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Effect of Mixing Whey Protein with Jameed Past on the Chemical Composition, Rheological and Microbial Properties

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Abstract: Nine treatments of Jameed were made as follow: (A) Jameed made from sheep buttermilk (control), (B) made from goat skim milk, (C) made from goat skim milk+10% (of curd weight) whey protein (WP), (D) made from goat skim milk+15% (of curd weight) WP, (E) made from goat skim milk+20% (of curd weight) WP, (F) made from cow skim milk, (G) made from cow skim milk+10% (of curd weight) WP, (H) made from cow skim milk+15% (of curd weight) WP, and (I) made from cow skim milk+20% (of curd weight) WP Results showed the following; the addition of WP paste (10, 15 and 20%) to goat or cow skim milk didn't exhibited clear changes in yield values and relatively more acidic, compared to that made without adding it, while, increased increase in WSN, WSN/TN, NPN and NPN/TN values, on the other hand, slightly increased in TS, total protein, ash and salt and decreased fat contents. Incorporation 10, 15 or 20% WP paste with Jameed increased its TVBC, LAB and proteolytic bacteria counts. The highest wettability levels recorded in Jameed samples contained 20% WP paste, while, Jameed contained 20% WP recorded the weakest textural properties values. In Jameed treatments manufactured from goat or cow skim milk with addition of 10, 15 and 20% WP, protein matrices had rigid plate's structure, little aggregates and more spaces scattered in matrix. Economic study for utilization of WP in Jameed production showed that incorporation of 10 and 15% WP paste with goat or cow skim milk Jameed curd increased the net profit.

Keywords: Jameed; Whey protein; Chemical composition; Rheological & Microbial properties.

1. Introduction

Jameed is a dried fermented milk product that is wildly 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 widely used after reconstitution in preparation of popular dishes in place of fresh yoghurt in the Middle East countries such as Jordan, Syria, Iraq and Egypt [1] It is preferably made from sheep and goat milk but it can be made from cow and camel milk.

Whey protein isolate was used by Kent, *et al.* [2] to reduce dead prostate cells. Prostate cells where protected from oxidant-induced cell death after the level of intracellular glutathione was increased when whey protein isolate was supplied during cell incubation. Hinrichs and Steffl [3] studied the effect of degree of denaturation on the retention of whey proteins in soft and semi-hard cheese using two whey protein concentrates (WPC) and a whey protein isolate (WPI) which were heated and shear-treated in order to particulate the whey proteins. The amount of WPC or WPI added was varied between 0.3 to 1.25%. There was a significant increase in retention as a result of increasing degree of denaturation for WPC and WPI. The maximum retention of 70% for semi-hard cheese was achieved for >90% denaturation. During soft cheese production a higher recovery of whey protein is possible, especially when WPI was particulate.

The acid curd obtained from the buttermilk is the major component of the Jameed. This curd is mixed thoroughly with table salt and dried in the sun [4]. The final product is un-hygroscopic and can be stored in cloth bags or sealed jars for two years without any detectable change [5]. The low moisture content and low pH are safeguards against spoilage of Jameed and the growth of microorganisms.

On the other hand, whey protein is a pure, natural, high quality co-product of the cheese making process. Whey protein is more soluble than casein and also has a higher quality rating. It is often referred to as the "Gold Standard" of protein as it is the most nutritious protein available. During the last 15-20 years the value of whey protein has

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become more widely known, especially in the area of sports nutrition [6, 7]. Recently in Egypt, salted whey resulted from Ras cheese manufacture is used for production whey protein paste. The method followed for its processing is very similar to Ricotta cheese making. Therefore, the aim to study the possibility of blinding various levels of whey protein paste with Jameed paste and investigate effect of this technic on the chemical composition, rheological and microbial properties of produced Jameed.

2. Material and Method

2.1. Materials

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. Whey protein was prepared in El-Serw Animal Production Research Station from Ras cheese whey. Dry commercial food grade sodium chloride obtained from El-Nasr Salines Company, Egypt, was used during this investigation.

2.2. Methods

2.2.1. Preparation of Whey Protein

Ras cheese whey was skimmed and heated to 95°C for 10 min., cooled and the flocculated denatured whey proteins were recovered by straining through cloth bags for three hrs. The precipitate was transferred to wooden frames and pressed overnight.

Jameed manufacture

Jameed treatments were made according to the traditional method described by Quasem, *et al.* [8].

2.2.2. Adding of Whey Protein to Jameed

After kneading with 5% salt, Jameed paste was re-kneaded with whey protein paste and shaped as a ball then sun dried. Jameed samples were as follow:

Treatment A: Jameed made from sheep butter milk (control).
Treatment B: Jameed made from goat skim milk.
Treatment C: Jameed made from goat skim milk+10% (of Jameed curd weight) whey protein.
Treatment D: Jameed made from goat skim milk+15% (of Jameed curd weight) whey protein.
Treatment E: Jameed made from goat skim milk+20% (of Jameed curd weight) whey protein.
Treatment F: Jameed made from cow skim milk.
Treatment G: Jameed made from cow skim milk+10% (of Jameed curd weight) whey protein.
Treatment H: Jameed made from cow skim milk+15% (of Jameed curd weight) whey protein.
Treatment I: Jameed made from cow skim milk+20% (of Jameed curd weight) whey protein.

The dried Jameed balls were packaged in polyethylene bags and stored at room temperature 6 months. Samples were analyzed when fresh and after 15, 30, 60, 90, 120, 150 and 180 days of storage period.

2.2.3. Yield

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

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

2.2.4. Chemical Analysis

Total solids, fat, total nitrogen and ash contents of samples were determined according to the A. O. A. C [9]. 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 [10]. The 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 (NPN) of Jameed were estimated according to Ling [11]. The Volhard's method as described by Richardson [12] 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)

Amino acid profile of six months stored Jameed was performed following the protocol of Walsh and Brown [13]. Hydrochloric acid (6 M) was added to the sample vial for a final concentration of 5 mg of protein/mL of HCl. Hydrolysis vial was placed in an ultrasonic cleaner and flushed with nitrogen gas before sealing under vacuum. Sample was placed in a heating block for 4 hr. at 145°C. Afterwards, sample was removed from the heating block and allowed to cool before filtration through 0.2 µm filter. Sample was dried with nitrogen gas and dissolved in a dilution buffer. The prepared sample was analyzed for amino acid profile by running through Automated Amino Acid Analyzer (Model: L-8500 A, Hitachi, Japan). Areas of amino acid standards were used to quantify each amino acid in representative sample.

2.2.5. 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 [14].

2.2.6. Textural Measurements

Force and torque measurements of Jameed treatments stored for six months 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.

