumi cheese, the hardness of the resulting processed cheese increased. Also Desouky et al., (2013) showed that the change in the apparent viscosity of Labneh made from camel milk was linear with the increase in the thermal treatment of milk, where the highest treatment (95°C/30 min) increase in the solids concentration led to highest apparent viscosity. As appeared from Table 9, jameed made from cow skim milk had higher significant ($P<0.05$) values of hardness, cohesiveness, gumminess and chewiness and lower significant ($P<0.05$) values of springiness than jameed made from goat skim milk.

3.9. Microstructure of jameed at the end of storage period

Microstructure has a major impact on the texture and other physical properties of acid milk gels (Desouky et al., 2013). Thus, scanning electron microscopy (SEM) was performed for control and high thermally treated jameed treatments.

The microstructure of the jameed samples using SEM is shown in Figure 1. There was clear distinction between the microstructure of the jameed treatments. Protein matrices composed of casein micelle chains and clusters were entirely different among jameed samples. The scanning electron microscopy showed that the protein matrices of sheep butter milk jameed dried in sun (sample A) appeared to be relatively more intensive than other treatments and spaces in it were very small and filled by the fat globules. In this treatment, the casein micelles were predominantly linked by particle fusion into big aggregates, rather than by particle to particle attachment in chains with comparatively small interspaced voids. In goat and cow skim milk jameed dried in sun (samples B and G), protein matrices characterized by coarse structure and no casein micelle fusion especially in goat skim milk jameed. Void spaces occupied by the fat globules uniformly scattered within the jameed matrix.

The micrograph images of partially dried jameed treatments showed that protein matrices characterized by little aggregates, plates structure, more open protein network and high fusion. These properties were more obvious with higher temperature heat treatments and in goat skim milk jameed. The SEM observations of our study are relatively close to those reported by Desouky et al., (2013) who cleared that for control of Labneh made from camel milk, protein structure characterized by short casein micelles chains and no appreciable casein micelle fusion were observed. The control exhibited a more open, loose and less dense protein network than thermal treatments.

4. Conclusions

Using of partial drying technique at 75ºC/8h and 90ºC/6h saved the cost production of jameed by reducing time of solar drying to half. Jameed made from goat or cow skim milk using this technique exhibited good chemical, microbial and rheological properties during storage period for six months.

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