Improvement of the quality of buffalo’s milk soft cheese by camel’s whey protein concentrate

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ABSTRACT

Objective: The objective of this study was to investigate the impact of whey protein concentrate (WPC) derived from camel’s milk on cheese yield, some chemical, microbial, and organoleptic properties of low salt soft cheese during refrigerated storage.

Materials and Methods: Cheeses made from buffalo’s milk without and with adding 4,000 and 8,000 µg/ml WPC.

Results: Addition of WPC significantly increased the yield, titratable acidity, and decreased pH of the resultant cheese samples. Cheese treated with 8,000 µg/ml WPC had the highest effect on the reduction of the total bacterial count, coliform, molds, and yeast up to 29th day of storage in comparison to the 25th day and 17th day in cheese with 4,000 µg/ml and control samples, respectively. The organoleptic evaluation indicated that adding of WPC improved flavor, body, and texture and appearance of the cheese.

Conclusion: The present study demonstrated that the application of camel’s WPC at 8,000 µg/ml in cheese can improve organoleptic and microbiological properties of low salt soft cheese and prolong its shelf-life at refrigerated storage up to 29 days in comparison to 25 days and 17 days in cheese treated with 4,000 µg/ml WPC and control cheeses, respectively. So, the present WPC has a potential for preservation as a food ingredient and natural food preservative.

Introduction

Nowadays the consumer is usually looking for healthier food with natural additives, so he started avoiding the application of synthetic preservatives [1]. Application of natural preservatives of plants, animals, or microbial origin is commonly used for the production of safe and high-quality food that fulfill consumer demands. Lysozyme (egg white, and figs), saponins and flavonoids (herbs and spices), bacteriocins, chitosan (shrimp shells) and lactoferrin, casein, and whey (milk) are considered the best example for natural antimicrobial agents [2].

Milk is one of the most important nutrients which is characterized by not only high nutritive value but also having many of antimicrobial proteins. Camel’s milk is an important food as it has a functional and healthy benefit due to the presence of active biological substances. However, the majority of people consume cow’s milk regularly than camel’s milk due to the fact that cows and buffaloes give much more milk and require less maintenance and labor. Unfortunately, people are not aware about the nutritive value and therapeutic effects of camel’s milk. Camel’s milk is regarded to be the most important and major source of proteins, especially for people who accommodate in the desert area of the world. These proteins present mainly in whey of camel’s milk with high concentration and are rich in antimicrobial ingredients including lysozyme, lactoferrin, lactoperoxidase, and peptidoglycan recognition protein [3]. In addition, immunoglobulin IgA and IgG have powerful antimicrobial efficacy against some bacterial and viral pathogens. Consumption of milk of camel’s origin has a positive effect on reducing diseases that are caused by nutritional deficiencies in the adult [4].

KEYWORDS

Camel’s milk; whey protein; soft cheese

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Whey protein (WP) concentrate (WPC) is preferred to use in cheese manufacturing as it increases its yield and improves its organoleptic characters. Furthermore; it contains some antimicrobial proteins that improve the quality of the final product. Camel’s milk has a higher WP concentration than milk from other animal species, especially the content of albumin and lactoferrin [5].

Cheese is mainly characterized by highly nutritive value. It is considered the best source for protein and some minerals, especially calcium and phosphorus which are mainly required for human health and nutrition. At the same time, it is mainly susceptible to physical, chemical, and biochemical spoilage due to its high nutritive value. Therefore, the preservation of such product is very essential. In addition, soft cheese considered a vehicle for food spoilage organisms which cause bad effects on flavors, color, and body and texture [6,7]. To overcome the fast spoilage of cheese and prolong the shelf-life, natural antimicrobial preservatives are now applied in the dairy industry [8].

Considering these aspects, the current work was aimed to evaluate the effect of WPC separated from the milk of camel’s origin on soft cheese quality through assessing the organoleptic, acidity indices, and microbiological status of soft cheese during refrigerating storage.