2.2.6.1. Wettability 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.* [8]. The excess free water was carefully decanting weighed to calculate the soaked amount as follows:
Absorbed water (%) = [(315 ml water-X) /Weight of cubs in g] x 100
X= the weight of excess water in g.

2.2.6.2. SynERESIS (Whey Separation) Test

The soaked cube (45 g) was mixed with (315 ml water) for 2 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 1 h and 24 h Quasem, *et al.* [8]. Syneresis (whey separation) was calculated, as follow:
Syneresis (%) = (X/Y) ×100 Where; X= the height of the clear zone and Y= total height of Jameed dispersion.

2.2.7. Scanning Electron Microscopy (SEM) Examination

Jameed samples were prepared for SEM according to the method of Brooker and Wells [15]. 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.

2.2.8. Statistical Analysis

The obtained results were statistically analyzed using a software package [16] based on analysis of variance. When F-test was significant, least significant difference (LSD) was calculated according to Duncan [17] for the comparison between means. The data presented, in the tables, are the mean (± standard deviation) of 3 experiments.

3. Results

3.1. Yield of Jameed

The potential benefits of improved properties of Jameed that may be produced by adding whey protein to Jameed paste could be less attractive if they are accompanied by decreases in yield efficiency. Jameed yield values of different treatments are shown in Table (1). Results of both yield-1 and yield-2 of Jameed manufactured from sheep buttermilk were very higher than Jameed prepared from goat and cow skim milk. Values of yield-1 of goat skim milk Jameed were slightly higher than cow skim milk Jameed. On the contrary, yield-2 levels were lower in the former than the latter. Addition of whey protein paste (10, 15 and 20%) to goat or cow skim milk Jameed didn’t exhibited clear changes in both yield-1 and 2. The increase in cheese yield was more pronounced with adding whey proteins to cheese curd as compared to its addition to milk. This may be due to resolubilization and loses of the added whey proteins in whey. Hinrichs [18] stated that the yield of cheese is influenced by different factors, e.g., it is increased (i) as the fat and protein contents of milk increase; (ii) by retaining or re-incorporating whey proteins, and (iii) by integrating other milk constituents such as lactose or ash, as well as water.

Table-1. Effect of mixing whey protein with Jameed past on yield values

Treatments	Yield-1	Yield-2
A	16.03[a]	54.66[a]
B	7.57[b]	39.33[c]
C	7.51[b]	38.34[c]
D	7.50[b]	38.30[c]
E	7.50[b]	38.28[c]
F	6.80[c]	40.84[b]
G	6.80[c]	40.80[b]
H	6.80[c]	40.81[b]
I	6.78[c]	40.79[b]

Treatment A: Jameed made from sheep buttermilk (control).
Treatment B: Jameed made from goat skim milk.
Treatment C: Jameed made from goat skim milk + 10% (of Jameed curd weight) whey protein.
Treatment D: Jameed made from goat skim milk + 15% (of Jameed curd weight) whey protein.
Treatment E: Jameed made from goat skim milk + 20% (of Jameed curd weight) whey protein.
Treatment F: Jameed made from cow skim milk.
Treatment G: Jameed made from cow skim milk + 10% (of Jameed curd weight) whey protein.
Treatment H: Jameed made from cow skim milk + 15% (of Jameed curd weight) whey protein.
Treatment I: Jameed made from cow skim milk + 20% (of Jameed curd weight) whey protein.

Chemical composition of milk and whey protein used in Jameed manufacture

Chemical composition of sheep buttermilk, goat and cow skim milk and whey protein used in Jameed production was presented in Table 2.

Table-2. Chemical composition of milk and whey protein used in Jameed manufacture

Treatments	Acidity%	pH values	TS%	Fat%	Total Protein%	SNF%	Salt%
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]	-
Whey protein	0.35	5.04	27.75	0.8	15.45	-	7.11

[abcde] Letters indicate significant differences between milk treatments

3.2. Chemical Composition of Jameed during Storage Period

Some physico-chemical properties of analogue of Jameed made from various types of milk and with adding different concentrations of WP is shown in Table (3). The results obtained showed variation in the acidity of Jameed made from sheep buttermilk, goat and cow skim milk treatments at zero time and during storage period. Sheep buttermilk Jameed had higher acidity than Jameed prepared from goat and cow skim milk. Furthermore, the developments of acidity levels during storage period were also higher in sheep buttermilk Jameed. On the other side, cow skim milk Jameed contained slightly lower acidity values than goat skim milk Jameed. Form the foregoing results; it is clear that not only milk type affected Jameed acidity but also incorporation of WP.

Water soluble nitrogen (WSN) and non-protein-nitrogen (NPN) in Jameed treatments are shown in Table (3). These contents differed significantly between Jameed of different TP contents. The highest levels of WSN and NPN within storage period were detected in sheep buttermilk Jameed (sample A). Goat skim milk Jameed had slightly higher values of mentioned nitrogen fractions than those measured in Jameed made from cow skim milk. Increasing of TP and proteolytic bacteria counts in sheep buttermilk Jameed may be led to raising these contents.

Table-3. Effect of mixing whey protein with Jameed past on some physico-chemical properties

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	3.45[ab]
	C	2.10	2.85	3.50	3.85	4.18	4.28	4.43	4.52	3.71[ab]
	D	2.18	2.90	3.73	4.08	4.35	4.49	4.65	4.78	3.90[ab]
	E	2.24	3.04	3.88	4.19	4.51	4.65	4.79	4.90	4.06[ab]
	F	1.72	2.60	3.10	3.38	3.62	3.83	3.96	4.08	3.29[b]
	G	2.08	2.68	3.42	3.68	3.93	4.11	4.24	4.36	3.57[ab]
	H	2.12	2.75	3.60	3.85	4.19	4.34	4.51	4.67	3.75[ab]
	I	2.18	2.94	3.77	4.08	4.37	4.50	4.67	4.80	3.91[ab]
	Means	2.05[D]	2.90[CD]	3.60[CD]	3.91[AB]	4.20[AB]	4.36[AB]	4.48[AB]	4.65[A]	
TS %	A	48.67	82.00	84.95	86.12	87.08	87.87	88.58	89.06	81.79[a]
	B	31.89	75.79	78.14	79.10	81.11	82.15	82.21	82.95	73.54[c]
	C	32.50	75.90	78.34	79.27	81.27	82.30	82.32	83.16	74.38[bc]
	D	32.80	76.15	78.52	79.42	81.39	82.44	82.41	83.29	74.55[bc]
	E	33.12	76.34	78.78	79.65	81.60	82.61	82.53	83.46	74.76[b]
	F	34.14	76.24	79.12	80.26	81.33	82.46	82.97	83.78	75.03[b]
	G	34.77	76.40	79.27	80.45	81.57	82.59	83.11	83.89	75.26[b]
	H	34.95	76.57	79.46	80.66	81.74	82.78	83.27	83.97	75.43[b]
	I	35.19	76.75	79.63	80.84	81.88	82.90	83.42	84.17	75.41[b]
	Means	35.23[E]	76.35[D]	79.58[C]	80.64[C]	82.11[B]	83.07[AB]	83.42[A]	84.19[A]	
Fat %	A	3.85	10.40	10.64	10.87	11.05	11.14	11.23	11.35	10.06[ab]
	B	4.19	11.36	11.57	11.71	11.84	11.98	12.20	12.35	10.90[a]
	C	4.15	11.32	11.51	11.65	11.80	11.96	12.21	12.30	10.86[a]
	D	4.10	11.25	11.49	11.61	11.76	11.92	12.18	12.27	10.82[a]
	E	4.07	11.20	11.45	11.57	11.74	11.89	12.15	12.24	10.79[a]

