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# Influence Whey Proteins on the Characteristics of Buffalo Mozzarella Cheese

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## ABSTRACT

This study was planned to improve the functional properties of buffalo Mozzarella through incorporating Whey Protein Concentrate (WPC) in different forms either deneturated from cheese milk or addition in powder form in buffalo milk. Raw Buffalo milk was divided into 5 portions, the first portion was served as control without any treatments. Two portions were heated at temperatures of 75 and 85°C for 5 sec. Whey protein concentrate powder was added to rest two milk portions in ratio of 0.15 and 0.30%. Two controls of Mozzarella cheese were made from untreated cow and buffalo milk. All resultant cheeses were analysed for chemical, physical and sensory properties when fresh and after 2 and 4 weeks of storage period at 5±2°C. The cheese microstructure and texture analysis were also examined in fresh treatments. Addition of WPC into buffalo milk or higher heat treated milk lead to increase moisture of resultant cheese. The acidity value of raw buffalo Mozzarella (control) was the lowest compared to treatments either with added WPC into milk or of heat treated milk. Adding WPC into buffalo Mozzarella increased the meltability by up to double folds compared to buffalo control. The results indicated that, treatment fortified with WPC exhibited significantly lower hardness in resultant Mozzarella than that with higher heat treatment or raw milk. Also, adding 0.3% WPP in buffalo milk changed the structure of Mozzarella cheese to be more open and have more fibers. All cheeses were sensory acceptable but the best Mozzarella cheese of buffalo milk resulted by adding WPC in ratio 0.3% into buffalo milk.

**Key words:** Mozzarella, buffalo cheese, WPC, functional properties, meltability, microstructure, texture analysis

## INTRODUCTION

In Egypt, Mozzarella cheese for pizza is produced from cow milk in all modern plants and from mixed milk in small private diary artisan. Buffalo milk is regularly characterized by its high contents of fat, mineral (especially calcium), lactose and protein with larger casein micelles compared to cow milk (Sabikhi and Kanawjia, 1992). Using buffalo milk in making Mozzarella cheese came with some advantages such as the preferred white colour, more piquant and aromatic flavor and higher cheese yield. Unfortunately, buffalo Mozzarella cheese does not resemble that made of cow milk and usually of inferior quality known to show harder body, less watery, lower meltability with higher oiling off (Patel *et al*., 1986; Bikash and Singh, 1996; Mostafa *et al*., 1996) which are unsuitable properties in Pizza processing. The differences in Mozzarella properties of buffalo and cow milk are mainly due to the differences in physical and chemical composition. Several attempts have been tried to enhance these physical characteristics when dealing with buffalo milk. Most of these attempts were focused on reduction of calcium contents in buffalo caseinate, such as addition of some emulsifying salts (Mostafa *et al*., 1996; Abd El-Hamid *et al*., 2006), addition of sodium and potassium chlorides (Paulson *et al*., 1998) or direct acidification technique (Metzger *et al*., 2000). If the total calcium content of cheese is reduced, the amount of cross-linking between casein polymers is reduced and the cheese becomes softer (Solorza and Bell, 2007).

The commonly used heat treatments such as preheating, pasteurization and sterilization always affect the structure and properties of whey proteins either reversibly or irreversibly. Reversible changes of protein structure occur mostly at temperatures up to 60°C which may affect the association or dissociation behavior of some whey proteins (MacRitchie, 1973) while irreversible changes occur at >60°C. There is an increasing interest in incorporating whey proteins in cheese. The protein contained in the whey approximately 0.6% is of high biological value (Hambraeus, 1982). Whey proteins can be incorporated in cheese in two ways: (1) Directly by addition of whey protein to the cheese milk and (2) Indirectly by incorporation of whey proteins naturally present in the cheese milk.

