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# Research Article
# Improvement of some Rheological Characteristics of Jameed by Adding Whey Protein

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## Abstract
**Background and Objective:** Jameed is a dried fermented milk product, usually formed as dried round balls. It is made up of sheep buttermilk. The aim of this research was to study the possibility of mixing different amounts of whey protein paste (by-product in Ras cheese production) with jameed paste and investigate the effect of this technic on the rheological properties of produced jameed. **Materials and Methods:** Nine treatments of jameed were made from sheep buttermilk, goat and cow skim milk with adding 10, 15 and 20% whey protein paste to jameed curd. Jameed samples were stored at room temperature for 180 days and chemically and microbiologically analysed every month. The obtained results were statistically analyzed using a software package based on analysis of variance (One-factor analysis of variance, ANOVA, with SPSS software). **Results:** The obtained results showed that values of wettability for sheep buttermilk jameed were higher than those of jameed made from goat or cow skim milk. Syneresis results had the opposite trend of wettability. Also, sheep buttermilk jameed had higher levels of hardness, cohesiveness, gumminess and chewiness than goat or cow skim milk jameed. Adding whey protein considerably enhanced wettability of jameed but reduced values of hardness, cohesiveness, gumminess and chewiness. The scanning electron micrographs showed that protein matrices of whey protein jameed had rigid plates structure, little aggregates and more spaces scattered in matrix. **Conclusion:** This study revealed that rheological properties of jameed such as wettability, hardness, cohesiveness, gumminess and chewiness were highly improved by mixing 10 or 15% whey protein paste with jameed curd.

Key words: Jameed, whey protein paste, hardness, cohesiveness, microstructure

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Jameed is a dried fermented milk product that is wildly used in Jordan, Syria, Egypt, Northern Saudi Arabia and the western part of Iraq. Jameed plays an important role in the nutritional well-being of Bedouins where it forms a major component of their diets. Jameed is basically a hard cheese-like product considered a very stable and safe dried fermented milk product. It is mainly produced by Bedouins during the spring season when milk is produced in surplus amounts. It is preferably made from sheep and goat milk but it can be made from cow and camel milk. It is prepared from yoghurt (heat-fermented dairy product) and drained using bags of cheesecloth, followed by salting, pressing and drying in the sun to produce the final dairy product[1].

On the other hand, whey is a major by-product of the cheese industry and is further processed by separation or fractionation techniques to remove water, lactose, lipids, minerals, plus enzymes, hormones and growth factors[2]. In addition to their nutritional contributions, some of the whey components also play physiological roles in healthy foods. Whey protein has been related with a lower risk of metabolic disorders and other diseases due to high content of biologically active components. Thus, whey protein is currently one of the most growing sectors in the dairy industry[3]. Whey protein contains a higher content of branched-chain amino acids, primarily leucine compared to other high quality proteins[4]. It has also been known that whey protein can improve the rheological properties of dairy products. Delikanli and Ozcan[3] showed that enrichment of nonfat yoghurt with the whey protein additives led to increases in the hardness, cohesiveness and elasticity values, resulting in improved textural properties. Recently in Egypt, salted whey resulted from Ras cheese making is used for production whey protein paste[5].

Texture, particularly in cheese, is one of the most important property which helps to measure the identity of a product. Fracture attributes of solid and semi-solid foods are important because of their relation to sensory texture[6]. In recent years, much attention has been given to the microstructure of cheese. In particular, the use of scanning electron microscopy has become the method of choice in many investigations. It has proved to be an efficacious method to identify cheese components when fat, protein and moisture are the major constituents. In complex food structures, like dairy products, the sizes and distributions of dispersed and continuous phase regions and also the fine structure within each phase and at interfaces, determine the mechanical (textural and rheological) properties of these systems[7].

The aim of this study was to investigate the textural and microstructure characterizes of jameed made from sheep buttermilk, goat and cow skim milk. Also, the effect of adding different levels of whey protein paste to jameed paste on the solubility, textural and microstructure properties of jameed was evaluated.

## MATERIALS AND METHODS

**Materials:** Fresh sheep, goat and cow milk were obtained from Animal Production Research Institute, Agricultural Research Center, Egypt. A commercial classic yoghurt starter containing *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* (1:1) (Chr. Hansen's Lab A/S Copenhagen, Denmark) was used.