	F	3.17	9.90	9.95	10.19	10.31	10.40	10.49	10.60	9.38^{b}
	G	3.12	9.84	9.90	10.17	10.24	10.38	10.46	10.56	9.33^{b}
	H	3.08	9.80	9.88	10.13	10.20	10.33	10.41	10.54	9.17^{b}
	I	3.04	9.77	9.84	10.07	10.18	10.30	10.39	10.50	9.26^{b}
	Means	3.64^{B}	10.54^{A}	10.69^{A}	10.77^{A}	11.01^{A}	11.14^{A}	11.30^{A}	11.41^{A}	
Total protein %	**A**	29.55	51.13	53.05	53.16	53.31	53.61	53.70	53.81	50.17^{a}
	B	14.95	43.91	47.01	47.34	47.45	47.66	47.78	47.92	43.00^{c}
	C	15.25	44.36	47.30	47.70	47.80	47.94	47.99	48.24	43.32^{c}
	D	15.61	44.75	47.57	45.02	48.17	48.20	48.31	48.56	43.27^{c}
	E	15.94	44.98	47.84	45.29	48.35	48.45	48.64	48.82	43.54^{c}
	F	17.24	47.11	49.23	49.54	49.69	49.87	49.99	50.28	45.37^{b}
	G	17.58	47.37	49.47	49.70	49.97	50.11	50.28	50.60	45.64^{b}
	H	17.96	47.69	48.70	49.95	50.26	50.34	50.52	50.79	45.78^{b}
	I	18.34	47.97	48.97	50.28	50.58	50.67	50.80	50.97	46.14^{b}
	Means	18.05^{E}	46.59^{D}	48.66^{C}	48.85^{CB}	49.51^{CAB}	49.65^{AB}	49.78^{AB}	50.00^{A}	
Ash %	**A**	11.50	14.87	14.95	15.38	15.59	15.81	16.04	16.14	15.04^{a}
	B	10.14	13.57	13.81	13.97	14.31	14.47	14.60	14.74	13.70^{b}
	C	10.68	13.78	13.97	14.11	14.41	14.60	14.81	14.93	13.91^{b}
	D	10.82	13.88	14.16	14.25	14.58	14.76	14.97	15.14	14.00^{b}
	E	10.97	14.04	14.31	14.47	14.73	14.91	15.21	15.32	14.24^{ab}
	F	9.97	13.30	13.57	13.69	13.94	14.27	14.49	14.64	13.48^{b}
	G	10.21	13.47	13.72	13.82	14.17	14.42	14.63	14.80	13.66^{b}
	H	10.37	13.62	13.86	13.98	14.36	14.59	14.78	14.97	13.82^{b}
	I	10.48	13.76	13.98	14.17	14.54	14.78	14.92	15.19	13.98^{b}
	Means	10.57^{D}	13.81^{C}	14.04^{CB}	14.20^{CAB}	14.51^{CAB}	14.73^{CAB}	14.94^{AB}	15.04^{A}	
Salt in moisture %	**A**	12.03	36.23	41.27	43.34	45.48	47.26	48.94	50.29	40.61^{a}
	B	8.59	28.65	31.62	33.01	35.48	36.93	37.14	38.27	31.15^{e}
	C	8.87	29.14	32.38	33.37	35.99	37.50	37.61	38.90	31.72^{dec}
	D	9.05	29.83	32.90	33.69	36.31	37.97	38.15	39.48	32.17^{dbc}
	E	9.34	30.30	33.52	34.35	36.86	38.53	38.57	40.03	32.68^{b}c
	F	8.20	28.80	31.72	33.79	35.41	36.78	37.75	39.11	31.45^{de}
	G	8.41	29.40	32.30	34.26	35.81	37.33	38.24	39.57	31.92^{dec}
	H	8.68	29.04	32.90	34.99	36.27	37.87	38.74	39.90	32.30^{dbc}
	I	8.83	30.41	33.45	35.62	37.25	38.82	39.71	40.93	33.13^{b}
	Means	9.11^{G}	30.20^{F}	33.56^{E}	35.10^{D}	37.20^{C}	38.78^{B}	39.42^{B}	40.72^{A}	
WSN %	**A**	0.468	1.401	1.435	1.463	1.478	1.492	1.510	1.521	1.346^{a}
	B	0.450	1.187	1.194	1.222	1.237	1.245	1.260	1.272	1.133^{a}
	C	0.467	1.207	1.216	1.239	1.256	1.270	1.287	1.297	1.155^{a}
	D	0.481	1.229	1.240	1.267	1.285	1.299	1.321	1.323	1.181^{a}
	E	0.498	1.256	1.269	1.286	1.304	1.327	1.348	1.364	1.207^{a}
	F	0.441	1.159	1.177	1.193	1.206	1.217	1.230	1.242	1.108^{a}
	G	0.455	1.176	1.198	1.216	1.233	1.247	1.265	1.280	1.134^{a}
	H	0.467	1.197	1.225	1.247	1.266	1.282	1.300	1.317	1.163^{a}
	I	0.482	1.221	1.243	1.269	1.290	1.314	1.332	1.351	1.188^{a}
	Means	0.468^{A}	1.225^{A}	1.244^{A}	1.267^{A}	1.284^{A}	1.299^{A}	1.317^{A}	1.329^{A}	
NPN %	**A**	0.089	0.271	0.280	0.290	0.298	0.310	0.317	0.325	0.272^{ab}
	B	0.077	0.250	0.259	0.266	0.261	0.269	0.285	0.293	0.248^{ab}
	C	0.093	0.256	0.280	0.294	0.286	0.298	0.327	0.336	0.276^{ab}
	D	0.109	0.274	0.305	0.317	0.309	0.321	0.359	0.374	0.308^{ab}
	E	0.133	0.295	0.329	0.355	0.332	0.345	0.398	0.401	0.333^{a}
	F	0.078	0.240	0.249	0.256	0.273	0.279	0.273	0.278	0.238^{b}
	G	0.090	0.254	0.267	0.278	0.305	0.318	0.306	0.314	0.262^{ab}
	H	0.107	0.269	0.287	0.299	0.331	0.347	0.330	0.341	0.283^{ab}
	I	0.129	0.287	0.306	0.320	0.369	0.384	0.359	0.372	0.306^{ab}
	Means	0.100^{B}	0.267^{A}	0.285^{A}	0.297^{A}	0.307^{A}	0.319^{A}	0.328^{A}	0.343^{A}	