Whey protein is a pure, natural, high quality co-product of the cheese making process. Whey proteins are highly functional and nutritious proteins used in a variety of products. It can be used in sports and nutrition bars and beverages infant formula, dairy foods, meat and other foods. The advantages of incorporating whey protein into cheese are higher nutritional value, increased cheese yield and sensory improvement, especially in the case of low fat cheese. Concentrated whey, Whey powder, Whey protein fractions, Whey Protein Concentrate (WPC) and Whey Protein Isolates (WCI) are few products that can be obtained from processing of liquid whey. Whey proteins have many functional characteristics such as high solubility, dispersibility, water binding, foaming, whipping, emulsification, gelation and buffering power and are used frequently in food applications (Evans *et al*., 2009). There are several dairy products that have been made with the inclusion of whey protein products. Pinto *et al*. (2007) used whey protein concentrate in processed cheese spread manufacture. Also, Henriques *et al*. (2010) added liquid WPC in the milk used to make fresh cheese and set yoghurt, as well as their functional and sensorial properties. Ismail *et al*. (2011) added Denatured Whey Proteins (DWP) into milk to improve the properties of low fat Mozzarella cheese.

The objective of the present study was to enhance the quality of buffalo Mozzarella cheese by incorporating the whey proteins in different forms either denatured from cheese milk or addition in powder form and evaluate the physical, chemical, rheological and sensory quality attributes of resultant Mozzarella product.

## MATERIALS AND METHODS

**Materials:** Raw buffalo and cow milks were obtained from the herd of Higher Institute of Agriculture Cooperations, Egypt. Whey protein concentrate (powder) produced by Australian Dairy Products, Ltd., Australia was used. The composition of previous materials is summarized in Table 1. Starter culture consists of *Streptococcus salvarius* ssp. thermophilus and *Lactobacillus delbrueckii* ssp. bulgaricus, 1:1 (Cairo MIRCEN Culture Collection Center, Faculty of Agriculture, Ain Shams University) was used. Calf rennet powder (Chr. Hansen's Laboratories, Denmark) was used as coagulant.

**Cheese manufacture:** Mozzarella cheese was made from raw buffalo milk as described by Kosikowski (1982). Raw buffalo milk was divided into 5 portions; the first portion was served as control without any treatments. Two portions were heated at 75 or 85°C for 15 sec. Whey protein

Table 1: Composition of raw materials used in the manufacture of Mozzarella cheese

| Materials | Moisture (%) | Fat (%) | Protein (%) | lactose (%) | Ash (%) |
|---|---|---|---|---|---|
| Buffalo milk | 85.76 | 3.30 | 4.12 | 5.67 | 1.15 |
| Cow milk | 88.00 | 3.00 | 3.35 | 4.87 | 0.71 |
| WPC | 4.12 | 4.30 | 47.88 | 35.00 | 7.71 |

WPC: Whey protein concentrate

concentrate powder was added to rest two milk portions in ratios of 0.15 or 0.30% and the calculated amounts of WPC were mixed properly in the cheese milk. Therefore, the starter culture (1.5%) was added to each milk portion and the mixture was left at 38±2°C till the pH reach 6.4 within 40-60 min. The manufacture steps were continued as described by Kosikowski (1982). Another control treatment of Mozzarella cheese was also made from raw cow milk without any treatments. All resultant Mozzarella cheeses were analysed for chemical, physical and sensory properties when fresh and after 2 and 4 weeks of storage period at 5±2°C.

**Cheese analysis:** Mozzarella cheese samples were tested for moisture, fat, protein, titratable acidity, lactose and ash contents as described in (AOAC., 1995). The pH value was measured using electric pH meter "HANNA", with combined glass electrode (Electric Instruments Limited). Samples of cheese were also tested for; meltability and oil separation index by the method of Nilson and Laclair (1976). Cheese firmness was measured using a penetrometer "Koehler" Co. Inc., USA as mentioned by El-Shabrawy *et al.* (2002). Texture of Mozzarella samples was determined by a texture analyzer (Cometech, B type, Taiwan) according the method of Bourne (2002). Scanning electron microscopy was performed using modified methods of Tamime *et al.* (1990). Sensory evaluation of cheese samples was carried out for fresh and after 2 and 4 weeks of storage according to the method of Nelson and Trout (1956).

**Statistical analysis:** The data obtained was statistically analysed according to SAS (1990) using General Linear Model (GLM). Duncan's multiple range was used to separate among means of three replicates of samples.