**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 obtained by filtering through cheesecloth overnight. The precipitate was transferred to wooden frames and pressed for 2 h.

**Jameed manufacture:** Nine treatments of jameed were made from sheep buttermilk and from goat and cow skim milk according to the method of Quasem *et al.*[8]. Figure 1 illustrates jameed manufacture. After jameed kneading with 5% salt, jameed paste was re-kneaded with whey protein paste and shaped as a ball then dried in sun. Jameed samples were as follow:

- **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

The dried jameed balls were packaged in polyethylene bags and stored at room temperature for 180 days. Samples

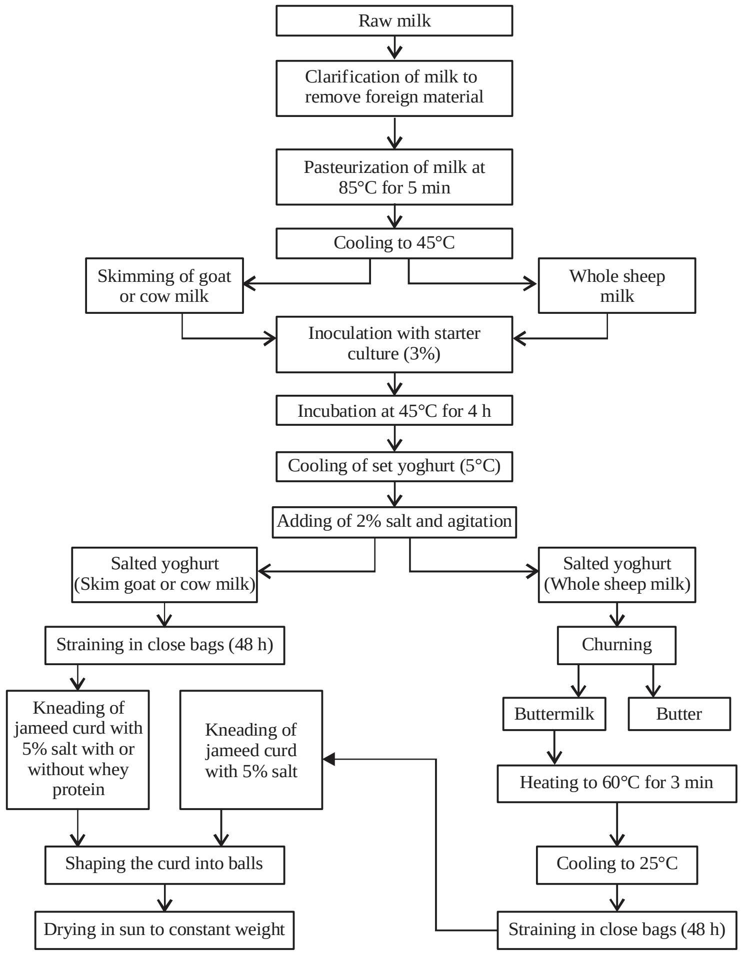


Fig. 1: Processing steps for jameed manufacture

were analyzed when fresh and after 15, 30, 60, 90, 120, 150 and 180 days of storage period.

Preparation of whey protein, jameed manufacture and analyses were carried out in the laboratory of Animal Production Research Institute, Agricultural Research Center, Egypt. The study was conducted within the period of January-June, 2015.

**Chemical analyses:** Total solids, fat, total nitrogen and ash contents of samples were determined according to AOAC[9]. Titratable acidity in terms of percentage of lactic acid was measured by titrating 10 g of sample mixed with 10 mL of boiling distilled water against 0.1 N NaOH using a 0.5% phenolphthalein indicator to an end point of faint pink color. 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). The Volhard's method as described by Richardson[10] was used to determine the salt content of jameed.

**Wettability (Diffusibility) 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[8]. The excess free water was carefully decanting weighed to calculate the soaked amount as follows[8]:

$$\text{Absorbed water (\%)} = \frac{\text{315 mL water-X}}{\text{Weight of cubs (g)}} \times 100 \quad (1)$$

where, X is the weight of excess water (g).

**Syneresis (whey separation) test:** The soaked cube (45 g) was mixed with (315 mL water) for 2 min 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 and 24 h[8]. Syneresis (whey separation) was calculated, as follow:

$$\text{Syneresis (\%)} = \frac{X}{Y} \times 100 \quad (2)$$

where, X is the height of clear zone and Y is total height of jameed dispersion.