Materials and Methods

Preparation of WPC

Camel’s milk was obtained from Halayeb and Shalteen at the New Valley Governorate. Milk had been centrifuged at 5,000 × g/30 min at 10°C for removing fat content. WP was obtained by adding 10% (v/v) acetic acid to skimmed milk till the pH was closed at 4.6 and then incubated at 37°C for 10 min. It was neutralized using 1M sodium acetate and then centrifuged at 10,000 × g/5 min at 4°C. The casein pellet was rested at the bottom of the centrifugation tube, while the whey (supernatant) floats at the top. The resultant whey, which contained the undenatured WPs, was saturated with 80% ammonium sulfate to precipitate the WPs [9]. WPs are then lyophilized (freeze dried) using a laboratory-scale freeze dryer at ~75°C for almost 6–24 h (WPC).

Cheese manufacturing

Low salt soft cheese (3%) was made according to the method of El-Sheikh et al. [10]. The manufactured cheese was divided into three groups; the first was regarded as control (C), the second was inoculated by 4,000 µg/ml camel’s WPC (T1), and the third was inoculated by 8,000 µg/ml camel’s WPC (T2). The three groups were kept at 42°C till proper curd was obtained, then the curd was kept draining for 18 h in some previously sterilized stainless-steel frames lined with cheese cloth.

The obtained cheese with their respective whey was packaged in pre-sterilized aluminum cups and tightly covered with aluminum foil paper then kept at the refrigerator. Cheeses were sampled fresh (zero time) and at 7th, 14th day then every 4 days till the spoilage signs were visible. The experiment was repeated in triplicates and an average result for each group was tabulated.

Cheese analyses

Yield: The cheese yield was calculated as per the formula described by Hanafy et al. [11].

Chemical examination

Cheese samples were examined for pH value and titratable acidity (TA). The titrimetric method was used for the determination of TA according to AOAC [12]. Briefly, in 250 ml conical flask, 100 ml of distilled water and 1 ml of 1% alcoholic solution of phenolphthalein were mixed with 5 gm of cheese sample. The sample was then titrated with 0.1N sodium hydroxide until the faint pink appeared and persisted for 30 sec. The amount of alkali used was recorded and TA% was calculated. In addition, pH meter (Jenway 3051 pH meter) was used for the determination of the pH values of cheese samples. It was calibrated by standard buffer solutions pH 4.00 and pH 7.00 at 25°C before each measure.

Microbiological examination

Cheese samples (10 gm) were homogenized with sodium citrate (2%) and then added to 90 ml of 0.1% buffered peptone water (Biolife Italiana, Italy). Ten-fold serial dilutions were prepared and plated on plate count agar and violet red bile lactose (Oxoid, UK) and aerobically incubated at 37°C for 24–48 h for total mesophilic bacterial count and coliform, respectively, as described by British standards Institution [13]. Dextrose tryptone agar medium (HiMedia, India) was used for the enumeration of aerobic spore-formers. The samples were incubated at 37°C for 24–48 h; whereas yeasts and molds were determined on Sabaroud dextrose agar (Lab M), after the addition of 0.1 g/l chloramphenicol, incubated aerobically at 25°C for 5–7 days [14]. The specific colonies were counted, and data were demonstrated as Log10 cfu/gm.

Organoleptic examination

Nine panelists have applied the sensory evaluation of examined cheese samples for an overall score of 100 points through 45 points for flavor, 35 points for body and texture, and 20 points for appearance International Dairy Federation [15].

Statistical analysis

One-way analysis of variance was used for statistically comparing among the groups. The results were considered
significantly different with $p < 0.05$ [16]. The experiment was repeated in triplicates and average results for each group was tabulated.

**Results and Discussion**

The current experiment was applied to evaluate the effect of WPC derived from camel’s milk on soft cheese quality at different concentrations. The current results showed that WPC could improve keeping quality of white soft cheese at concentrations more than 4,000 µg/ml.

**Effect of camel’s WPC on cheese yield**

It is clear from Figure 1 that the addition of camel’s WPC to milk intended for cheese making significantly increased the yield of cheese. The higher of the added WPC was, the significantly higher the cheese yield. The increasing rates % of cheese yield were 19%, 25%, and 29% in control and groups of 4,000 and 8,000 µg/ml camel’s WPC, respectively. These results were agreed with those reported by El-Sheikh et al. [10], Hanafy et al. [11], and Othman [17]. Similar trend was also given by Sakr and Mehanna [18] and Ismail [19] via using WPC in the manufacture of Cheddar and Ras cheese.