## RESULTS AND DISCUSSION

Chemical composition of buffalo mozzarella cheese as affected by heating milk or adding whey protein concentrate powder to cheese milk during storage at 5°C up to 28 days is presented in Table 2. Control buffalo Mozzarella had the lowest moisture content while control cow Mozzarella had the highest. Generally, addition of WP into buffalo milk or higher heat treated milk lead to increase moisture of resultant cheese. This increase of moisture content could be due to be the changes that occurred in the nature of proteins and increasing the water binding capacity of the cheese. The data also revealed that moisture content of buffalo Mozzarella cheese fortified with WP or heat treated milk showed significant differences with different ratios of added WP or higher heat treatment. However, treatments fortified with WP exhibited significantly higher moisture content in resultant Mozzarella than that with higher heat treatment. Similar observations were reported by Mead and Roupas (2001). Increasing heat treatment of cheese milk also lead to increase of moisture content in resultant Mozzarella cheese. These results are in agreement with those reported by Rynne *et al.* (2004) who stated that increasing pasteurization temperature from 72-87°C resulted in significant increases in the levels of moisture. During storage of Mozzarella cheese, there was a slight decrease in moisture content and as a sequence a slight increase in total solids. The decrease of moisture during storage could be due to slight water evaporation.

Table 2: Chemical composition of buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk during storage at 5±2°C

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Control (Raw milk) | | Buffalo milk treated at | | Buffalo milk with adding WP | |
| Character and storage period | Cow | Buffalo | 75°C | 85°C | 0.15% | 0.30% |
| **Moisture** | | | | | | |
| Fresh | 52.00 | 41.93 | 42.52 | 42.84 | 42.84 | 43.83 |
| 2 weeks | 51.72 | 41.35 | 42.17 | 42.45 | 42.45 | 43.54 |
| 4 weeks | 51.01 | 40.81 | 41.92 | 42.09 | 42.09 | 43.18 |
| **Fat** | | | | | | |
| Fresh | 23.88 | 32.00 | 31.00 | 30.90 | 30.90 | 29.90 |
| 2 weeks | 24.25 | 32.30 | 31.20 | 31.00 | 31.00 | 30.00 |
| 4 weeks | 24.85 | 32.70 | 31.30 | 31.20 | 31.20 | 30.20 |
| **Protein** | | | | | | |
| Fresh | 19.50 | 20.10 | 20.50 | 20.30 | 20.30 | 21.00 |
| 2 weeks | 19.90 | 20.40 | 20.80 | 20.80 | 20.80 | 21.30 |
| 4 weeks | 20.20 | 20.50 | 21.00 | 21.10 | 21.10 | 21.50 |
| **Ash** | | | | | | |
| Fresh | 2.80 | 3.37 | 3.35 | 3.37 | 3.37 | 3.38 |
| 2 weeks | 3.00 | 3.41 | 3.58 | 3.39 | 3.39 | 3.51 |
| 4 weeks | 3.24 | 3.52 | 3.73 | 3.43 | 3.43 | 3.59 |
| **Salt** | | | | | | |
| Fresh | 2.00 | 1.70 | 1.80 | 1.80 | 1.90 | 2.00 |
| 2 weeks | 2.10 | 1.80 | 1.90 | 2.00 | 2.00 | 2.10 |
| 4 weeks | 2.30 | 1.90 | 2.00 | 2.00 | 2.10 | 2.20 |
| **Lactose** | | | | | | |
| Fresh | 1.02 | 2.53 | 2.63 | 2.59 | 2.56 | 1.89 |
| 2 weeks | 0.95 | 2.39 | 2.25 | 2.36 | 2.40 | 1.65 |
| 4 weeks | 0.75 | 2.27 | 2.08 | 2.18 | 2.19 | 1.53 |

Buffalo Mozzarella cheese (control) exhibited significantly higher fat content than that of cow (control) or buffalo treatments with higher heat treatments (75-85°C). However, increasing pasteurization temperature from 72°C-87°C reduced the fat content in the cheese. This decrease in fat level is due to fat concomitant increase in moisture and hence, the reductions in level of cheese dry matter (Rynne *et al.*, 2004). Addition of WP in buffalo cheese milk lowered the retention of fat compared to all treatments including raw buffalo control. These results are similar to those obtained by Punidadas *et al.* (1999). There was a slight increase in fat content during storage at 5±2°C up to 4 weeks. The phenomenon of increase in fat is mainly due to the loss of moisture content from the cheese samples during storage since it was packed in polyethylene bags which is not tightly closed.