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

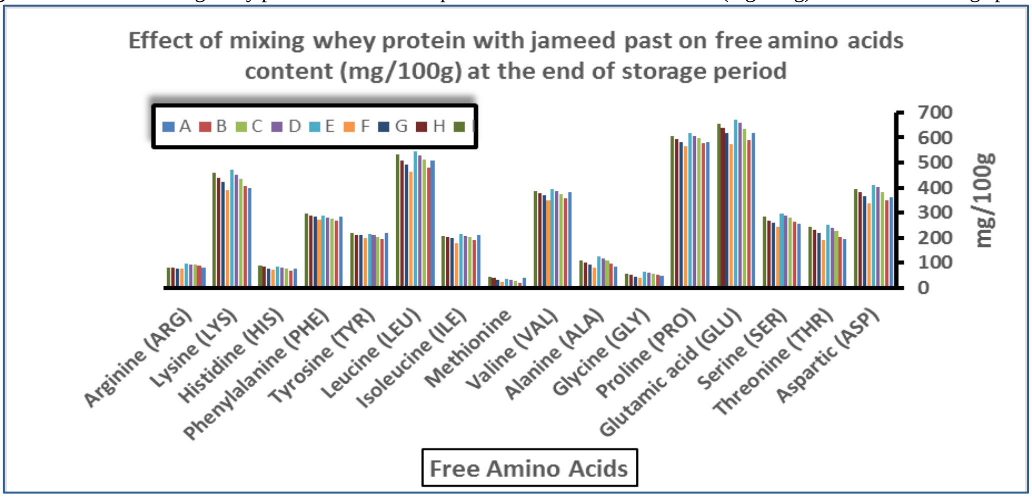
Data in Figure 1 and Table 4 compare the composition of FAA in jameed made from sheep buttermilk, goat and cow skim milk with or without adding WP at the end of storage period (6 months). The total free amino acids (FAA) content is clearly affected by the type of milk or adding WP. Sheep buttermilk Jameed contained higher amount of total amino acids as compared with that made from goat skim milk. The lowest values of FAA were found in cow skim milk Jameed. This may be related to the high TP, WSN and NPN contents of sheep buttermilk Jameed.

Table-4. Effect of mixing whey protein with Jameed past on free amino acid indices ratios

Treatments	Total amino acids (mg/100g)	Total EAA (mg/100g)	Total Non-EAA (mg/100g)	Total BCAA (mg/100g)	E/T* (%)	Total BCAA/Total (%)
A	4373	2095	2278	1104	47.91	25.24
B	4230	1992	2238	1026	47.09	25.25
C	4514	2130	2384	1087	47.19	24.08
D	4675	2206	2469	1121	47.19	23.98
E	4825	2283	2542	1153	47.23	23.90
F	4075	1944	2131	994	47.70	24.39
G	4367	2092	2275	1058	47.90	24.23
H	4540	2176	2364	1090	47.93	24.01
I	4704	2262	2442	1128	48.09	23.98

*EAA/Total amino acids

Figure-1. Effect of mixing whey protein with Jameed past on free amino acids content (mg/100g) at the end of storage period.



A: Jameed made from sheep buttermilk (control).
B: Jameed made from goat skim milk.
C: Jameed made from goat skim milk + 10% whey protein.
D: Jameed made from goat skim milk + 15% whey protein.
E: Jameed made from goat skim milk + 20% whey protein.
F: Jameed made from cow skim milk.
G: Jameed made from cow skim milk + 10% whey protein.
H: Jameed made from cow skim milk + 15% whey protein.
I: Jameed made from cow skim milk + 20% whey protein.

3.3. Changes in Microbial Counts of Jameed during Storage

The impacts of milk type and addition of WP paste to Jameed on total viable bacterial counts (TVBC) and the viable counts of lactic acid bacteria, proteolytic bacteria, moulds and yeasts were illustrated in Table 5. Firstly, coliform bacteria were not detected over the storage period in various Jameed treatments. These findings confirm the hygienic conditions of the manufacture. It is quite apparent from the results reported in Table 5 that the numbers of TVBC significantly ($p \leq 0.05$) increased in sheep buttermilk Jameed (treatment A) comparing with goat and cow skim milk Jameed (treatments B and F respectively). Cow skim milk Jameed had the lowest TVBC among various samples. Quite the contrast, the highest loss of viability 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 viability for samples A, B, and F were 85.07, 87.93 and 90.00% respectively. On the other hand, incorporation 10, 15 or 20% WP paste with Jameed increased its TVBC. This effect was clearer in goat skim milk Jameed. As previously mentioned, this may be due to the stimulation influence of WP on microbes. This is in close agreement with the report of Ismail, *et al.* [19] who reported that significantly ($p<0.001$) increase were observed in TVBC, proteolytic and *bifidobacteria* of analogue Feta cheese as a result of addition WP. Lactic acid bacteria counts had the same trend of TVBC. Their numbers in goat skim milk Jameed were at an intermediate position. Goat skim milk Jameed possessed lower levels of viability loss through storage period than cow skim milk Jameed but were higher than Jameed made from sheep buttermilk. Also, lactic acid bacteria numbers increased in Jameed contained WP. These results are in line with those reported by Baig and Prasad [20], they stated that improvement in the growth of probiotic organisms have been reported with incorporation of cottage cheese whey solids in yoghurt mix and using whey based medium. Since cottage cheese whey is believed to be rich in small peptides and free amino acids, incorporation of solids derived from it could have a significant effect on improvement of the viability of probiotic bacteria and starter performance in yoghurt.