The improvement of cheese yield may be related to the addition of WPC and/or denatured WPs that resulted from severe heat-treatment milk. Such treatments lead to the integration of WPs into cheese and/or higher retention of serum in cheese matrix, resulted in a pronounced increase in cheese yield [20]. Henriques et al. [21] stated that the concentration of milk proteins not only WPs but also caseins have a great effect on improvement in the cheese yield.

Generally, cheese yield is increased by a high content of milk fat and protein, integration of WPs, lactose, ash, and moisture [22].

**Acidity profile of examined soft cheese**

Measuring milk acidity is mainly reflecting milk quality physically, chemically, and microbiologically for the manufacture of different dairy products [23]. Acidity characteristics of fresh white soft cheese samples during the storage period were shown in Table 1. Acidity increased continuously until the end of the refrigerated storage period in tested groups ($p \leq 0.05$). However, the control cheese samples had a higher pH value and lower TA% than the cheese samples containing WPC ($p \leq 0.05$). The pH values for control samples (C) were 6.45 ± 0.02, 6.28 ± 0.02, 6.05 ± 0.01 at zero-day, 7th, and 14th day of storage, respectively. However, they decreased gradually along the storage period and reached to 5.86 ± 0.02 at the 17th day of storage (Table 1). While pH value in treated samples with WPC (T1) 4,000 µg/ml was 6.30 ± 0.03 at zero-day and reached to 5.54 ± 0.02 at the end of refrigerated storage (21st days). The addition of WPC (T2) 8,000 µg/ml had significantly lower pH values than control which reached to 5.47 ± 0.02 at 29th days of refrigerated storage. These results were agreed with Othman [17]. Tashakori et al. [24] observed that there was a higher acidity % in Feta cheese containing WPC in comparison to control. Yazici and Akgun [25] found that strained yogurt with WPC had lower pH values than control. Similar trend was also observed by Ismail [19] in Ras Cheese treated with WPC. These results may be due to the higher concentration of protein and other buffering constituents in supplemented samples than control and/or the increase in available nutrients from WPs may promote the activity and growth of yogurt bacteria [26]. However, generally, such a pH decrease in all groups may be due to the higher growth of lactic acid bacteria that ferments lactose to lactic acid, thus leading to acid production [27].

Addition of WPC in (T2) had a slight increase ($p < 0.05$) in TA%. It increased from 0.28 ± 0.02, at zero time to 0.46 ± 0.02 at the end of refrigerated storage (Table 1). Protein content has a great reflection on acidity % of milk, where a high TA% suggested a high concentration of proteins and/or buffering constituents in treated samples than control and/or the increase in available nutrients from WPs [11,28].

**Microbiological changes of cheese during storage period**

Soft white cheese is widely consumed by the Egyptian population, but it is one of limited shelf-life dairy products because of its high water activity and low salt level [29], and consequently higher microbial spoilage may occur during cheese making, storage, and handling [30].

Table 2 showed the total bacterial count (TBC) in cheese in the presence of WPC. The TBC in control samples increased gradually from zero-day of production and reached to $3.28 \pm 0.2$ Log$_{10}$cfu/gm and reached its...
maximum level at the end of refrigerated storage to be 4.78 ± 0.20 Log_{10} cfu/gm. However, the TBC in T1 and T2 were lower than control samples from 7th day with a mean count of 3.43 ± 0.02 and 3.35 ± 0.01 Log_{10} cfu/gm, respectively, till the end of storage. In addition, they reached to 2.15 ± 0.25 Log_{10} cfu/gm for T1 at 25th day of storage until reached its maximum level 1.98 ± 0.02 and 2.58 ± 0.01 Log_{10} cfu/gm for mold and yeast, respectively, at the end of refrigerated storage. These

The extended shelf-life of low salt soft cheese with 8,000 µg/ml camel’s WPC up to the 29th day of refrigerated storage with restricted and relatively low coliforms may result from the suppressive effect of antimicrobial components that present in milk WP milk [31]. In the same context, camel’s whey contains higher protein % than that of cow’s whey. These results reflected the concentration of protein in the final undenatured WP. It ranged from 34.4% in cow’s milk to 55% in camel’s milk [32].

