# STUDIES ON THE PRODUCTION OF MOZZARELLA CHEESE AND ITS ANALOGUES

By

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B.Sc. Agric. Sc., (Dairy Science and Technology) Ain Shams University, 2008

M.Sc. Agric. Sc., (Dairy Science and Technology) Ain Shams University, 2013

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# ABSTRACT

**Ahmed Osama Abd El-Samiea Emam: Studies on the production of Mozzarella cheese and its analogues. Unpublished Ph.D. Thesis, Department of Food Science, Faculty of Agriculture, Ain Shams University, 2016.**

The aim of this study was conducted to evaluate the functionality of full and reduced fat Mozzarella cheeses, and to evaluate the performance of some dried dairy protein ingredients in both the Mozzarella cheese analogue and processed Mozzarella cheese with regard to the functionality of the final product, and to identify suitable blends to achieve particular desirable functional attributes in cheese. As well as to study the manufacture possibility and quality of either the conventionally made fat-replaced Mozzarella cheese or the fat-replaced analogue one; with emphasis on some rheological, microstructural and chromatic attributes.

To achieve this study, firstly several samples of full fat Mozzarella cheese were collected from small scale factories in El-Giza, El-Minea, Kafrelsheikh and Alexandria governorates, during the period expended from 1/7/2014 to 1/12/2014. Likewise, some packages of large factories' full fat and light Mozzarella cheese were collected from the local market, during the same period. All samples were in ranges of age from 1-10 days for the 1$^{st}$ group and from 10-20 days for the 2$^{nd}$ group according to their label data. Moreover, cow's and buffalo's Mozzarella cheeses were made from standardized milk (3% fat for full fat and 1% fat for low fat) either without pre-acidification or citric pre-acidified to pH 6.3, using 2.5% (w/v) activated YC starter culture. Furthermore, fat was replaced in low fat cow's Mozzarella cheeses using modified potato starch (MPS) (1.5%), Novagel or xanthan gum (0.25%), Versagel or Maltrin (1.25%). Furthermore, Mozzarella cheese analogues were made using palm oil as a lipid source and dried rennet casein (DRC), sodium caseinate (DSCN), milk protein concentrate (DMPC) or scalded Mozzarella curd (SC) as

sources of protein, and the MPS was added as filler to all formulas. Tri-sodium citrate and di-sodium orthophosphate were used as emulsifying salts. Inaddition, miscellaneous types of fat replacers were added individually to the imitation low fat Mozzarella cheese, where carrageenan gum, xanthan gum, guar gum, SGB, Novagel, Maltrin, Slendid or Dairygel was added at a rate of 0.25%, while inulin was added at a rate of 5%, whereas versagel or whey protein concentrate (WPC) was added at rates of 1.25 or 7.765 respectively. The MPS was added to all formulas as a bulking agent to offset the decrease in total solids due to fat replacement. Finally, processed low fat Mozzarella cheeses were made starting from preparing a bulk premix containing DRC, DSCN, DMPC, DWPC or a blend of the foregoing materials mixed with the skim milk powder, MPS, sodium chloride, potassium sorbate, tri-sodium citrate, di-sodium orthophosphate, flavour, and Meyprogen. The shredded mother Mozzarella cheese, lecithin and citric acid were added.

The results of the survey indicated that, significant differences were found in all studied compositional criteria of all samples whether those of small or large scale factories. Although all the $2^{nd}$ samples were in coincidence with the legal standards, some samples of the $1^{st}$ group were out of standards. Moreover, significant differences occurred in the counts of lactic acid bacteria (LAB), total bacteria (TBC) as well as yeasts and molds (Y&M). Likewise, chromatic and functional parameters varied considerably among samples.