**Textural measurements:** Force and torque measurements of jameed treatments stored for six months were measured using a Texturometer model Mecmesin Emperor ™Lite 1.17 (USA). Mechanical primary characteristics of hardness, springiness, gumminess and cohesiveness and also the secondary characteristic of chewiness (hardness×cohesiveness×springiness) were determined from the deformation Emperor ™Lite Graph. Because jameed samples were very hard, they were soaked in distilled water for 6 h at room temperature before measurements.

**Scanning Electron Microscopy (SEM) Examination:** Jameed samples were prepared for SEM according to the method of Brooker and Wells[11]. 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.

**Statistical analysis:** The obtained results were statistically analyzed using a software package[12] based on analysis of variance. One-factor analysis of variance (ANOVA) was carried out with SPSS software (SPSS Inc., Chicago, Illinois, USA) version 17. When F-test was significant, Least Significant Difference (LSD) was calculated according to Duncan[13] for the comparison between means. Significance was set at $p<0.05$. The data presented in the tables are the mean (± Standard Deviation) of 3 experiments.

## RESULTS AND DISCUSSION

**Chemical composition of milk and whey protein used in jameed manufacture:** Results of the chemical composition of milk and whey protein used in jameed making are presented in Table 1. Acidity value of sheep buttermilk was higher than goat or cow skim milk whereas, total solids and solids-not-fat values were higher in goat and cow skim milk than that of sheep buttermilk. Goat skim milk had the highest fat content among milk samples. 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, the fat content of whey protein paste was very low. Conversely, protein content was high. The addition of salt through Ras cheese production caused rising of salt level in whey protein paste. On a general note, the chemical composition results of whey protein paste detected in this study located in the ranges cleared by Ismail *et al.*[5].

**Changes in solubility of jameed during storage:** In foods, protein solubility is affected by the pH, ionic strength, temperature, solvent polarity, isolation method, processing conditions, interactions with other components and mechanical treatments. These factors affect the solubility of the proteins, mainly causing alterations in the hydrophilic and hydrophobic interactions of the surface groups of the protein with the solvent. Milk whey protein concentrates and isolates show good solubility throughout a wide range of pH values, temperatures, protein concentrations, water activities and ionic strengths[14]. The results given in Table 2 describe the influence of utilization of various milk types and mixing whey protein 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.

Blending of whey protein 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% whey protein paste. This may be attributed to the high Water Holding Capacity (WHC) of whey protein. These outcomes indicate improvement the most important property of jameed by adding whey protein. Consequently, mixing of whey protein paste with jameed facilitates and accelerates the reconstitution process. These results are in agreement with the observation of Delikanli and Ozcan[3], who found that the addition of whey protein

Table 1: Chemical composition of milk and whey protein used in jameed manufacture

| Treatments | Acidity (%) | pH values | Total solids (%) | Fat (%) | Total protein (%) | Solids not fat (%) | Salt (%) |
|---|---|---|---|---|---|---|---|
| Sheep buttermilk | $0.99^{a}$ | $5.92^{b}$ | $7.81^{c}$ | $0.7^{a}$ | $5.10^{b}$ | $6.50^{b}$ | - |
| Goat skim milk | $0.16^{c}$ | $6.61^{a}$ | $9.88^{b}$ | $0.9^{a}$ | $3.12^{c}$ | $8.98^{a}$ | - |
| Cow skim milk | $0.18^{c}$ | $6.58^{a}$ | $9.40^{b}$ | $0.3^{b}$ | $3.01^{c}$ | $9.10^{a}$ | - |
| Whey protein | $0.35^{b}$ | $5.04^{c}$ | $27.75^{a}$ | $0.8^{a}$ | $15.45^{a}$ | - | $7.11^{a}$ |

$^{a-e}$Different letters indicate significant differences between milk treatments, Significance was set at $p<0.05$, data are expressed in ±SD

Table 2: Effect of mixing whey protein with jameed on wettability and syneresis

| | | Storage period (days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Properties | Treatments | 15 | 30 | 60 | 90 | 120 | 150 | 180 | Mean |
| **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 1 h 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 | 68.9 | 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 24 h 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 | 61.2 | 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 | $84.70^{a}$ |

$^{a-e}$Different letters indicate significant differences between jameed treatments, $^{A-D}$Different letters indicate significant differences between storage times, Significance was set at p<0.05, data are expressed in ±SD

increased the WHC of yoghurts during storage time. The highest values were obtained with the yoghurts enriched with whey protein concentrates, while the lowest values were recorded with the yoghurts fortified whey protein 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 whey protein to jameed exhibited opposite trend. As wettability values of jameed increased by mixing whey protein, also syneresis levels increased.