Yeast and mold play an important role in the spoilage of dairy products primarily in fermented milk and cheese [33]. At the first week of manufacture, yeast and mold growth was not detected in control and treated samples in all as shown in Tables 4 & 5. However, their counts increased gradually in control samples from 7th day of storage until reached its maximum level 1.98 ± 0.02 and 2.58 ± 0.01 Log_{10} cfu/gm for mold and yeast, respectively, at the end of refrigerated storage. These

### Table 1. Influence of camel’s WPC of camel milk on pH and titratable acidity of soft cheese.

| Storage time | pH          | TA%          |
|--------------|-------------|--------------|
|              | C           | T1           | T2           |
|              | C           | T1           | T2           |
|              | C           | T1           | T2           |
|              | C           | T1           | T2           |
|              | C           | T1           | T2           |

C = Control, T1 = Cheese with 4,000 µg/ml WPC, T2 = Cheese with 8,000 µg/ml WPC, S = spoiled sample. *The value given was the mean ± standard error (SE).

### Table 2. TBCs (Log_{10} cfu/gm) in the examined cheese samples during their refrigerated storage.

| Storage (days) | Total Bacterial Counts (Log_{10} cfu/gm) (Mean ± SE*) |
|----------------|------------------------------------------------------|
| Zero time      | 3.28 ± 0.24C  | 3.18 ± 0.07A | 3.18 ± 0.05AB |
| 7              | 3.65 ± 0.17C  | 3.43 ± 0.02A | 3.35 ± 0.01A  |
| 14             | 4.53 ± 0.20C  | 2.89 ± 0.01A | 2.74 ± 0.07A  |
| 17             | 4.78 ± 0.20C  | 2.45 ± 0.04A | 2.34 ± 0.18C  |
| 21             | S            | 2.28 ± 0.25A | 2.16 ± 0.15AB |
| 25             | S            | 2.15 ± 0.25A | 2.08 ± 0.11A  |
| 29             | S            | S            | 2.00 ± 0.03A  |
| 33             | S            | S            | S             |

C = Control, T1 = Cheese with 4,000 µg/ml WPC, T2 = Cheese with 8,000 µg/ml WPC, S = spoiled sample. *SE = Standard error.

### Table 3. Influence of camel’s WPC on coliform counts in the examined cheese samples during their refrigerated storage.

| Storage (days) | Total coliform counts (Log_{10} cfu/gm) (Mean ± SE*) |
|----------------|------------------------------------------------------|
| Zero time      | <1                                                   |
| 7              | 1.65 ± 0.05C                                         |
| 14             | 2.53 ± 0.03C                                         |
| 17             | 3.28 ± 0.03C                                         |
| 21             | S                                                     | 1.89 ± 0.04AB |
| 25             | S                                                     | 2.18 ± 0.05A  |
| 29             | S                                                     | 2.25 ± 0.05A  |
| 33             | S                                                     | S             | 2.48 ± 0.02A  |

C = Control, T1 = Cheese with 4,000 µg/ml WPC, T2 = Cheese with 8,000 µg/ml WPC, S = spoiled sample. *SE = Standard error.

Additional note: Table 4 & 5 references are not provided in the document. Elbarbary and Saad / J. Adv. Vet. Anim. Res., 6(4): 528–535, December 2019
results exceed the permissible limit (<10 Log_{10} cfu/gm for mold and <40 Log_{10} cfu/gm for yeast) suggested by the Egyptian Organization for Standardization and Quality [34]. However, in T1 and T2 (treated groups), the mold and yeast count decreased gradually and reached to 1.95 ± 0.05 and 1.78 ± 0.02 Log_{10} cfu/gm for mold and 2.15 ± 0.05 and 2.39 ± 0.01 Log_{10} cfu/gm for yeast at 25th and 29th day of refrigerated storage, respectively. The current results may be related to many antimicrobial substances in WPC. There are high significant differences (p < 0.01) between the effect of WPC on the count of mold as well as on yeast count. These results were agreed with results demonstrated by Naidu [35] and Samaranayake et al. [36] who reported that lactoferrin which one of antimicrobial substance in WPC of camel milk had antifungal effect.