Table-5. Effect of mixing whey protein with Jameed past on some microbial groups

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	26.13^{f}
	B	58	25	20	15	14	13	9	7	19.94^{h}
	C	69	41	35	28	24	18	14	9	29.75^{e}
	D	82	55	46	39	31	25	20	15	39.13^{c}
	E	97	73	61	53	42	31	23	17	49.63^{a}
	F	50	18	17	15	10	8	6	5	16.13^{i}
	G	61	32	28	23	16	12	9	7	23.50^{g}
	H	73	47	41	33	24	17	13	10	32.25^{d}
	I	86	60	50	42	33	24	18	13	40.75^{b}
	Means	71.28^{A}	$42{,}89^{B}$	36.33^{C}	30.00^{D}	23.56^{E}	18.11^{F}	13.89^{G}	10.33^{H}	
Lactic acid bacteria ($x\ 10^3$)	**A**	55	28	21	16	13	10	9	8	20.00^{f}
	B	44	20	15	10	9	8	6	3	14.38^{h}
	C	54	31	25	18	15	11	8	6	21.00^{e}
	D	68	44	35	27	23	17	12	9	29.38^{c}
	E	83	57	46	36	31	24	17	12	38.25^{a}
	F	38	16	13	10	9	5	3	0.6	11.83^{i}
	G	47	24	19	15	12	8	6	4	16.88^{g}
	H	58	34	27	21	16	11	10	7	23.00^{d}
	I	71	47	40	32	24	17	14	10	31.88^{b}
	Means	57.56^{A}	33.44^{B}	26.78^{C}	20.56^{D}	16.89^{E}	12.33^{F}	9.44^{G}	6.62^{H}	
Proteolytic bacteria ($x\ 10^3$)	**A**	6	0.9	0.7	0.3	0.10	0.08	0.05	0.05	1.022^{f}
	B	4	0.6	0.4	0.07	0.06	0.04	0.03	0.01	0.65^{f}
	C	10	6	3	1	0.6	0.4	0.3	0.1	2.67^{d}
	D	16	11	7	4	2	1	0.8	0.6	5.30^{b}
	E	22	15	10	6	4	1	0.9	0.7	7.45^{a}
	F	3	0.2	0.09	0.08	0.05	0.04	0.03	0.01	0.43^{f}
	G	7	4	2	1	0.8	0.5	0.3	0.2	1.97^{e}
	H	12	8	5	3	1	0.9	0.7	0.5	3.88^{c}
	I	18	13	9	6	5	3	1	0.8	6.97^{a}
	Means	10.89^{A}	6.52^{B}	4.13^{C}	2.38^{D}	1.51^{E}	0.77^{F}	0.457^{F}	0.33^{F}	
Moulds & Yeast ($x10^3$)	**A**	ND*	ND	ND	ND	0.3	0.4	0.7	0.9	0.28^{cdb}
	B	ND	ND	ND	ND	0.1	0.3	0.6	0.8	0.23^{cd}
	C	ND	ND	ND	ND	0.4	0.5	0.8	1	0.34^{cdb}
	D	ND	ND	ND	ND	0.6	0.5	0.9	2	0.50^{cab}
	E	ND	ND	ND	ND	0.7	0.9	1	3	0.70^{a}
	F	ND	ND	ND	ND	0.09	0.2	0.3	0.5	0.14^{d}
	G	ND	ND	ND	ND	0.3	0.5	0.7	0.9	0.30^{cdb}
	H	ND	ND	ND	ND	0.5	0.7	0.9	1	0.39^{cadb}
	I	ND	ND	ND	ND	0.7	0.9	1	2	0.58^{ab}
	Means	ND	ND	ND	ND	0.41^{C}	0.54^{BC}	0.77^{B}	1.34^{A}	

^{abcde} Letters indicate significant differences between Jameed treatments
^{ABCD} Letters indicate significant differences between storage times
***ND:** not detected

3.4. Changes in Solubility of Jameed During Storage

The results given in Table (6) describe the influence of utilization of various milk types and mixing WP on wettability and syneresis properties of Jameed. Values of wettability for sheep buttermilk Jameed were higher than other treatments. The wettability levels of goat skim milk Jameed were higher than Jameed prepared from cow skim milk. Values of wettability of samples A, B and F after 120 day of storage were 228.79, 218.33 and 217.23% respectively.

Table-6. Effect of mixing whey protein with Jameed past on wettability 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^{ed}
	B	196.48	201.36	210.89	215.78	218.33	219.14	221.97	211.99^{e}
	C	219.52	227.00	235.07	241.88	245.29	248.54	252.23	239.22^{cd}
	D	231.93	240.04	249.33	256.06	260.99	264.81	275.14	254.04^{cb}
	E	246.66	254.07	263.54	270.68	276.34	280.43	285.64	268.19^{ab}
	F	191.85	202.88	210.04	212.87	217.23	218.20	219.09	210.31^{e}
	G	225.33	231.68	240.06	257.69	264.66	269.85	272.54	251.69^{cb}
	H	238.34	247.60	254.10	261.80	267.24	272.83	276.21	259.74^{b}
	I	260.45	265.85	272.04	281.92	285.02	290.47	293.47	278.25^{a}
	Means	224.60^{D}	232.36^{CD}	240.03^{CB}	247.31^{CB}	252.09^{AB}	255.02^{AB}	258.68^{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^{h}
	B	42.74	47.87	50.45	53.14	56.49	57.66	58.49	52.41^{g}
	C	50.64	56.87	58.95	62.54	65.08	68.25	70.45	61.83^{e}
	D	53.82	58.78	61.13	64.47	68.90	70.12	72.56	64.25^{d}
	E	59.03	63.90	66.77	70.09	75.26	78.08	81.01	70.72^{b}
	F	44.31	50.80	52.01	55.13	57.24	57.99	59.24	53.82^{f}
	G	53.56	57.44	61.06	64.09	66.23	69.25	61.38	61.86^{e}
	H	55.70	61.86	65.79	69.08	72.23	73.98	76.47	67.87^{c}
	I	63.07	69.88	75.38	79.40	82.02	82.74	84.64	76.73^{a}
	Means	51.47^{F}	57.25^{E}	59.95^{D}	63.37^{C}	66.46^{B}	68.21^{A}	69.05^{A}	
Syneresis % (after 24h of mixing with water)	A	42.42	50.00	50.11	54.65	57.14	60.12	63.16	54.09^{d}
	B	44.43	51.62	52.30	54.31	57.27	60.14	63.38	54.85^{d}
	C	53.03	61.11	63.84	66.42	69.24	71.58	74.51	65.78^{c}
	D	58.08	64.54	67.11	69.62	72.56	75.62	77.68	69.32^{c}
	E	67.09	73.62	76.07	78.74	80.98	83.41	85.98	77.34^{b}
	F	47.15	53.25	54.23	56.97	59.41	61.20	64.24	56.64^{d}
	G	57.12	63.89	66.74	69.10	72.20	74.86	76.42	68.62^{c}
	H	61.05	70.31	74.54	76.43	80.51	83.64	86.30	76.11^{b}
	I	70.90	79.81	83.14	85.79	88.34	91.73	93.16	84.70^{a}
	Means	55.80^{F}	63.18^{E}	65.34^{ED}	68.00^{CD}	70.35^{CB}	73.59^{AB}	76.09^{A}	

Blinding of WP paste with Jameed paste made from goat and cow skim milk considerably enhanced the wettability values. The highest wettability levels recorded in Jameed samples contained 20% WP paste. This may be attributed to the high water holding capacity (WHC) of WP. These outcomes indicate improvement the most important property of Jameed by adding WP. Consequently, mixing of WP paste with Jameed facilitates and accelerates the reconstitution process. The results were in agreement with the observation of Delikanli and Ozcan [21].

