School Lunch Pizzas Topped with Low-Fat Mozzarella Cheese

6260

ABSTRACT

The nutritional quality of meals served in the National School Lunch Program will be improved in the near future, and pizza is one of the entrees that will be affected. Pizza is one of the most popular meals in schools, but the percentage of calories from fat in the product is well over the desired maximum of 30%. The amount of fat in pizza can be substantially decreased by lowering the fat level in the Mozzarella cheese topping, but the reduced-fat Mozzarella cheeses on the market have not gained wide acceptance because of their poor texture, flavor, and meltability. A low-fat Mozzarella cheese developed in this laboratory has texture, melting, and stringing qualities comparable to those of full-fat Mozzarella. Manufacture of this cheese, which contains <10% fat, requires only minor changes in processing temperature and storage time. This low-fat Mozzarella has been produced on a commercial scale and processed into frozen pizzas for school lunches. Trials in public schools indicated that pizzas topped with this cheese are acceptable to students.

INTRODUCTION

School lunch pizzas

The USDA has announced that starting in 1998, meals served in the National School Lunch Program must meet the government's Dietary Guidelines for Americans (Groves, 1994; McGinley, 1994). Once the regulation is in place, no more than 30% of school lunch calories may come from fat. Only 1% of the 92,000 schools in the Program currently meet this guideline (McGinley, 1994).

Nearly all of the schools in the Program bake and serve frozen pizzas for lunch at least once a week. In most cases, 15-25% of the weight of a frozen plain pizza is Mozzarella cheese, which can account for at least 50% of the fat in the product (H. Engebretsen, Tony's Pizza Services, personal communication). Fat is responsible for at least 38% of the calories in most frozen pizzas, but if the fat content of the cheese can be reduced to <10%, the calories from fat will be lowered to the 30% guideline. Several reduced-fat Mozzarellas are commercially available, but their melting, texture, and flavor are generally unacceptable, which has and have limited their popularity.

Characteristics of low-fat cheese

Problems with flavor and texture have limited the sales of low-fat cheeses (Dryer, 1994). The relatively low number of fat globules in reduced-fat cheese results in a more extensive syneresis process and a denser structural matrix, leading to a cheese that is too firm, too dry, or not meltable enough (Emmons et al., 1980). In cheese, fat can be considered as a kind of filler which influences the rheology of the product (Desai and Nolting, 1994). Cheese becomes softer when the amount of liquid fat which is not bound to the protein matrix increases (Green et al., 1985; Luyten, 1988). Excessive hardness in cheese can also be prevented by manufacturing at an optimum ratio of moisture to casein (Lelievre and Gilles, 1982). In Mozzarella cheese, hardness and meltability are affected by the manner in which moisture is distributed in the protein matrix (Merrill et al., 1994). Protein fibers in Mozzarella are separated by columns of water, which contain emulsified fat droplets (Oberg et al., 1993). Removal of fat theoretically results in narrower columns, which would cause the fibers to coalesce and make the cheese harder and less meltable (Merrill et al., 1994). Increasing moisture content in low-fat Mozzarella should assist in control of hardness and meltability by preventing the protein fibers from compacting further.

Fat is a primary source of flavor in cheese (Fox et al., 1994). A 1992 taste test of low- and no-fat cheeses, including Mozzarella, indicated that most had little or no flavor (Burros, 1992). The flavor of cheese is adversely affected when the amount of fat is decreased since flavor compounds are dissolved in the fat and released when the cheese is eaten (Jameson, 1990). Flavor compounds in cheese include short-chain fatty acids resulting from lipolysis of triglycerides, as well as products generated from proteolysis at the fat-protein interface (Olson and Johnson, 1990). When fat is eliminated from cheese, these fat-soluble components are not perceived (Fox et al., 1994). Lipase enzymes, which are routinely added in the manufacture of Parmesan, Provolone, and Romano cheeses, will generate more flavor-producing fatty acids (Jameson, 1990; Olson and Johnson, 1990), but when the total amount of fat is low, additional lipases may not compensate for lack of fat as a source of, and a solvent for, flavor components.