Generally, camel’s WP contains a large number of antimicrobial agents, such as lysozyme, α-lactalbumin, serum albumin, lactophorin, immunoglobulin, and lactoferrin more than those in cow’s and goat’s milk in reverse to β-lactoglobulin. In the same context, goat’s WP contains double amount of lysozyme than that of cow’s WP [37]. Camel’s WPs showed the superiority among other used WPs and this may be attributed to their constituent from lactoferrin. Lactoferrin of camel milk’s has more potent antibacterial efficacy against wide varieties of bacteria than lactoferrin from milk of other animal species. Beaulieu et al. [38] which in turn it could preserve cheese for long period.

On the other hand, aerobic spore formers were not detected in all examined cheese samples at all stages of shelf life. This may be due to using good quality milk and good hygienic measures during the processing of cheese and storage. This result agreed with Awad [39] and Gamiel [40].

**Table 4. Effect of camel’s WPC on mold count in examined cheese samples.**

| Storage (days) | Total mold counts (Log_{10} cfu/gm) (Mean ± SE*) |
|---------------|---------------------------------|
|               | C | T1 | T2 |
| Zero time     | <1 | <1 | <1 |
| 7             | <1 | <1 | <1 |
| 14            | 1 ± 0.01* | <1 | <1 |
| 17            | 1.98 ± 0.02  | 1.24 ± 0.02  | <1 |
| 21            | S  | 1.60 ± 0.05  | <1 |
| 25            | S  | 1.95 ± 0.05  | 1.30 ± 0.05  |
| 29            | S  | S  | 1.78 ± 0.02  |
| 33            | S  | S  | S  |

C = Control, T1 = Cheese with 4,000 µg/ml WPC, T2 = Cheese with 8,000 µg/ml WPC, *SE = Standard error.

**Table 5. Effect of camel’s WPC on yeast count in examined cheese samples.**

| Storage (days) | Yeast count (Log_{10} cfu/gm) (Mean ± SE*) |
|---------------|---------------------------------|
|               | C | T1 | T2 |
| Zero time     | <1 | <1 | <1 |
| 7             | <1 | <1 | <1 |
| 14            | 2.45 ± 0.01  | 1.15 ± 0.01  | <1 |
| 17            | 2.58 ± 0.01  | 1.49 ± 0.04  | 1 ± 0.0  |
| 21            | S  | 1.78 ± 0.05  | 1.45 ± 0.0  |
| 25            | S  | 2.15 ± 0.05  | 1.95 ± 0.02  |
| 29            | S  | S  | 2.39 ± 0.01  |
| 33            | S  | S  | S  |

C = Control, T1 = Cheese with 4,000 µg/ml WPC, T2 = Cheese with 8,000 µg/ml WPC, *SE = Standard error.

**Effect of camel’s WPC on organoleptic characters of soft cheese**

The organoleptic evaluation is an important method for the determination of the quality of dairy products and consumer acceptance [41]. In this study, the addition of camel’s WPC improved the flavor of the cheese samples. The flavor score of cheese samples prepared with 8,000 µg/ml scores was higher than those of 4,000 µg/ml and control cheese samples storage period (Fig. 2A). These results were similar to those reported by Hanafy et al. [11] who demonstrated that the flavor score after the addition of WPC was better than the control samples in soft cheese. El sheikh et al. [10] concluded that WPC is a good fat replacer in skimmed milk cheese which positively improves mouth feel of cheese. Sakr and Mehanna [18] found that adding WPC significantly improved the flavor of low-fat Ras cheese.

Body and texture are an important sensory attribute of dairy products like cheese. In this study, groups with camel’s WPC have a better score than those without WPC (Fig. 2B). This improvement increased with an increase in the concentration of WPC. This agreed with Hanafy et al. [11], who reported that cheese containing 6% WPC showed low hardness and gumminess than cheese treated with 2% WPC and control samples. Lobatto-Calleros et al. [42] found that WPC caused significant modification on the body and texture of partial and full skimmed soft cheese. In other study, replacing fat with WPC increased the hardness, cohesiveness, gumminess, and chewiness values of soft cheese [43]. In the same context, Tashakori et al. [24] found that cheese prepared by the addition of 20% WPC improved the body, texture, and consistency of spread cheese. However, Henriques et al. [21] stated that body and texture were similar in control and treated cheese with WP. These differences...
may be due to the type and characters of the adding WPC and its concentration as well as the procedures of cheese making and chemical composition of resultant cheese.