The buffalo's cheeses showed significantly high values of DM, protein, FDM, ash, lactose and calcium than those of the cow's ones. The pre-acidified cheeses were distinguished with high contents of DM, protein and lactose as well as low values of FDM, ash, TA and calcium. Moreover, the low fat cheeses had higher levels of protein, ash, lactose and TA, whereas the full fat ones showed increments in the DM, FDM and calcium levels. The buffalo's cheeses gained the highest counts of both starter microorganisms and Y&M. Moreover, the pre-acidification

did not affect the LAB counts of cheeses but led to decrease their Y&M counts. The buffalo's cheeses were associated with increments in the values of hardness, cohesiveness, springiness, gumminess and adhesiveness as well as decreased shredding efficiency *versus* the cow's ones. Furthermore, the pre-acidification led to increase the hardness, cohesiveness and gumminess, and to decrease the adhesiveness and springiness of cheese, as well as it had no significant effect on cheese shreddability. The low fat cheeses obtained as high shredding efficiency as the full fat ones, moreover the low fat cheeses showed decrements in all determined TPA parameters along the studied cold storage period. The cow's cheeses showed significant increments in the melt distance, free oil and Hunter b-values *versus* the buffalo's ones, as well as decreased Tex, Hunter L and a-values, stretch extension and maximum load. However, the pre-acidification led to increase the Hunter L and a-values, stretch extension and maximum load, and to decrease the melt distance, Tex and Hunter b-values, it had no significant effect on the free oil of cheese. The low fat cheeses were characterized with Hunter L and a-values, and Tex, stretch extension and maximum load higher than those of the full fat ones. the microstructure of the buffalo's cheese was less porous with more dense protein fibers than the cow's one. The pre-acidified cheeses showed a combination of many larger channels and smaller pores. The reduction in fat led to obtain the typical microstructure of Mozzarella cheese.

No significant differences occurred among the fat-replaced Mozzarella cheeses either in the ash or calcium levels. The two control and Novagel cheeses were statistically similar toward their high TA contents; moreover, the Versagel and Maltrin cheeses were similar in their lower FDM. The MPS cheese reflectd increased levels of DM, protein and lactose. Furthermore, the xanthan cheese was distinguished with decrements in its DM and protein levels. The full fat control cheese was distinguished with its lowest lactose content. The MPS cheese showed significant increments in the counts of *Str. thermophilus* and Y&M which was as high as that of the full fat control. The xanthan cheese was

characterized with decreased counts of *Str. thermophilus* and Y&M, while the low fat control cheese had the highest *Lb. delbrueckii* ssp. *bulgaricu*s count; furthermore the Versagel one had the lowest count of that microorganism. Both the full and low fat controls showed comparatively increments in the cohesiveness degrees and shredding efficiency which was as high as that of both Maltrin and MPS cheeses. The Novagel cheese was characterized with the highest adhesiveness degree and was as low hard as the full fat control one. The MPS cheese reflected significant increments in the degrees of hardness, cohesiveness and gumminess, and showed decrement in its adhesiveness. Furthermore, the lowest hardness, springiness and gumminess were those of low fat control, Maltrin and Novagel cheeses respectively. The full fat control was associated with increments in its free oil and Hunter b-values, moreover the MPS cheese showed increments in its Hunter L and b-values, as well as stretch extension and maximum load, while the highest values of melt distance and Tex were for Novagel and low fat control cheeses respectively. The decrements in the values of melt distance and Tex were aspects for MPS and Novagel cheeses respectively, while Versagel one was characterized with decreased free oil, stretch extension and maximum load. The application of fat replacers led to increase the openness of cheese structure. The Maltrin cheese showed thick gel embedded within the protein matrix of cheese with few hydrated particles of the fat replacer. The MPS cheese contained spherical particles of the fat replacer embedded in the protein matrix; those particles were localized and acted similar to the fat globules.

The full fat cheese analogues were characterized with lower values of protein and TA, and higher values of FDM and ash *versus* the conventional control ones. Moreover, the highest ash and lactose contents were aspects of the DRC+DSCN+DMPC cheese, while the highest values of DM and sodium were associated with the DSCN cheese. The highest values of calcium and FDM were for DRC and DSCN+SC cheeses respectively, while the lowest values of protein, calcium and sodium were for DRC+SC, DSCN and conventional control cheeses respectively. The