As can be seen from the results, fortifying buffalo cheese milk with WP led to an increase in protein content of resultant Mozzarella. This is mainly due to that WP contains higher percent of protein and therefore will increase the percentage in resultant cheese. Among treatments, the protein content in the treatment with 0.3% WP was the highest while treatment of treated milk at 85°C was the lowest. A gradual increase in protein percent of all treatments including controls was observed as the storage period advanced.

From the same table, one can notice that ash content of buffalo Mozzarella cheeses including buffalo control were in narrow range and showed very close values. Ash content of Mozzarella cheese samples tended to increase gradually along the storage period.

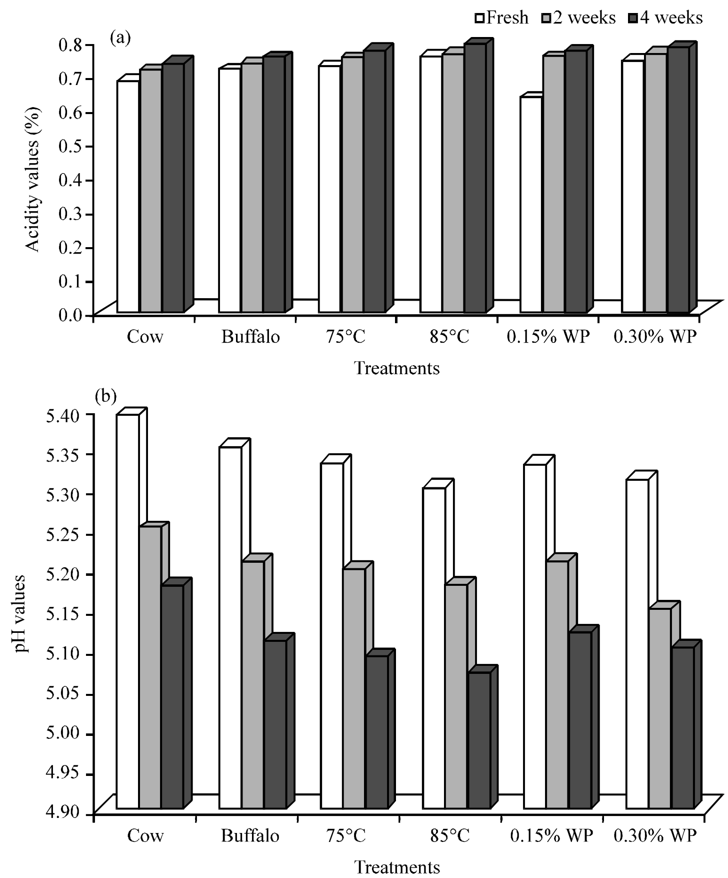


Fig. 1(a-b): Changes in (a) titratable acidity and (b) pH values of buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk during storage at 5±2°C

The salt content of treatments including controls had the same trend of ash content. These results are similar to those obtained by Abbas (2003) who found that the salt content increased to be 1.60 and 1.74% after 6 weeks storage of cheese made from cow and buffalo milk, respectively. The higher values of salt with increasing the added ratio of WP or higher heat treated milk (85°C) could be due to the higher moisture content in the sample (El-Shibiny *et al.*, 1998). As can be seen from the data, Mozzarella treatment of heat treated milk at 85°C had the highest lactose while treatment with 0.3% WP had the lowest. The differences among treatments in lactose content could be related to the acidity development during manufacture process of Mozzarella cheese treatments. The decrease in lactose content of cheese treatments during storage could be attributed to the limited growth of microflora and/or the enzyme activity in cheese during storage.