Evaluation of the appearance of control and camel’s WPC-treated cheese was shown in Figure 2C. It is clear that the integration of WPC with cheese milk markedly improved the appearance of cheese samples comparing to control. However, the highest \( p < 0.05 \) score was recorded in the cheese sample treated with 8,000 µg/ml WPC till the 29th day of refrigerating storage.

This result indicated that cheese prepared with 8,000 µg/ml camel’s WPC was superior in organoleptic properties to that prepared with 4,000 µg/ml camel’s WPC and control cheese samples when fresh as well as, this superiority continued till 29th day of refrigerated storage. Such variation was significant at \( p < 0.05 \) (Figure, 2). WP concentration has a direct proportion with the organoleptic characters of cheese [21]. In addition, WP acts as a fat replacer so that the quality of low-fat content cheese is improved [44].

Figure 2. Organoleptic properties of different cheese groups during their refrigerating storage. (A) Flavor score, (B) body and texture score and (C) appearance score. C: Control, T1 = Cheese with 4,000, T2 = Cheese with 8,000 µg/ml WPC.
Camel’s milk is hardly coagulated so the production of cheese from it was not an easy process; therefore, researchers used a mixture of camel’s and bovine milk. The bovine milk is commonly used for cheese production as it has good coagulation [45]. However; in the current study, the WPC derived from camel’s milk displayed significantly antimicrobial activities. It reduced the populations of coliform, TBC, yeast, and molds during refrigerated storage of cheese. Moreover, it preserved soft cheese for 29 days in comparison to 17 days in the control cheese group. In addition, it also improved the organoleptic properties of cheese. These activities increased by increasing the WPC concentration.

Conclusion

WPC extracted from camel’s milk could be applied as a natural antimicrobial agent that elongated the life of soft cheese, especially at the concentration of 8,000 µg/ml. Moreover; WPC would be used as a replacer for synthetic substances to meet consumer’s needs.

Conflict of interests

There are no potential conflicts of interest among the authors with respect to the research, authorship, and/or publication of this article.

Authors’ contribution

Hend Ahmed Elbarbary and Marwa Awad Saad designed the concept for this research and scientific paper. Marwa Awad Saad was provided camel’s milk and chemical substances. All authors participated in all examinations of groups. They also participated in manuscript’s draft and revision. All authors have read and approved the final manuscript.