control cheese showed increments in the cohesiveness, springiness and shredding efficiency, while other TPA criteria were decreased in that cheese, moreover the DRC cheese was marked by the highest hardness and gumminess, and lowest springiness degrees. Furthermore, all analogue cheeses were statistically similar to each other's in their low cohesiveness, while the lowest springiness and adhesiveness were aspects of the DRC+DSCN+DMPC cheese. The least shreddable cheese is that of the DSCN. The addition of SC had a positive effect on the shreddability of the DSCN based cheese. The control cheese hade higher free oil and Hunter a-values, and lower Tex, stretch extension and maximum load than those of the analogue cheeses. Moreover, the DRC cheese obtained the highest Tex and stretch maximum load, while its stretch extension was as high as that of the DRC+DSCN+DMPC cheese. The DSCN cheese was characterized by its highest melt distance and L-values, and lowest stretch extension and b-values. Furthermore, the addition of SC led to enhance the colouration and meltability of the DRC based cheese. The analogue cheeses had more uniform protein matrix. In those cheeses the bulk of protein appeared as a matrix, and the fibrous structure could not be noticed. Moreover, the DRC cheeses appeared with wider fat voids and thin protein threads could be seen coating the fat voids, when compared to the DSCN one. Furthermore, incorporating either the DRC or DSCN with SC increased the openness of structure.

The highest values of ash and calcium were for guar and Dairygel fat-replaced cheese analogues respectively. The guar cheese was characterized with its low DM, protein and lactose contents. The lowest significant contents of FDM, lactose and TA were for DWPC, Versagel and SGB cheeses respectively. Moreover, the conventional control gained the highest protein and TA, and the lowest ash and calcium contents; furthermore the analogue control one had the highest DM, FDM and lactose levels. The lowest values of cohesiveness, springiness, gumminess and adhesiveness were for the DWPC, inulin, analogue control and guar cheeses respectively. However, the Versagel cheese obtained the lowest

shredding efficiency and the highest hardness; the highest adhesiveness was for the DWPC one. The conventional control cheese was characterized with increment in free oil and decrements in the stretch maximum load, Tex and Hunter a-values. Moreover, the DWPC obtained comparatively higher Hunter a and b-values, and lower free oil and L-values. The stretch extension of Slendid cheese was as high as that of Maltrin, Novagel and SGB cheeses, while the lowest stretch extension was that of carrageenan cheese; furthermore the highest whiteness was for Maltrin cheese. The inulin cheese reflected smaller fat voids than the analogue control one, while the Slendid cheese appeared with more open protein network reflecting a sponge-like appearance contains the fat voids; moreover the serum channels could not be noticed.

The RC processed Mozzarella cheese was characterized with increments in the ash and calcium, and decrements in the DM and FDM contents, while the DSCN one was characterized with its highest protein and sodium levels. Furthermore, the lowest protein and TA contents were for the DMPC based cheese, moreover the highest DM, FDM and TA as well as the lowest ash and sodium levels were aspects for the conventional control cheese, which was distinguished with the highest hardness, springiness and gumminess, furthermore the cohesiveness degrees of the cheeses of DRC, DMPC and that made from the combination of DRC,DSCN,DMPC and DWPC were as low as that of the control one, while the springiness of the DRC cheese was as low as that of the DSCN one. The shredding efficiency values of both the DRC and DSCN cheeses were as high as that of the control cheese, while the lowest value was for the DMPC cheese. The control cheese obtained significantly higher free oil, Tex, stretch extension, stretch maximum load and Hunter b-values, as well as lower melt distance, Hunter L and a-values, moreover the highest melt distance and Hunter a-values were for the DSCN and DMPC cheeses respectively. The lowest yellowness was for the DSCN based cheese, while the lowest Tex, stretch extension and maximum load were aspects for the DMPC cheese.

Finally, the foregoing results led satisfactory to conclude that, Mozzarella cheese analogues are promising substitutes of the conventional cheese, in which several specific functional and nutritional properties could be easily controlled and achieved. The cheese analogue based on rennet casein besides scalded curd possessed the best overall functionality of all Mozzarella cheese styles.

**Key Words:** Textural profile – Instrumental stretchability – Meltability Shreddability - Imitation – Chromatic.

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