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5- SUMMARY AND CONCLUSION

Mozzarella is a semi-soft/semi-hard, plastic-curd cheese. Mozzarella was originally produced from buffalo's milk, but it is now made from cow's milk as well. It is a pasta filata cheese, which means that it goes through a cooker-stretcher step during processing. This step allows for the protein chains in the cheese to coalesce into larger strands that are oriented in the direction of the stretching. (**Jana and Upadhyay 1991**).

Whey protein is a pure, natural, high quality byproduct of the cheese making process. Whey protein is more soluble than casein and also has a higher quality rating. It is often referred to as the "Gold Standard" of protein as it is the most nutritious protein available. (**Belobrajdic *et al.*, 2004**).

The present study was carried out to study the following items:

Part 1:

Effect of adding 0.5, 1, 2, and 3% whey protein on rheological characteristics of buffalo's, cow's and goat's milk were studied. Also, the effects of increasing calcium levels of cow's and goat's milk to 0.150, 0.175, 0.200, 0.225 and 0.250% by adding CaCl₂, Ca-lactate or Ca-carbonate on rheological properties were investigated. The effects of replacement of cow's and goat's milk fats by buffalo's milk fat on the rheological properties of cow's and goat's milk were studied.

These results obtained could be summarized as follows:

- 1- As a result of adding whey protein to buffalo's, cow's and goat's milk, rennet coagulation time (RCT) and curd tension decreased and curd syneresis increased.
- 2- Addition of some calcium salts to cow's and goat's milk decreased RCT while increased curd tension and curd syneresis. The best of those salts was CaCl_2 .
- 3- Adding buffalo's milk cream to cow's milk contained 2 or 0% fat to raising its fat content to 4% increased RCT and curd tension whereas decreased curd syneresis.
- 4- Adding buffalo's milk cream to goat's milk contained 2 or 0% fat to raising its fat content to 4% decreased RCT and increased curd tension and curd syneresis.
- 5- From the previous results, 0.5 and 1% whey protein or 0.175 and 0.200% CaCl_2 or adding 2 and 4% buffalo's milk fat were chosen to process Mozzarella cheese.

Part 2:

Mozzarella cheese was made from buffalo's milk alone or with adding 0.5 and 1% whey protein.

Six treatments of Mozzarella cheese were made as follows:

- Mozzarella cheese made from whole buffalo's milk (6% Fat) as a control (Treatment A).
- Mozzarella cheese made from standardized buffalo's milk (4% Fat)

(Treatment B).

- Mozzarella cheese made from standardized buffaloe's milk (4% Fat) and 0.5% whey protein (Treatment C).
- Mozzarella cheese made from standardized buffaloe's milk (4% Fat) and 1.0% whey protein (Treatment D).
- Mozzarella cheese made from standardized buffaloe's milk (2% Fat) and 0.5% whey protein (Treatment E).
- Mozzarella cheese made from standardized buffaloe's milk (2% Fat) and 1.0% whey protein (Treatment F).

The resultant cheese from above treatments were stored for 28 days at $5\pm 1^{\circ}\text{C}$.

These results obtained could be summarized as follows:

- 1- Reducing of fat ratio of buffaloe's milk to 4% decreased T.S, fat, T.N, ash and calcium contents of Mozzarella cheese whey. Whereas adding of 0.5 or 1% whey protein to cheese milk increased acidity, T.S, ash and calcium contents of cheese whey.
- 2- Actual and adjusted cheese yield decreased by decreasing fat content of cheese milk. Adding whey protein to buffaloe's milk increased the actual and adjusted yield of cheese.
- 3- Making of Mozzarella cheese from 4% fat buffaloe's milk produced cheese was higher acidity, ash, salt and salt in moisture and lower pH, total solids, fat, calcium and TVFA contents than Mozzarella cheese from whole buffaloe's milk. T.N, S.N, N.P.N values were similar in both treatments.