References

[1] Zantar S, Yedri F, Mrabet R, Laglouai A, Bakkali M, Zerrouk MH. Effect of Thymus vulgaris and Origanum compactum essential oils on the shelf-life of fresh goat cheese. J Ess Oil Res 2014; 26(2):76–84; https://doi.org/10.1080/10412905.2013.871673
[2] Nazir F, Salim R, Yousf N, BashirM, Naik HR, Hussain SZ. Natural antimicrobials for food preservation. J Pharmacogn Phytochem 2017; 6(6):2078–82.
[3] Sharman C, Singh C. Therapeutic value of camel milk—a review. Adv J Pharm Life Sci Res 2014; 2:7–13.
[4] Singh R, Mal G, Kumar D, Patil NV, Pathak KML. Camel milk: an important natural adjuvant. Agric Res 2017; 6(4):327–40; https://doi.org/10.1007/s40030-017-0284-4
[5] Słowiński B, Mielo S, Gustaw W, Udeh KO. Effect of whey protein concentrates on texture, meltability and microstructure of acid casein processed cheese analogues. Milchwissenschaft 2010; 65:169–73.
[6] Ledenbach L, Marshall T. Microbiological spoilage of dairy products. In: Sperber WH, Doyle MP (Eds). Compendium of microbiological spoilage of foods and beverages. Food Microbiology and Food Safety (1st edition). Springer, New York, NY, pp 41–67, 2009; https://doi.org/10.1007/978-1-4419-0826-1_2
[7] Brooks JC, Martínez B, Stratton J, Bianchini A, Krockstrom R, Hultins R. Survey of raw milk cheeses for microbiological quality and prevalence of food borne pathogens. Food Microbiol 2012; 31:154–8; https://doi.org/10.1016/j.fm.2012.03.013
[8] Da Silva AS, Honjoya ER, Cardoso SC, De Souza CH, Costa MD, De Santana EHW, et al. Antimicrobial action of lactoferrin on Staphylococcus aureus inoculated in Minas frescal cheese. Arch Latinoam Nutr 2012; 62(1):68–72.
[9] Mariam M, Marwa HE, Aida SS, Waq ZAM. The effect of camel milk whey proteins on lactic acid bacteria isolated from camel and cow milks in Egypt A comparative study. Int J Adv Res 2018; 6(2):986–98; https://doi.org/10.21474/IJAR01/6519
[10] El Sheikh M, Farrag A, Shahein N, El-Shibliy S. Low fat Domati cheese with particulated whey protein concentrate (WPWC). Egypt J Dairy Sci 2001; 29:331.
[11] Hanafy NM, Ghanimah MA, Hassanein AM, Hashim MA. The effect of using whey protein concentrate on the quality of nonfat fresh cheese. J Biol Chem Environ Sci 2016; 11:545–69.
[12] AOAC. Association of official analytical chemist official method of analysis of AOAC international. 17th edition, Gaithersburg, MD, 2003.
[13] British standards Institution (BSI). Microbiological examination of dairy purposes. BS4285: Section 2010, 1984.
[14] American Public Health Association (APHA). Compendium of methods for the microbiological examination of foods. 3rd edition, American Public Health Association, Washington, DC, 1992.
[15] International Dairy Federation (IDF). Sensory evaluation of dairy products reference methods, IDF: 98B, 1995.
[16] Clark S, Costello M, Drake M. The sensory evaluation of dairy products. 2nd edition, Springer, New York, NY, 2009; https://doi.org/10.1007/978-0-387-77408-4
[17] Othman M. Improvement low fat soft white picked-cheese using some exopolysaccharide-producing cultures and whey protein concentrate. MSc Thesis, Faculty of Agriculture, Alexandria University, Alexandria, Egypt, 2008.
[18] Sakr H, Mehanna N. Quality of low fat Ras cheese made from milk fortified with whey protein concentrate. Egypt J Dairy Sci 2011; 39:253.
[19] Ismail M. Effect of adding denatured whey proteins to cheese milk or cheese curd on some properties of Ras cheese. Egypt J Dairy Sci 2012; 40:59.
[20] Lucey J, Kelly J. Cheese yield. Int J Dairy Technol 1994; 47:1–14; https://doi.org/10.1111/j.1471-0307.1994.tb01264.x
[21] Henriques M, Gomes D, Pereira C, Gill M. Effects of liquid whey protein concentrate on functional and sensorial properties of set yoghurs and fresh cheese. Food Bioproc Technol 2012; 6(1):952–63; https://doi.org/10.1007/s11947-012-0778-9
[22] Hinrichs J. Incorporation of whey proteins in cheese. Int Dairy J 2001; 11(4–7):495–503.
[23] Batool S, Rauf N, Tahir S, Razia K. Microbiological and physicochemical contamination in the wheat flour of the twin cities of Pakistan. Int J Food Safety 2012; 14:75–82.
[24] Tashakori A, Ali S, Arakani Y, Daneshi M. Effect of whey protein concentrate and cornstarch on chemical, rheological and sensorial properties of white feta cheese. Am J Food Sci Technol 2013; 1(3):25–9.
[25] Yazici F, Akgun A. Effect of some protein based fat replacers on physical, chemical, textural, and sensory properties of strained yoghurt. J Food Eng 2004; 62:245; https://doi.org/10.1016/S0260-8774(03)00237-1
[26] Akalin AS, Gonc S, Unal G, Fenderya S. Effects of fructooligosaccharide and whey protein concentrate on the viability of starter culture...
in reduced-fat probiotic yoghurt during storage. J Food Sci 2007; 72(7):222–7; https://doi.org/10.1111/j.1750-3841.2007.00436.x

[27] Fathollahi I, Hesari J, Azadmard S, Oustan S. Influence of proteolysis and soluble calcium levels on textural changes in the interior and exterior of Iranian UF white cheese during ripening. World Academy of Science, Engineering and Technology, Int J Nutr Food Eng 2010; 4(6):399–404.