Figure 1 illustrates the changes in titratable acidity and pH values of buffalo Mozzarella cheese as affected by adding WP in milk or heat treated cheese milk. Raw cow control had the highest acidity value compared to all treatments including buffalo control (raw milk). The acidity development of such cheese (cow control) during storage was also faster than those of all buffalo cheese treatments. This could be due to the higher moisture content of this treatment than other treatments. The acidity value of raw buffalo Mozzarella (control) was the lowest compared to treatments either with added WP into milk or of heat treated milk. The acidity values of treatments

Table 3: Physical properties of buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk during storage at 5±2°C

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Control (Raw milk) | | Buffalo Milk treated at | | Buffalo milk with adding WP | |
| Properties and storage period | Cow | Buffalo | 75°C | 85°C | 0.15% | 0.3% |
| **Meltability (%)** | | | | | | |
| Fresh | $89.10^{Ac}$ | $38.56^{Cc}$ | $49.24^{Cc}$ | $23.42^{Dc}$ | $34.51^{CDc}$ | $70.30^{Bc}$ |
| 2 weeks | $175.50^{Ab}$ | $49.73^{Eb}$ | $81.50^{Cb}$ | $32.30^{Fb}$ | $61.39^{Db}$ | $122.10^{Bb}$ |
| 4 weeks | $215.82^{Aa}$ | $76.89^{Ea}$ | $162.50^{Ca}$ | $45.90^{Fa}$ | $94.60^{Da}$ | $185.90^{Ba}$ |
| **Penetration (mm)** | | | | | | |
| Fresh | $10.20^{Ab}$ | $5.18^{Cc}$ | $8.10^{Bb}$ | $5.90^{Cc}$ | $8.31^{Bc}$ | $9.70^{Ac}$ |
| 2 weeks | $13.56^{Aab}$ | $8.46^{Cb}$ | $11.00^{Bab}$ | $7.62^{Cb}$ | $11.25^{Bb}$ | $12.65^{Ab}$ |
| 4 weeks | $16.20^{Aa}$ | $10.52^{Ca}$ | $12.37^{Ba}$ | $9.91^{Ca}$ | $13.87^{Ba}$ | $15.00^{Aa}$ |

$^{A,B,C}$Means with the same letter among treatments are not significantly different (p = 0.05) , $^{a,b,c}$Means with the same letter during storage period are not significantly different (p = 0.05)

with added WP into cheese milk were higher than treatments of heat treated milk. Addition of WP to buffalo milk raised the acidity and reduced pH values of Mozzarella cheese and this effect was more noted in treatment with 0.3% WP (Ismail *et al.*, 2011). In agreement with the earlier studies, Guinee *et al.* (1998) and Rynne *et al.* (2004) found that increasing pasteurization temperature of the milk significantly reduced the pH of cheese. The results also, revealed that the acidity was increased during storage in all treatments. The results agree with those found by Rynne *et al.* (2004) and Ismail *et al.* (2011). The pH values of Mozzarella cheese samples tended to decrease gradually along the storage period.

## Physical properties of Mozzarella cheese

**Meltability:** Meltability of buffalo Mozzarella cheese as affected by adding WP in milk or of heat treated cheese milk is shown in Table 3. The results indicated that cow Mozzarella (control) showed significantly higher meltability value compared to all treatments including raw buffalo cheese (control). Heat treated cheese milk up to 75°C improved to certain extent the meltability of resultant Mozzarella cheese but higher temperature led to lower value. However, Rynne *et al.* (2004) indicated that increasing pasteurization temperature from 72°C or 77°C to 82°C significantly reduces the flowability and stretchability of the melted cheese. Adding WP into buffalo Mozzarella increased the meltability compared to buffalo control. The meltability improvements in treatments with WP could be due to the high affinity of water retention in resultant Mozzarella. Addition of WP to buffalo milk increased the moisture retention in the product which may increase the meltability (Metzger *et al.*, 2001; Ismail *et al.*, 2011). As the storage time increased, meltability values in all treatments including control treatments were increased (Abbas, 2003). This could be due to the development of acidity that increased soluble calcium as well as the progressive cheese proteolysis during storage (Yun *et al.*, 1998; Poduval and Mistry, 1999; Abd El-Hamid *et al.*, 2006).