- 4- Addition of whey protein to cheese milk increased the acidity, TS, ash, salt, salt in moisture, T.N, S.N, S.N/T.N, N.P.N, N.P.N/T.N and TVFA and decreased the calcium values of Mozzarella cheese.
- 5- Meltability and oiling-off values were lower in 4%fat cheese than those of 6% cheese.
- 6- Addition of whey protein to cheese milk increased the meltability and oiling-off values of resultant cheese.
- 7- Results of scanning electron microscopy showed that protein matrix of Mozzarella cheese made from buffaloe's milk 4% fat without adding whey protein was smaller than those of cheese made from mixture of buffaloe's milk and whey protein.
- 8- Sensory evolution of cheese made from 4% fat buffalo's milk was lower than those of cheese made from 6% fat. Addition of whey protein to cheese milk improved the organoleptic properties of Mozzarella cheese.
- 9- Results from pizza baking cleared Mozzarella cheese made from buffaloe's milk (2% fat) mixed with 0.5 or 1% whey protein showed the best bake characteristics with larger white, nonscorched portions of the pizza.
- 10- A continuous increase was observed in acidity, TS, fat, Fat/DM, ash, salt, salt in moisture, T.N, S.N, S.N/T.N, N.P.N, N.P.N/T.N, TVFA, meltability, oiling-off and organoleptic properties values of cheese during storage in all cheese treatments.

Part 3:

Mozzarella cheese was produced from cow's milk after increasing its calcium content to 0.175 or 0.200% by adding CaCl_2 . Also, the cheese was made from cow's milk (4 or 2% fat) mixed with 0.5 and 1% whey protein.

The following seven treatments were carried out as follows:

- Mozzarella cheese made from whole cow's milk (4% Fat) (Treatment G).
- Mozzarella cheese made from whole cow's milk (4% Fat) and 0.175% Ca (Treatment H).
- Mozzarella cheese made from whole cow's milk (4% Fat) and 0.200% Ca (Treatment I).
- Mozzarella cheese made from whole cow's milk (4% Fat) and 0.5% whey protein (Treatment J).
- Mozzarella cheese made from whole cow's milk (4% Fat) and 1.0% whey protein (Treatment K).
- Mozzarella cheese made from standardized cow's milk (2% Fat) and 0.5% whey protein (Treatment L).
- Mozzarella cheese made from standardized cow's milk (2% Fat) and 1.0% whey protein (Treatment M).

These results obtained could be summarized as follows:

- 1- Whey of Mozzarella cheese made from cow's milk fortified with CaCl_2 had higher TS and calcium contents than those of cheese made from cow's milk alone, whereas the values of acidity, pH, fat, TN and ash were similar

in both types of cheese whey.

- 2- Adding whey protein to cheese milk increased acidity, T.S, T.N, ash and calcium contents of cheese whey.
- 3- Increasing calcium content of cow's milk to 0.175 or 0.200% increased the actual and adjusted Mozzarella cheese yield. Also, addition of 0.5 or 1% whey protein to cheese milk increased the actual and adjusted cheese yield.
- 4- Adding CaCl_2 to cow's milk decreased acidity and increased TS, fat, Fat/DM, ash, salt, salt in moisture, calcium and TVFA contents of resultant cheese.
- 5- Incorporation of whey protein to cheese milk increased acidity, TS, fat, Fat/DM, ash, salt, salt in moisture, calcium and TVFA contents of Mozzarella cheese.
- 6- TN values were similar in both cheese without and with adding CaCl_2 to cow's milk. CaCl_2 cheese possessed lower S.N, S.N/T.N, N.P.N and N.P.N/T.N values than those of control cheese.
- 7- Whey protein cheese had higher T.N, T.N/D.M, S.N, S.N/T.N, N.P.N and N.P.N/T.N values than those of control cheese.
- 8- Increasing calcium content of cow's milk decreased the meltability values and increased oiling-off values of Mozzarella cheese.
- 9- Addition of whey protein to cow's milk increased the meltability and oiling-off values of Mozzarella cheese
- 10- The microstructure of cheese made from cow's milk contained 0.200%

calcium showed a dense protein matrix compared with that made from cow's milk contained 0.145%. Similar microstructure was observed in scanning electron micrographs for control and cheese with 0.5 or 1% whey protein.

- 11- Adding of CaCl_2 to cheese milk lowered the organoleptic evolution scores while adding whey protein improved it.
- 12- Data of pizza baking test revealed that control and 0.175% calcium milk cheese were similar in appearance, whereas the 0.200% calcium milk cheese had lower suitable appearance. Adding 0.5 or 1% whey protein to cow's milk improved the meltability, flow, shred fusion, and reduced browning and blistering of Mozzarella cheese.
- 13- Acidity, T.S, fat, Fat/DM, ash, salt, salt in moisture, T.N, S.N, S.N/T.N, N.P.N, N.P.N/T.N, TVFA, meltability, oiling-off and organoleptic properties values of cheese increased during storage in all cheese treatments.