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^{a}	0.309^{a}	1.497^{a}	6.846^{a}	4.573^{a}
B	14.72^{bc}	0.153^{ab}	0.757^{b}	3.266^{b}	6.410^{a}
C	11.84^{dec}	0.139^{ab}	0.790^{b}	3.160^{b}	6.314^{a}
D	9.91^{gef}	0.119^{b}	0.825^{b}	3.025^{b}	6.205^{a}
E	6.78^{g}	0.107^{b}	0.847^{b}	2.882^{ab}	6.084^{a}
F	15.66^{b}	0.172^{ab}	0.628^{b}	4.371^{ab}	6.860^{a}
G	13.42^{dbc}	0.159^{ab}	0.657^{b}	4.275^{ab}	6.772^{a}
H	10.27^{def}	0.146^{ab}	0.689^{b}	4.153^{ab}	6.678^{a}
I	8.32^{gf}	0.136^{ab}	0.710^{b}	4.015^{ab}	6.566^{a}

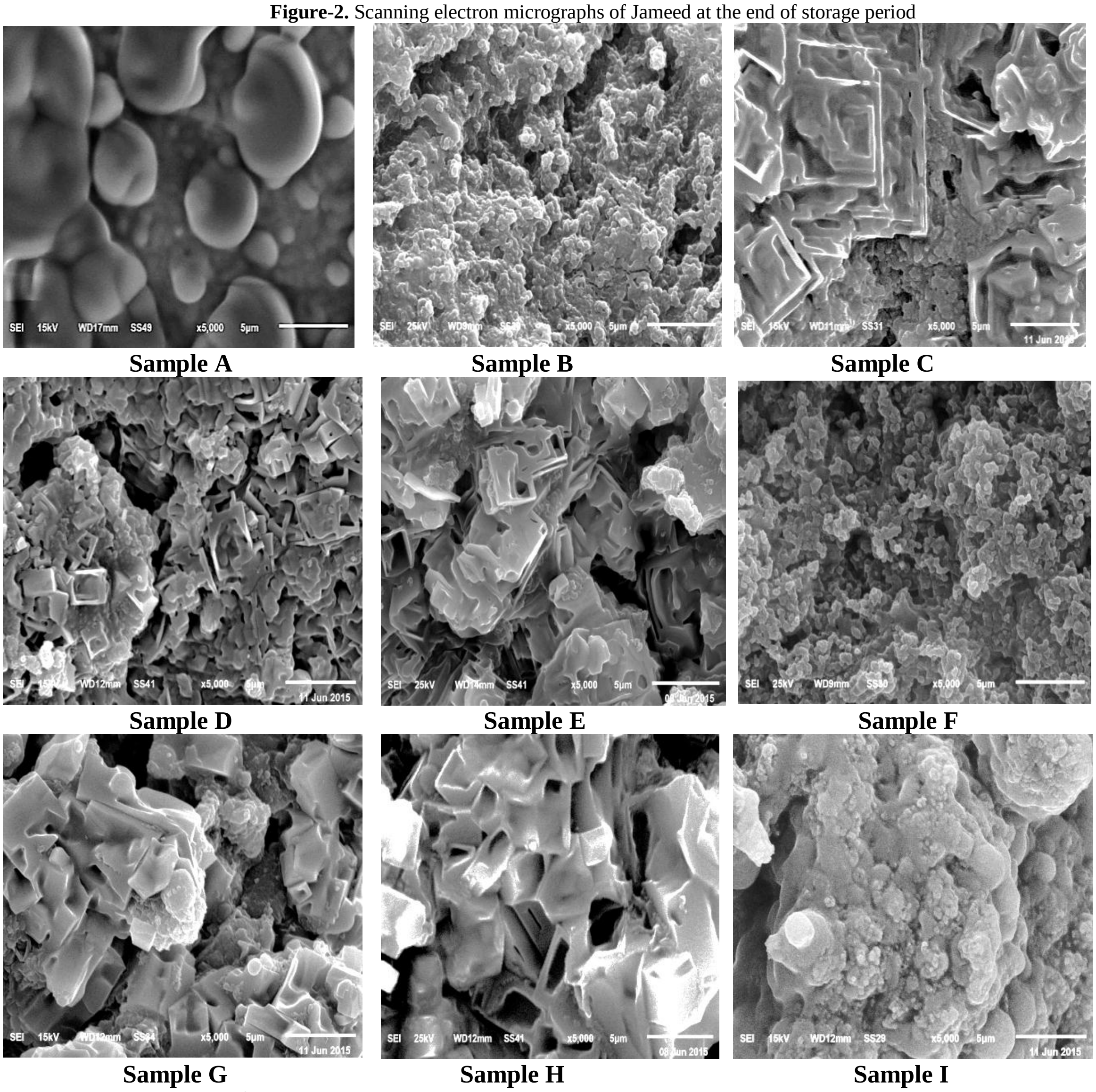
3.5. Changes in Textural Characterizes of Jameed at the End of Storage

Gunasekaran, *et al.* [22] reported that the textural attributes of foods play a major role in consumer appeal, buying decisions, and eventual consumption. For some foods, texture is more important to consumers than flavor and color. Good correlations have been reported, in general, for hardness, chewiness, adhesiveness, and springiness. Rheological texture assessment of cheese can be used to replace or supplement sensory analysis for quality control purposes [23].

3.6. Microstructure of Jameed at the End of Storage Period

Structural characteristics of coagulated dairy products affect both textural and rheological characteristics. The structural arrangement of the network determines the textural characteristics are affected by the factors such as composition and manufacturing processes. The microstructure of these products consists of a continuous protein matrix with a loose and open structure, the space being occupied by the fat globules dispersed through the protein network [24]. The effect of milk type and WP addition on the microstructures of Jameed samples at the end of storage period are shown in Figure 2.