**Firmness:** Effect of heat treated buffalo milk or adding WP to buffalo Mozzarella cheese on the penetration values are also represented in Table 3. The penetration reading is inversely related to cheese firmness. The data indicated that buffalo control cheese had the highest hardness (lowest penetration) value. Heat treatment for buffalo milk up to 75°C significantly improved the softness of resultant cheese by increasing the penetration value then it decreased at 85°C but still higher

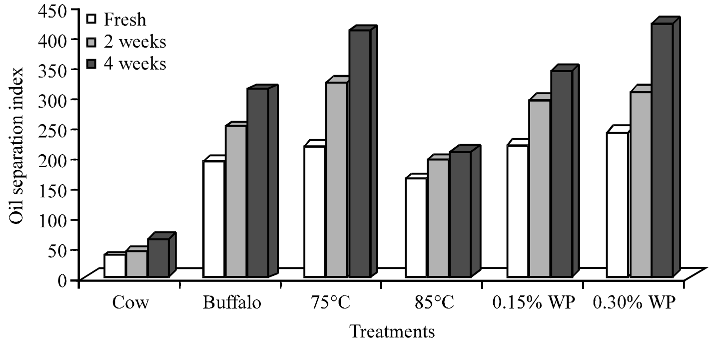


Fig. 2: Oil separation index of buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk during storage at 5±2°C

than that of buffalo control. Merrill *et al.* (1994) used higher pasteurization conditions (175°F for 29 sec) to denature some of the whey proteins and increase the water holding capacity of the cheese curd. Zisu and Shah (2005) illustrated that cheeses containing whey protein concentrate had a greater melt distance of 41.61 mm. than that of control cheeses. Addition of WP to buffalo milk cheese significantly increased the softness of Mozzarella cheese being softer with increasing the added ratio of WP. This may be attributed to the high water-holding capacity of whey protein which increased the moisture content in the resultant cheese. This increase in moisture led to decrease in hardness and increased the Meltability of Mozzarella cheese (Tunick *et al.*, 1993). The firmness of Mozzarella decreased with the increase of moisture content (Joshi *et al.*, 2002). The firmness decreased gradually as the storage period progressed in all treatments including controls. Yun *et al.* (1993) and Abd El-Hamid *et al.* (2006) found that the hardness of Mozzarella cheese decreased during refrigeration storage.

**Oil separation:** The changes in oil separation index of Mozzarella cheese as affected by adding WP to buffalo milk or heat treating buffalo milk are shown in Fig. 2. It is clear from the results that treatments with WP showed the highest and significant oil separation while heat treated buffalo Mozzarella cheeses had the lowest. High heat treatment of buffalo milk up to 75°C increased oil separation values compared to buffalo control. Values of oil separation were higher with increasing the ratio added of WP in buffalo milk. Ismail *et al.* (2011) stated that addition of 0.5 or 1% whey protein to 4 or 2% fat buffalo milk slightly increased the oiling-off values of Mozzarella cheese. Extending the storage period of Mozzarella cheese significantly increased the oil separation value in all treatments including controls. The increase in oil separation values during storage could be due to the protein degradation and weakness of casein network which may led to demulsification and easy fat separation. These observations are in agreement with Yun *et al.* (1993).

**Texture properties of mozzarella cheese:** Changes in texture parameters of fresh buffalo Mozzarella cheeses as affected by incorporation of whey protein either by heat treating or adding Whey Protein (WP) to cheese milk are shown in Table 4. The firmness values were significantly affected by adding WP to cheese milk or heat treated milk of Mozzarella cheese. The results also

Table 4: Texture Profile Analysis (TPA) of fresh buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk

| Properties | Raw buffalo | Milk treated at 75°C | 0.3% WP |
|---|---|---|---|
| Firmnness (N) | 8.190 | 6.570 | 3.140 |
| Springiness (mm) | 0.816 | 0.749 | 0.617 |
| Cohesiveness (ratio) | 0.742 | 0.653 | 0.536 |
| Gumminess (N) | 6.076 | 4.288 | 1.684 |
| Chewiness (N) | 4.959 | 3.214 | 1.040 |

indicated that, treatments fortified with WP exhibited significantly lower firmness in resultant Mozzarella than that with higher heat treatment or raw milk (control). However, addition of WP into buffalo milk led to increase moisture content and decrease pH value of resultant cheese.