Part 4:

Mozzarella cheese in this part was made from goat's milk (4 or 2% fat) mixed with 0.5 or 1% whey protein. Also, in this part Mozzarella cheese was made from goat's milk after substitution its fat with 2 or 4% buffaloe's milk fat.

The following seven treatments were carried out as follows:

- Mozzarella cheese made from whole goat's milk (4% Fat) (Treatment N).
- Mozzarella cheese made from whole goat's milk (4% Fat) and 0.5% whey protein (Treatment O).

- Mozzarella cheese made from whole goat's milk (4% Fat) and 1.0% whey protein (Treatment P).
- Mozzarella cheese made from standardized goat's milk (2% Fat) and 0.5% whey protein (Treatment Q).
- Mozzarella cheese made from standardized goat's milk (2% Fat) and 1.0% whey protein (Treatment R).
- Mozzarella cheese made from standardized goat's milk (2% Fat) and 2% buffalo's milk fat (Treatment S).
- Mozzarella cheese made from fresh skim goat's milk and 4% buffalo's milk fat (Treatment T).

These results obtained could be summarized as follows:

- 1- Adding of whey protein to goat's milk increased acidity, TS, fat, TN, ash and calcium contents of cheese whey, while non significant differences in chemical composition of whey were observed between samples of Mozzarella cheese made from goat's milk alone or fortified with buffalo's milk fat.
- 2- Addition of whey protein to goat's milk increased the actual and adjusted yields of cheese. Substitution of 2% fat of goat's milk with 2% buffalo's milk fat decreased the actual and adjusted yield of cheese, whereas substitution with 4% buffalo's milk fat increased it.
- 3- Fat values were similar in both cheese without and with adding whey protein to goat's milk. Whey protein cheese had higher contents of acidity, TS, ash, salt and salt in moisture, while had lower calcium values

than those of control cheese.

- 4- Adding buffaloe's milk fat to goat's milk (2 or 0% fat) increased the acidity values of cheese. Replacement of 2% fat of goat's milk with 2% buffaloe's milk fat reduced T.S and fat contents but increasing of replacement ratio to 4% fat increased T.S and fat contents of cheese. Ash, salt, salt in moisture and calcium contents were similar in cheese made from goat's milk alone or mixed with buffaloe's milk fat.
- 5- Adding whey protein to cheese milk increased T.N, S.N, S.N/T.N, N.P.N, N.P.N/T.N and TVFA values of cheese.
- 6- Non significant differences in T.N content were found between cheese made from goat's milk alone or mixed with buffaloe's milk fat. S.N and N.P.N values were higher and TVFA values were lower in the later cheese than those of the former.
- 7- Meltability and oiling-off values for whey protein cheese were higher than those of control cheese. Adding of buffaloe's milk fat to goat's milk (2 or 0%) decreased meltability and increased oiling-off values of cheese.
- 8- Scanning electron microscopy showed that protein matrix of Mozzarella cheese made from goat's milk with adding 1% whey protein was larger than those of control cheese. Also, skimming of goat's milk and mixing it with buffaloe's milk fat changed the size and shape of protein matrix of the resultant Mozzarella cheese.
- 9- Adding whey protein or buffaloe's milk fat to goat's milk improved the organoleptic properties of Mozzarella cheese.

- 10- Results of pizza baking test showed that Mozzarella cheese made from part skimmed goat's milk (2% fat) mixed with 0.5 or 1% whey protein or cheese made from skimmed goat's milk mixed with buffalo's milk fat showed the best bake characteristics with nonscorched portions of the pizza.
- 11- Acidity, T.S, fat, Fat/DM, ash, salt, salt in moisture, T.N, S.N, S.N/T.N, N.P.N, N.P.N/T.N, TVFA, meltability, oiling-off and organoleptic properties values of different samples of cheese increased during cold storage.

Conclusion

Mozzarella cheese with good chemical, rheological and organoleptic properties successfully produced from:

- 1- Buffalo's milk contained 4% fat.
- 2- Buffalo's milk, Cow's milk or Goat's milk contained 4 or 2% fat mixed with 0.5 or 1% whey protein.
- 3- Goat's milk contained 4% fat after replacement partly or all fat content with buffalo's milk fat.