Figure-2. Scanning electron micrographs of Jameed at the end of storage period



Treatment A: Jameed made from sheep buttermilk (control).
Treatment B: Jameed made from goat skim milk.
Treatment C: Jameed made from goat skim milk + 10% whey protein.
Treatment D: Jameed made from goat skim milk + 15% whey protein.
Treatment E: Jameed made from goat skim milk + 20% whey protein.
Treatment F: Jameed made from cow skim milk.
Treatment G: Jameed made from cow skim milk + 10% whey protein.
Treatment H: Jameed made from cow skim milk + 15% whey protein.

4. Discussion

Regarding with different types of milk, acidity value of sheep buttermilk was higher than goat or cow skim milk. On the contrary, TS and SNF% were higher in goat and cow skim milk than that of sheep buttermilk. Fat% 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. Whey protein paste characterized with high acidity and low pH values which may be attributed to increasing whey acidity during Ras cheese manufacture. Because Ras cheese whey was skimmed, fat content of whey protein paste was very low. Conversely, protein concentration was high. Addition of salt through Ras cheese production led to a rise of salt in the resulted whey protein paste. On a general note, outcomes of the chemical composition of whey protein paste cleared in our work located in the ranges reported by Ismail, *et al.* [25].

Jameed made using of WP was relatively more acidic, compared to that made without adding it. Acidity values of samples B, C, D, and E at the end of storage were 4.40, 4.52, 4.78 and 4.90% respectively. These results are confirmed with those reported by Tashakori, *et al.* [26], who found that the control white Feta cheese sample had the lowest acidity, and the sample with 1.5% whey protein concentrate had the highest acidity. As storage period advanced, the acidity of Jameed in all treatments increased gradually ($p<0.05$). The significantly ($p<0.05$) highest values of TS were found in Jameed samples manufactured from sheep buttermilk followed by cow skim milk Jameed and in the last rank came goat skim milk Jameed. TS levels of treatments A, B and F at the sixty day of storage stage were 86.12, 79.10 and 80.26% respectively. Inversely, goat skim milk Jameed had the highest fat concentrations while that made from cow skim milk possessed the lowest. Blinding various WP paste levels with Jameed paste slightly increased TS contents in the resultant Jameed. The increase was proportional with whey protein amounts added. In the opposite trend, Jameed prepared from goat or cow skim milk and containing WP had slightly lower fat contents compared with control. These results are in line with those reported by Punidadas, *et al.* [27]. Ismail [28] stated that addition of WP paste to cow's milk slightly decreased TS and fat contents of Ras cheese. Ismail, *et al.* [25] showed that Mozzarella cheese made from buffalo milk (4% fat) and containing WP had significantly higher ($p<0.001$) TS contents compared with control cheese. Regardless of milk type or WP adding, TS and fat contents of different Jameed samples increased with the advancing of storage period. The highest levels of increases were noted at the end of sun drying period (after 15 days). Jism [29] 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 [30, 31] Mazahreh, *et al.* [32] reported a fat content up to 31.7%, which indicate the low efficiency churning in traditional Jameed processing methods.

Cow skim milk Jameed possessed higher TP and lower ash contents than Jameed made from goat skim milk. The results obtained showed similarities in the salt in moisture contents of goat and cow skim milk Jameed at zero time and during storage period. As expected, adding different amounts of WP paste to Jameed increased TP values and the rate of increasing was proportional with the amount added: this was due to the high protein content of WP (15.45%). Because WP added to Jameed contained 7.11% salt, it was normal that the ash and salt in moisture values significantly increased in Jameed made from goat or cow skim milk and WP admixture. As storage period progressed, TP and salt in moisture contents of Jameed in all treatments increased gradually. The gradual increase in the above contents of the Jameed is due to the progressive loss in the moisture occurring during storage. These results are similar to those obtained by Abbas [33] who found that the salt content increased to be 1.60 and 1.74% salt after 6 weeks storage of cheese made from cow's and buffalo milk respectively.

Generally, during storage period, the WSN and NPN contents of Jameed significantly increased. Furthermore, there was a significant interaction of nitrogen level and age, indicating that the differences in the rates of increase in WSN and NPN were significantly different between Jameed of differing nitrogen percentages. The increasing rats of WSN and NPN were higher in treatments contained WP which had higher nitrogen values than that of other treatments. The increasing contents of WSN and NPN in whey protein treatments may be not related to just high amount of nitrogen but also may be due to the stimulation effect of WP on Jameed microorganisms. In this sense, Leh and Charles [34] showed that peptides having an average molecular weight of about 720 were the most suitable for the growth of lactobacilli. Whey protein hydrolysate (WPH) is a potential nutrient supplement which is readily useable by microbes [35]. Also, Fitzpatrick and O'Keeffe [36] reported that supplementation of whey permeate by WPH had a beneficial effect on lactose utilization and Lactobacillus helveticus growth during fermentation. Supplementation at 3–4% WPH is required to obtain high lactose conversion and lactic acid yield.

The fermentation of the milk with lactic acid bacteria results in delivering a vast number of bioactive peptides and free amino acids (FAA) with different biological activity such as inhibition of the angiotensin converting enzyme [37, 38], immune activity [39] and antioxidative activity [40].

Samples A, B and F contained 4373, 4230 and 4075 mg/100g total free amino acids respectively. This is consistent with previous study by Nateghi Leila [41] who showed that NPN values of reduced fat Cheddar cheese parallel increased with increasing of total and free amino acids.

The sheep buttermilk Jameed, however, is higher in aspartic, glutamic acid, proline, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, histidine, lysine and cysteine but lower in threonine, serine, glycine, alanine and arginine than those of goat skim milk Jameed. The majority of amino acids values were higher in goat milk Jameed than that made from cow skim milk except methionine, tyrosine, phenylalanine and histidine. On the other side, incorporation of Jameed paste with different levels of WP greatly increased the total FAA content. Addition of 20% whey protein to Jameed recorded the highest increase. In all tested Jameed samples, the highest acid content of total FAA was that of glutamic acid, which is responsible for protection from cardiovascular diseases, followed by proline. On the contrary, methionine and cystine acids had the lowest contents of total amino acids.

Like total free amino acids, Jameed made from sheep buttermilk possessed the highest amounts of threonine, valine, methionine, isoleucine, leucine, phenylalanine, histidine and lysine. The contents of these essential amino acids (EAA) were higher in goat skim milk Jameed than those determined in Jameed made from cow skim milk. In contrast, various samples of Jameed contained similar values of EAA to total amino acids (E/T). It should be pointed out that EAA values raised in Jameed contained WP. The highest increasing rates were detected in leucine followed by threonine and valine whereas the lowest was in methionine and histidine. This special character of WP Jameed increased the priority for human nutrition. On the whole, in various Jameed treatments, the major EAA was leucine followed by valine and phenylalanine. Methionine content was the lowest. Similar trend to EAA values, the concentrations of nonessential amino acids (Non-EAA) were higher in sheep buttermilk Jameed sample than those of goat or cow skim milk Jameed samples. The values of Non-EAA also have increased when WP paste mixed with Jameed paste. The highest increasing levels were observed in glutamic acid followed by aspartic and lysine. In general, glutamic acids and proline were the predominant of Non-EAA in different Jameed samples. The three branched-chain amino acids (BCAA) leucine, isoleucine and valine support numerous metabolic processes ranging from the fundamental role as substrates for protein synthesis to metabolic roles as energy substrates [42]. In the present study, Jameed manufactured from sheep buttermilk had higher amounts of total BCAA than that made from goat or cow skim milk.