**Changes in textural characterizes of jameed at the end of storage:** The force necessary to attain a given deformation with a maximum force bite when the sample is placed between molars is termed as hardness[15]. Cohesiveness is defined as the extent to which a sample can be deformed before it ruptures[16]. Gumminess is defined as the energy needed to disintegrate a semisolid food until it becomes ready for swallowing[15]. Chewiness is defined as the number of masticates required for a certain amount of sample in order to satisfactorily decrease the consistency for swallowing[15]. The results of texture parameters obtained from texture profile analysis for jameed samples at the end of storage period are given in Table 3. 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.*[17] and Gunasekaran and Ak[18], who stated 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

Table 3: Textural properties of jameed at the end of storage period

| Treatments | Hardness (N) | Cohesiveness (B/A area) | Springiness (mm) | Gumminess (N) | Chewiness (N $mm^{-1}$) |
|---|---|---|---|---|---|
| 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 | $8.32^{gf}$ | $0.136^{ab}$ | $0.710^{b}$ | $4.015^{ab}$ | $6.566^{a}$ |

$^{a-e}$Different letters indicate significant differences between jameed treatments, Significance was set at $p<0.05$, data are expressed in ±SD

cause varieties in cheese texture. Moreover, there are effects of moisture, pH, salt content, proteolysis which is affected by ripening conditions on cheese texture. Fox *et al.*[17] 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 6 h at room temperature before measurements. Because of high water holding capacity of whey protein, the levels of hardness, cohesiveness, gumminess and chewiness of whey protein 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.*[19] reported that hardness and gumminess decreased when WPC (20 g $kg^{-1}$) was added to the low-fat Feta cheese. The 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. Mihulova *et al.*[20] showed that the effect of whey protein addition on the texture and rheology of cheese was dependent on protein concentration and modification. Native whey concentration in comparison with water decreased hardness and chewiness and enhanced adhesiveness of samples. Higher concentration increased hardness and chewiness and lowered adhesiveness. Modified whey compared to the native one produced softer and better chewable products.

**Microstructure of jameed at the end of storage period:** In recent years, much attention has been given to the microstructure of cheese. In particular, the use of scanning electron microscopy has become the method of choice in many investigations. It has proved to be an efficacious method to identify cheese components when fat, protein and moisture are the major constituents. In complex food structures, such as dairy products, the sizes and distributions of dispersed and continuous phase regions and also the fine structure within each phase and at interfaces, determine the mechanical (textural and rheological) properties of these systems[7]. The effect of milk type and whey protein addition on the microstructures of jameed samples at the end of storage period are shown in Fig. 2.

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 whey protein. In jameed treatments manufactured from goat or cow skim milk with the addition of 10, 15 and 20% whey protein (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% whey protein (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. Zhang *et al.*[21] reported that microstructure analysis of the nonfat goats' milk yogurt by scanning electron microscopy revealed that