With these concepts in mind, this laboratory set out to produce a low-fat Mozzarella with acceptable texture, melting, and flavor. Such a Mozzarella was developed using 22.7-kg batches of milk (Tunick et al., 1991, 1993). Its textural and melting characteristics are similar to those of Mozzarellas containing at least twice the fat. At the request of the Food and Nutrition Service, which administers the National School Lunch Program, preparation of this cheese was scaled up in a commercial plant to determine if it is suitable for frozen pizzas. The purpose of this study is to show that low-fat Mozzarella cheese can be manufactured commercially using accepted cheesemaking ingredients and procedures, processed into frozen pizza, and accepted by students.

MATERIALS & METHODS

Cheese manufacture

A 9275-kg batch of milk was standardized to 0.8% milkfat and pasteurized at 73C for 17s; the total solids contents was 9.7%. After the addition of 250 ml lipase (Sanofi Bio-Industries, Waukesha, WI) and 0.9 kg CaCl2, the milk was heated to 35C in a closed vat (Damrow, Fond du Lac, WI) over a 45-min period. When the temperature was reached, 113L of liquid starter culture, a proprietary mixture of *Streptococcus thermophilus-Lactobacillus bulgaricus* starter (Marshall-Rhone Poulenc, Madison, WI) and Streptococcus lactis (Chr. Hansen's Laboratory, Milwaukee, WI), were added. After another 55 min, 1.18 L of calf rennet (Chr. Hansen's) were added. The rest of the cheesemaking procedure is shown in Table 1. The cheese was packaged in 2.3-kg loaves and stored at 4C for 10 wk. The final pH was 5.24.

Pizza manufacture

During the storage period, the cheese was shipped to a commercial pizza processor. There, the cheese was shredded and placed on round (13 cm diameter) individual pizzas, which were then flash frozen. Each 140-g pizza contained 28 g low-fat Mozzarella. The frozen pizzas were shipped to schools where they were heated, without thawing, in conventional ovens at 175° for 20 min prior to serving.

Analytical tests

The moisture content of the low-fat Mozzarella was determined by the forced-draft oven method (AOAC, 1990) and fat content was determined by the modified Babcock test (Kosikowski, 1982). Percentage of protein was determined by automated Kjeldahl analysis (CEM Corp., Matthews, NC), and percentage of NaCl was determined by chloride ion electrode (Orion Research, Inc., Boston, MA).

RESULTS & DISCUSSION

The cheese was manufactured without artificial ingredients or major changes in cheesemaking procedures. Mozzarella is normally cooked at 40°C or higher (Kosikowski, 1982), which removes moisture from the cheese and causes some inactivation of the chymosin and starter culture microorganisms (Kindstedt, 1993). When the cook temperature is reduced to 35°C, the curd retains more moisture, which results in a softer cheese and a higher level of proteolysis after the cheese is made (Tunick et al., 1991, 1993). The breakdown products of α_{s1} casein that takes place during the extended storage period weakens the dense protein matrix, softens the cheese further, and eliminates the textural and melting problems often displayed by reduced-fat Mozzarellas (Tunick et al., 1991, 1993). The breakdown products of α_{s1}-casein have been shown by computer-assisted molecular modeling to be small compact structures which could easily move aside when force is applied (Malin and Brown, 1994). Degradation of β-casein, which produces bitter-tasting peptides, does not occur to any extent in Mozzarella (Kiely et al., 1993; Tunick et al., 1991, 1993). The peptides created by proteolysis of α_{s1}-casein increase the flavor, as do the fatty acids resulting from the addition of lipase enzyme. Laboratory trials have shown that an adjunct culture of *Lactobacillus casei*, which generates a desirable diacetyl flavor, can be added in place of lipase. Calf rennet was used since it is the traditional coagulant for Mozzarella; preliminary experiments have demonstrated that other types of rennet will produce similar results (Malin, unpublished results).

No reduced-fat food can improve anyone's diet if it is not eaten. Therefore, tests on the pizza were performed in a cafeteria in a local middle school with students in grades 6-8. Students who chose pizza lunches were given questionnaires on which they could rate the product. Ninety usable responses were received and rating points were assigned (Table 3). The average rating was 3.08, which corresponds to "good". The students who assigned "fair" and "poor" ratings ate the pizzas without complaint and without leaving much uneaten, which indicates that many of these responses were not entirely serious.