It is of interest to note that the contents of BCAA for WP Jameed were greater than the values found for the one made without WP addition. The raising rates were more pronounced in leucine content. The raising rates were more pronounced in leucine content. Also, leucine was the abundant acid of total BCAA for all Raybe samples. Studies of both Wit [43] and Ha and Zemel [44] reported similar observation where WP structure is rich in BCAA such as leucine, valine, and isoleucine. Both human clinical studies and animal research have demonstrated the health properties of whey proteins, for instance Chitapanarux, *et al.* [45] cleared the effectiveness of supplementing WP products in the treatment and prevention of liver and metabolic diseases.

Additionally, it could also reduce environmental concerns, lower production cost and improve the functional properties of fermented products. Also, Marafon, *et al.* [46] showed that addition of 0.5% whey protein concentrate (WPC) and other milk ingredients to replace non-fat dry milk resulted in an increase *of Streptococcus thermophilus, Lactobacillus delbrueckii* ssp. *bulgaricus* and *Bifidobacterium animalis* counts after 14 days of storage at 4°C. In the same study, after 28 days of storage at 4°C, counts of *Streptococcus thermophilus* and *Bifidobacterium animalis* were higher in yogurt supplemented with 0.5% WPC than counts in yogurt with added skim milk.

Little numbers of proteolytic bacteria were detected in different Jameed samples. They followed the same orders of TVBC and lactic acid bacteria. Sheep buttermilk Jameed contained the highest counts as compared with that determined in goat and cow skim milk Jameed. Fortification with WP highly increased proteolytic bacteria counts of Jameed. During storage period, the numbers of TVBC, lactic acid bacteria and proteolytic bacteria in all Jameed treatments significantly ($p<0.001$) decreased reaching its minimum at the end of storage period. This decrease could be evidently attributed to the increase in titratable acidity and salt levels which controls the rate of bacterial growth, or acted as bactericidal agent [47]. Concerning moulds and yeasts, they were detected at the ninety day of storage in all Jameed treatments. WP samples had the highest numbers of moulds and yeasts.

Delikanli and Ozcan [21] found that the addition of WP increased the WHC of yoghurts during storage time. The highest values were obtained with the yoghurts enriched with WP concentrates, while the lowest values were recorded with the yoghurts fortified WP isolates. In contrast to wettability values, syneresis levels of sheep buttermilk Jameed were lower than those of Jameed made from goat or cow skim milk. Jameed manufactured from cow skim milk possessed higher syneresis values than those of goat skim milk Jameed. However syneresis values often contradict with wettability results, but effect of adding WP to Jameed exhibited opposite trend. As wettability values of Jameed increased by mixing WP, also syneresis levels increased. We don't have explanation for this phenomenon.

The results of texture parameters obtained from texture profile analysis for Jameed samples at the end of storage period are given in Table 7. The average hardness, cohesiveness, gumminess and chewiness values of sheep buttermilk Jameed samples were higher while springiness values were lower than those of Jameed made from goat or cow skim milk. On the other side, using of cow skim milk in Jameed manufacturing slightly increased the levels of these textural properties except springiness comparing with goat skim milk Jameed. These results indicate that the textural attributes of Jameed affected by the milk type used in production. These findings are in line with those reported by Fox, *et al.* [23] and Gunasekaran, *et al.* [22], they reported that texture is affected during production and ripening of cheese. Network structure of curd is critically affected by composition of milk and technological conditions of coagulation. Therefore, cheese production technology cause varieties in cheese texture. Moreover, there are effects of moisture, pH, salt content, proteolysis which is affected by ripening conditions on cheese texture [48]. Fox, *et al.* [23] explained that salting affects cheese texture due to protein solubility and protein conformation and cause hard cheese. As it is well known, Jameed is a stone hard balls thus for measuring texture parameters, Jameed samples were soaked in distilled water for 6h at room temperature before measurements. Because of high water holding capacity of whey protein, the levels of hardness, cohesiveness, gumminess and chewiness of WP Jameed were the lowest among various treatments. Jameed sample contained 20% whey protein recorded the weakest textural properties values but springiness. In agreement with this finding, Rashidi, *et al.* [49] reported that hardness and gumminess decreased when WPC (20 g kg^{-1}) was added to the low-fat Feat cheese. WPC increased moisture of cheese and disrupted protein matrix so that less force was needed to disrupt the texture of cheese in compression stage. Also, the minimum chewiness was observed when WPC was the only fat replacer used. The WPC decreased chewiness of low-fat cheese, and this finding showed that this level of the WPC was able to loosen the structure of the protein matrix of cheese. Therefore, less energy is needed for chewing of the cheese in the mouth and preparing it for being swallowed.

The micrographs of scanning electron showed that the protein matrix for the sheep buttermilk Jameed (sample A) was thicker than the Jameed made from goat and cow skim milk (samples B and F respectively). On the other side, the protein matrix of goat and cow skim milk Jameed was coarser and more granular as compared with that of sheep buttermilk Jameed. Comparing between the images of samples B and F cleared that the protein matrix of cow skim milk Jameed was relatively denser structure than that of goat skim milk Jameed. In both kinds of Jameed, the small voids contained fat globules scattered in the protein network but they were clearer in goat skim milk Jameed. Pronounced differences were found between scanning electron micrographs of Jameed samples with respect to adding WP. In Jameed treatments manufactured from goat or cow skim milk with addition of 10, 15 and 20% WP (samples C, D, E, G and H), protein matrices had rigid plate's structure, little aggregates and more spaces scattered in matrix. Cow skim milk Jameed contained 20% WP (sample I) showed completely different structure. Protein network exhibited a very compact matrix with very small casein micelles. The matrix was highly interspersed with very small fat globules. Fat globules appeared to be losing their membranes and were uniform in size and shape and evenly distributed throughout the Jameed matrix.

5. Conclusion

Adding 10 and 15% whey protein highly improved the wettability which is the most important property of Jameed. Consequently, mixing of whey protein paste with Jameed facilitates and accelerates the reconstitution process. On the other hand, mixing of 10 and 15% whey protein paste with Jameed curd increased the gains.

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