[28] McCarthy O, Sing H. Physico-chemical properties of milk. In: Meswenoyn PHL, Fox PF (eds.), Advanced dairy chemistry. Lactose, water, salts and minor constituents. Springer Science and Business Media, LLC, Vol. 3, 2009; https://doi.org/10.1007/978-0-387-84865-5_15

[29] Dermiki M, Ntzimani A, Badeka A, Savvaidis IN, Kontominas M. Self-life extension and quality attributes of the whey cheese Myzithra Kalathaki using modified atmosphere packaging. LWT-Food Sci Technol 2008; 41(2):284–94; https://doi.org/10.1016/j.lwt.2007.02.014

[30] Aygun O, Aslantas O, Oner S. A survey on the microbiological quality of Carra, a traditional Turkish cheese. J Food Eng 2005; 66(3):401–4; https://doi.org/10.1016/j.jfoodeng.2004.04.013

[31] Kelleher SL, Lonnerdal B. Immunological activities associated with milk. Adv Nutr Res 2001; 10:39–65; https://doi.org/10.1007/978-1-4615-0661-4_3

[32] Elbarbary HA, El-Nahas EM, Karam-Allah EL. Anti-rotaviral activity of whey proteins derived from milk of different animal species. Int J Adv Res 2014; 2(4):214–21.

[33] Welthagen JF, Viljoen BC. Yeast profile in Gouda cheese during processing and ripening. Int J Food Microbiol 1998 41(3):185–94; https://doi.org/10.1016/S0168-1605(98)00042-7

[34] EOSQ “Egyptian Organization for Standardization and Quality”. ES: 1008-5/2005 Soft cheeses, part 5 (Gold stored cheese). ICS: 67.100.30, Arab Republic of Egypt, 2005.

[35] Naidu AS. Natural food antimicrobial systems. CRC press, Boca Raton, FL, 2000; https://doi.org/10.1201/9781420039368

[36] Samaranayake YH, Samaranayake LP, Pow EH, Yeung KW. Antifungal effects of lysozyme and lactoferrin against genetically similar, sequential Candida albicans isolates from a human immunodeficiency virus-infected Southern Chinese Cohort. J Clin Microbiol 2001; 39(9):3296–302; https://doi.org/10.1128/JCM.39.9.3296-3302.2001

[37] Kappeler SR, Heuberger C, Farah Z, Puhan Z. Expression of the pep-tidoglycan recognition protein, PGRP, in the lactating mammary gland. J Dairy Sci 2004; 87 (8):2660–8; https://doi.org/10.3168/jds.s0022-0302(04)73392-5

[38] Beaulieu J, Dupont C, Lemieux P. Whey proteins and peptides: beneficial effects on immune health. Therapy 2006; 3(1):69–78; https://doi.org/10.2217/14750708.3.1.69

[39] Awad S. Microbial safety and quality of traditional Egyptian kareish cheese. Afr J Microbiol Res 2016; 10(22):804–12; https://doi.org/10.5897/AJMR2016.8022

[40] Daniels DA. Studies on production of some processed cheese related products. PhD Thesis, Faculty of Agriculture, Benha University, Toulk, Egypt, 2017.

[41] Karagul-Yuceer Y, Drake Mk. Sensory analysis of Yogurt. In: Chandan RC and Kilara A (Eds.), Manufacturing Yogurt and Fermented Milks, 2nd edition, Wiley-Blackwell, Inc. pp 353–67, 2013.

[42] Lobato-Calleros C, Reyes-Hernández J, Beristain CI, Hornelas-Uribe Y, Sánchez-García JE, Vernon-Carter EJ. Microstructure and texture of white fresh cheese made with canola oil and whey protein concentrate in partial or total replacement of milk fat. Food Res Int 2007; 40(4):529–37; https://doi.org/10.1016/j.foodres.2006.10.011

[43] Abd El-Salam B. Effect of milk fat replacement with vegetable oil and/or whey protein concentrate on microstructure, texture and sensory characteristics of fresh soft cheese. Int J Dairy Sci 2015; 10(3):117–25; https://doi.org/10.3923/ijds.2015.117.125

[44] Stella A, Schreiber R, Hafemann M, Kessler H. Influence of whey protein aggregates on the renneting properties of milk. Int Dairy J 1999; 9(3):403–40; https://doi.org/10.1016/S0958-6946(99)00107-7

[45] Ibrahim SA, El Zubeir IEM. Processing, composition and sensory characteristic of yoghurt made from camel milk and camel–sheep milk mixtures. Small Rum Res 2016; 136:109–12; https://doi.org/10.1016/j.smallrumres.2016.01.014