Table 1. Manufacture of low-fat Mozzarella cheese

Event	Time (hr:min)	pH
Starter addition	0:00	
Rennet addition	0:55	6.44
Curd cut	1:15	6.41
Curd transferred to draining table	1:50	6.36
Curd sliced into slabs and piled	2:25	6.10
Slabs inverted	2:40, 3:20	
Slabs into stretcher at 88°C for 3 min	3:45	5.29
Cheese into brine (23% NaCl) at 7°C	4:00	
Cheese packaged	14:00	

Table 3. Results of student surveys

Rating	Points	% of Students
Excellent	5	21
Very Good	4	23
Good	3	18
Fair	2	18

The pizzas were also served in another middle school and an elementary school. Informal discussions with the students at those schools revealed that they liked the product; the older students were especially interested in the fat reduction. The amount of uneaten pizza, a key indicator of acceptance, was low at all of the schools. Cafeteria personnel did not experience any difficulties in heating the pizzas. The cheese toppings browned heavily only when the time and temperature conditions in the oven were too severe.

The labeling laws enacted in 1993 permit the use of the descriptor "light" on a food label if the fat content is at least 50% less than that of the reference food (Mermelstein, 1993). The Mozzarella in this study contains less than half the fat of part skim Mozzarella (Table 2) and thus can be marketed as "Light Mozzarella".

CONCLUSIONS

A natural Mozzarella cheese containing less than 10% fat can be prepared on an industrial scale and processed into frozen pizzas. The Mozzarella contains no ingredients not ordinarily found in cheese, and can be manufactured without making radical changes in cheesemaking procedures. The proteolysis and lipolysis that occurs in the cheese during

Table 2. Compositional analyses of Mozzarella cheeses (Posati and Orr, 1976) and of the low-fat Mozzarella in this study

Mozzarella Type	% Fat	% H_2O	% Protein	%NaCl
Low-Fat	7.0	54.5	31.2	1.22
Regular	21.6	54.1	19.4	0.94
Low Moisture	24.6	48.4	21.6	1.07
Part Skim	15.9	53.8	24.3	1.20
Low Moisture Part Skim	17.1	48.6	27.5	1.35

refrigerated storage enhance the texture, melting, and flavor of the product. The low-fat pizzas were well accepted by school students in lunch room trials.

REFERENCES

Association of Official Analytical Chemists. 1990. *Official Methods of Analysis*, 15th ed. AOAC, Washington, DC.

Burros, M. 1992. If butterfat is cut, cheese doesn't cut it. New York Times, June 3, p. C1.

Desai, N. and Nolting, J. 1994. Microstructure studies of reduced fat cheeses containing fat substitute. In *Structure/Function Relationships in Cheese*, E.L. Malin and M.H. Tunick (Eds.), Plenum Press, New York, NY.

Dryer, J. 1994. Good news, bad news about light cheeses. Dairy Foods 95(6):20.

Emmons, D.B., Kalab, M., Larmond, E., and Lowrie, R.J. 1980. Milk gel structure. X. Texture and microstructure in Cheddar cheese made from whole milk and from homogenized low fat milk. J. Texture Stud. 11:15.

Fox, P.F., Singh, T.K., and McSweeney, P.L.H. 1994. Biogenesis of flavour compounds in cheese. In *Structure/Function Relationships in Cheese*, E.L. Malin and M.H. Tunick (Eds.), Plenum Press, New York, NY.

Green, M.L., Marshall, R.J., and Brooker, B.E. 1985. Instrumental and sensory texture measurement and fracture mechanisms of Cheddar and Cheshire cheeses. J. Texture Stud. 16:351.

Groves, D. 1994. School lunches will meet dietary guidelines by '98 under new USDA proposal. Cheese Reporter 118(47):1.

Jameson, G.W. 1990. Cheese with less fat. Aust. J. Dairy Technol. 45:93.

Kiely, L.J., Kindstedt, P.S., Hendricks, G.M., Levis, J.E., Yun, J.J., and Barbano, D.M. 1993. Age related changes in the microstructure of Mozzarella cheese. Food Struc. 12:13.

Kindstedt, P.S. 1993. Effect of manufacturing parameters, composition, and proteolysis on the functional characteristics of Mozzarella cheese. Crit. Revs. Food Sci. Nutr. 33:167.