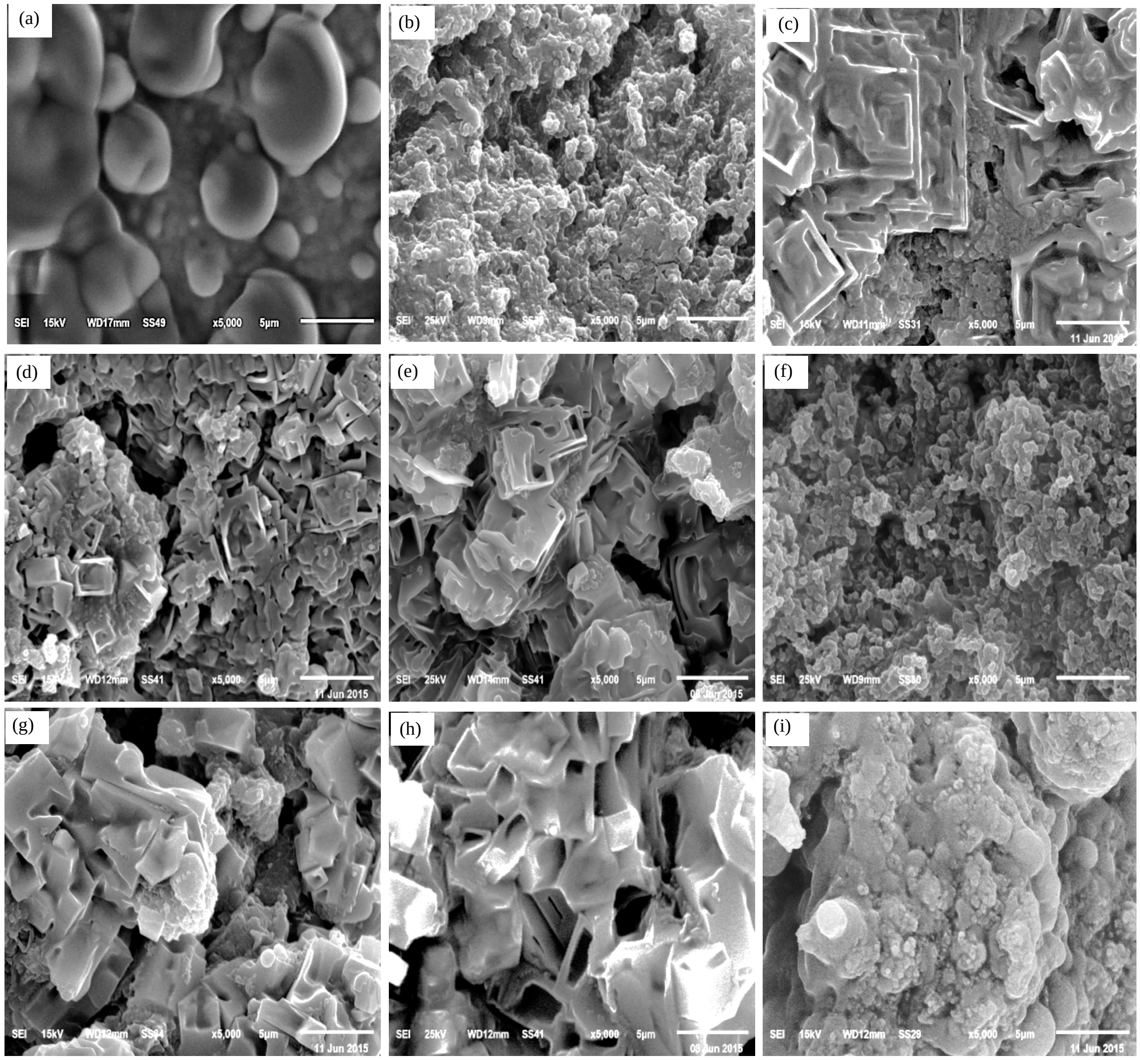


Fig. 2(a-i): Scanning electron micrographs of jameed at the end of storage period (a) Sample A, (b) Sample B, (c) Sample C, (d) Sample D, (e) Sample E, (f) Sample F, (g) Sample G, (h) Sample H and (i) Sample I

Heat-treated Whey Protein Concentrate (HWPC) interacted with casein micelles to form a relatively compact network in the yogurt gel. The results indicated that HWPC could be used as a fat replacer for improving the consistency of nonfat goats' milk yogurt and other similar products.

## CONCLUSION

Jameed is usually made from sheep butter milk. The results of this study proved that jameed can be made with good rheological properties from goat or cow skim milk. 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.

## SIGNIFICANCE STATEMENTS

This study discovers the possible improvement impact of whey protein paste (by-product in Ras cheese manufacture) that can be beneficial for rheological properties of Jameed such as wettability, hardness, cohesiveness, gumminess, chewiness and microstructure. This study will help the researcher to uncover the critical area of Jameed reconstitution process that many researchers were not able to explore. Thus, a new theory on rheological properties and microstructure may be achieved.