Similar result was found by Lucey *et al.* (2003) who reported that the gel hardness increased with a reduction in pH value. On the other hand, treatment of heat treated milk at 75°C showed lower firmness than that of raw milk cheese. This decrease could be attributed to the increase in moisture content of heat treated milk of Mozzarella cheese. The obtained data is in agreement with Lucey *et al.* (2003) and Guinee *et al.* (2002). The results in Table 4 also indicated that, addition of WP in buffalo cheese milk lowed cohesiveness value compared to other treatments. This may be due to the high moisture content due to the change that occurred in the nature of protein and increasing the water binding capacity of cheese. As a result, increasing the moisture content reduces the cohesiveness of the protein matrix and resulted in softer products. Similar findings were reported by Lee *et al.* (2004). Gumminess value which expresses the energy required to masticate the cheese and its value is dependent on firmness and cohesiveness showed that addition of WP into buffalo cheese milk and heat treatment decreased the gumminess values compared to raw milk (control cheese). Chewiness is secondary derived from gumminess and springiness. Chewiness followed the same trend of gumminess being lower in heat treatment of cheese milk at 75°C than raw milk cheese (control). Cheese firmness, springiness, cohesiveness gumminess and chewiness followed a reverse linear trend with the moisture content.

**Mozzarella cheese microstructure:** Understanding the microstructure of Mozzarella cheese, particularly how the casein and fat interact during and after manufacture, can provide valuable insight into what constitutes are affected the product quality. Microstructure of buffalo Mozzarella cheese was studied by Scanning Electron Microscopy (SEM) and taken micrographs are shown in Fig. 3. As shown in electron micrographs, the differences in cheese microstructure were a function of WP either denatured or native. In control cheese (Fig. 3a), there were protein fibers but the structure was less open with lower serum channels between fibers which formed during stretching. With respect to the effect of heat treatment (Fig. 3b), some structural changes in the casein micelles during heat treatment were occurred. In this respect, Fox (1993) mentioned that the main complex formed during heat treatment of milk is the β-lactoglobulin/K-casein complex. However, heating the buffalo milk at 75°C during manufacture of buffalo Mozzarella cheese (Fig. 3b) resulted in acceptable cheese characteristics with even higher protein solubilization and open structure. From the same micrograph it could be also noticed that even with higher protein solubilization the ability to obtain longer fibers is less. adding 0.3% WPP in buffalo milk also changed the structure

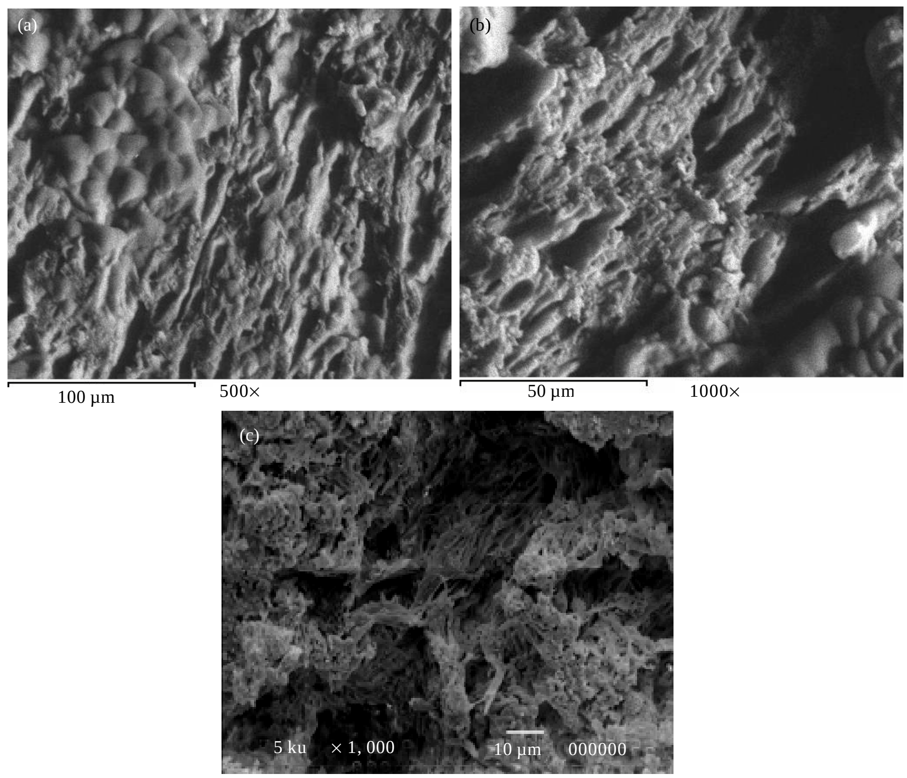


Fig. 3(a-c): Scanning electron micrographs of buffalo Mozzarella cheese from, (a) Raw milk, (b) Milk treated at 75°C and (c) Milk with 0.3% WP, White area: protein matrix, Black areas: Fat and serum pockets

of Mozzarella cheese to be more open and have more fibers (Fig. 3c). The fibrous structure was not longer in cheese of Fig. 3a than in cheese of Fig. 3b and 3c thinner fibrous casein micelles were observed in cheese of Fig. 3c.