Kosikowski, F.V. 1982. Cheese and Fermented Milk Foods. 3rd ed. Edwards Bros., Inc., Ann Arbor, MI.

Lelievre, J. and Gilles, J. 1982. The relationship between the grade (product value) and composition of young commercial Cheddar cheese. N.Z. J. Dairy Sci. Technol. 17:69.

Luyten, H. 1988. The rheological and fracture properties of Gouda cheese. Ph.D. thesis, Wageningen Agricultural Univ., Netherlands.

Malin, E.L. and Brown, E.M. 1994. Influence of casein peptide conformations on textural properties of cheese. In *Structure/Function Relationships in Cheese*, E.L. Malin and M.H. Tunick (Eds.), Plenum Press, New York, NY.

McGinley, L. 1994. Planned new school-lunch guidelines prompt food sellers to think nutrition. Wall Street J., June 6, p. B1.

Mermelstein, N.H. 1993. A new era in food labeling. Food Technol. 47(2):81.

Merrill, R.K., Oberg, C.J., and McMahon, D.J. 1994. A method for manufacturing reduced fat Mozzarella cheese. J.Dairy Sci. 77:1783.

Oberg, C.J., McManus, W.R., and McMahon, D.J. 1993. Microstructure of Mozzarella cheese during manufacture. Food Structure. 12:251.

Olson, N.F. and Johnson, M.E. 1990. Light cheese products: characteristics and economics. Food Technol. 44(10):93.

Posati, L.P. and Orr, M.L. 1976. Composition of foods. Dairy and egg products. Raw, processed, prepared. Agric. Handbook No. 8-1. ARS-USDA, Washington, DC.

Tunick, M.H., Mackey, K.L., Sheieh, J.J., Smith, P.W., Cooke, P., and Malin, E.L. 1993. Rheology and microstructure of low-fat Mozzarella cheese. Int. Dairy J. 3:649-662.

Tunick, M.H., Mackey, K.L., Smith, P.W., and Holsinger, V.H. 1991. Effects of composition and storage on the texture of Mozzarella cheese. Neth. Milk Dairy J. 45:117-125.

ACKNOWLEDGEMENTS

The authors thank Vicky Urcuyo, Regina Heath, and Lorie Conneen of the Food and Nutrition Service, USDA, for arranging school trials, and Kathleen Middleton, Philadelphia School District, and Chris Gimbel, Princeton Food Management Associates, for conducting student surveys.

1994 ALFA LAVAL AGRI DAIRY EXTENSION AWARD GIVEN TO ROBERT L. BRADLEY, JR.

Robert L. Bradley, Jr., Professor, Food Science, University of Wisconsin, Madison, is the 1994 recipient of the Alfa Laval Agri Dairy Extension Award. Bradley received his award during the awards ceremony of the 89th Annual Meeting of the American Dairy Science Association, hosted by University of Minnesota.

Bradley was recognized for his 30 years of innovative leadership and valuable contributions in extension activities for the dairy processing industry. Bradley has been instrumental in the development and instruction of industry short courses in cheese making, ice cream manufacture, analysis of dairy products, and milk pasteurization. His pasteurization course alone has attracted over 1000 students from throughout the US, Ireland, Puerto Rico, Brazil, and Venezuela. Bradley's research program in ice cream technology, dairy equipment cleaning and sanitation, and milk fat utilization complement and strengthen his extension activities. His expertise is well recognized throughout the industry, and his advice on dairy foods processing issues is widely sought.

Bradley received his B.S. degree in dairy technology in 1958 from University of Massachusetts, Amherst, and his M.S. (1960) and Ph.D. (1964) degrees in food science from Michigan State University, East Lansing. Bradley joined the University of Wisconsin faculty in 1964 as Assistant Professor, was promoted to Associate Professor in 1969, and to Professor in 1974.

Previous honors include the Advisor Award of Merit (1989) from University of Wisconsin, The Distinguished Alumni Award in Food Science (1987) from Michigan State University, and the Milk Industry Foundation Teaching Award in Dairy Manufacturing (1981).

Alfa Laval, award sponsor, is the largest supplier of dairy farm equipment, feeding equipment, and computerized dairy herd management systems, as well as a complete line of supplies for the dairy farm.