## ACKNOWLEDGMENT

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## REFERENCES

1. Al-Omari, A., J.M. Quasem and A.S. Mazahreh, 2008. Microbiological analysis of solar and freeze-dried jameed produced from cow and sheep milk with the addition of carrageenan mix to the jameed paste. Pak. J. Nutr., 7: 726-729.
2. Baldasso, C., T.C. Barros and I.C. Tessaro, 2011. Concentration and purification of whey proteins by ultrafiltration. Desalination, 278: 381-386.
3. Delikanli, B. and T. Ozcan, 2014. Effects of various whey proteins on the physicochemical and textural properties of set type nonfat yoghurt. Int. J. Dairy Technol., 67: 495-503.
4. Tang, J.E. and S.M. Phillip, 2009. Maximizing muscle protein anabolism: The role of protein quality. Curr. Opin. Clin. Nutr. Metab. Care, 12: 66-71.
5. Ismail, M., E.T. Ammar and R. El-Metwally, 2011. Improvement of low fat Mozzarella cheese properties using denatured whey protein. Int. J. Dairy Technol., 64: 207-217.
6. Ak, M.M. and S. Gunasekaran, 1992. Stress-strain curve analysis of Cheddar cheese under uniaxial compression. J. Food Sci., 57: 1078-1081.
7. Lobato-Calleros, C., E. Rodriguez, O. Sandoval-Castilla, E.J. Vernon-Carter and J. Alvarez-Ramirez, 2006. Reduced-fat white fresh cheese-like products obtained from $W_1/O/W_2$ multiple emulsions: Viscoelastic and high-resolution image analyses. Food Res. Int., 39: 678-685.
8. Quasem, J.M., A.S. Mazahreh, I.A. Afaneh and A. Al Omari, 2009. Solubility of solar dried jameed. Pak. J. Nutr., 8: 134-138.
9. AOAC., 2000. Official Methods of Analysis of the Association of Official Analytical Chemists. 17th Edn., Association of Official Analytical Chemists, Washington, DC., USA., Pages: 234.
10. Richardson, G.H., 1985. Standard Methods of the Examination of Dairy Products. 15th Edn., American Public Health Association, Washington, DC., USA.
11. Brooker, B.E. and K. Wells, 1984. Preparation of dairy products for scanning electron microscopy: Etching of epoxy resin-embedded material. J. Dairy Res., 51: 605-613.
12. SAS., 1991. SAS User's Guide Statistics. SAS Institute Inc., Cary, NC.
13. Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.
14. De Carvalho-Silva, L.B., F.Z. Vissotto and J. Amaya-Farfan, 2013. Physico-chemical properties of milk whey protein agglomerates for use in oral nutritional therapy. Food Nutr. Sci., 4: 69-78.
15. Nateghi, L., 2012. Effects of different adjunct starter cultures on proteolysis of reduced fat Cheddar cheese during ripening. Afr. J. Biotechnol., 11: 12491-12499.
16. Chen, A.H., J.W. Larkin, C.J. Clark and W.E. Irwin, 1979. Textural analysis of cheese. J. Dairy Sci., 62: 901-907.
17. Fox, P.F., T.P. Guinee, T.M. Cogan and P.L.H. McSweeney, 2000. Fundamentals of Cheese Science. 1st Edn., Chapter 10. Aspen Publishers Inc., Gaithersburg, MD, USA.
18. Gunasekaran, S. and M.M. Ak, 2003. Cheese Rheology and Texture. 1st Edn., CRC Press, Boca Raton, FL., ISBN-13: 978-1587160219, Pages: 512.
19. Rashidi, H., M. Mazaheri-Tehrani, M.A. Razavi and M. Ghods-Rohany, 2015. Improving textural and sensory characteristics of low-fat UF Feta cheese made with fat replacers. J. Agric. Sci. Technol., 17: 121-132.
20. Mihulova, M., M. Vejlupkova, J. Hanusova, J. Stetina and Z. Panovska, 2013. Effect of modified whey proteins on texture and sensory quality of processed cheese. Czech J. Food Sci., 31: 553-558.
21. Zhang, T., J. McCarthy, G. Wang, Y. Liu and M. Guo, 2015. Physiochemical properties, microstructure and probiotic survivability of nonfat goat's milk yogurt using heat-treated whey protein concentrate as fat replacer. J. Food Sci., 80: M788-M794.