**Sensory evaluation:** Sensory evaluation scores of buffalo Mozzarella cheese as affected by adding either WP in buffalo milk or heating buffalo milk up to 85°C, when fresh and during storage at 5±2°C are given in Table 5. The obtained results indicated that treatment of heated milk at 85°C scored the lowest while highest score was gained by cow control. It is also obvious from the data that adding WP significantly improved the quality of resultant buffalo Mozzarella cheese. Fresh buffalo cheese exhibited nearly flavour while the body and texture was sticky with slight acidity. Most improvements with treated buffalo milk were showed in body and texture which could be attributed to higher moisture in these cheeses. Generally, the addition of higher ratio of WP in the cheese milk produced somewhat soft body and smooth texture. The appearance was less differed from treatment to another. All cheeses were sensory acceptable but the best Mozzarella cheese of buffalo milk resulted by adding WP in ratio 0.3% into buffalo milk. It could be also seen that, the sensory quality of all cheese were gradually improved during storage period reaching the highest score at the end of storage period. These results are in line with the finding of Abd El-Hamid *et al.* (2006).

Table 5: Sensory evaluation of buffalo Mozzarella cheese as affected by incorporation of whey protein either of heat treating or adding Whey Protein (WP) to cheese milk during storage at 5±2°C

| | Treatments | | | | | |
|---|---|---|---|---|---|---|
| | Control (Raw milk) | | Buffalo Milk treated | | Buffalo milk with adding WP | |
| Storage period and sensory attributes | Cow | Buffalo | 75°C | 85°C | 0.15% | 0.3% |
| **Fresh** | | | | | | |
| Flavor (50) | 46.80 | 45.80 | 46.10 | 44.30 | 45.40 | 46.30 |
| Body and texture 35 | 33.30 | 30.80 | 31.90 | 30.30 | 32.00 | 32.20 |
| Appearance (15) | 13.60 | 13.20 | 13.40 | 12.80 | 13.20 | 13.50 |
| Total (100) | 93.70[Ab] | 89.80[ABb] | 91.40[Ab] | 87.40[Bb] | 90.10[ABb] | 91.00[Ab] |
| **2 weeks** | | | | | | |
| Flavor (50) | 37.10 | 46.20 | 46.40 | 44.50 | 46.20 | 46.90 |
| Body and texture (35) | 34.00 | 31.00 | 32.50 | 30.60 | 32.90 | 33.40 |
| Appearance (15) | 14.00 | 13.50 | 13.80 | 13.00 | 13.70 | 13.90 |
| Total (100) | 95.10[Aa] | 90.70[ABab] | 92.70[Aab] | 88.10[Ba] | 92.80[Aab] | 94.20[Aa] |
| **4 weeks** | | | | | | |
| Flavor (50) | 47.30 | 46.80 | 46.90 | 45.00 | 46.60 | 47.50 |
| Body and texture (35) | 34.50 | 31.50 | 33.00 | 31.20 | 33.20 | 34.00 |
| Appearance (15) | 14.20 | 13.80 | 14.10 | 13.30 | 14.00 | 14.20 |
| Total (100) | 96.00[Aa] | 92.10[ABa] | 94.00[Aa] | 89.50[Ba] | 93.80[Aa] | 95.70[Aa] |

[A B C]Means with the same letter among treatments are not significantly different (p = 0.05), [a,b,c]Means with the same letter during storage period are not significantly different (p = 0.05)

## CONCLUSION

The results obtained may lead to the conclusion that, incorporation of whey protein either by adding into buffalo milk or which obtained from heat treated of milk is capable of improving the texture and functional properties of buffalo Mozzarella cheese.

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