Short Communication: Modified Schreiber Test for Evaluation of Mozzarella Cheese Meltability[1]

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ABSTRACT

Modifications to the traditional Schreiber test for evaluation of cheese meltability were proposed. We investigated the effect of oven temperatures in the range of 60 to 232°C and of three heating surfaces, namely, glass Petri dish, aluminum plate, and stainless steel on the extent of cheese spread. Determinations were made measuring both the maximum diameter and area of spread. Five shredded Mozzarella cheeses supplied by a commercial manufacturer were used. From the results, it is proposed that the Schreiber test for evaluation of cheese meltability should be modified such that the tests are performed at a lower temperature (90°C) on an aluminum plate and that the area of the melted cheese is measured as an indicator of cheese meltability.
(**Key words**: meltability, Mozzarella cheese, Schreiber test)

INTRODUCTION

The dairy industry and food processors have long used different empirical methods to determine the meltability of cheese. Meltability may be defined as the ease with cheese flows or spreads upon heating. The reported methods for meltability assessment are those described by Olson and Price (7), Kosikowski (4), and Arnott et al. (1). The method proposed by Kosikowski (4) is known as the Schreiber's test, which is the most commonly used method for evaluating the meltability of cheese. In this test, a plug of cheese, placed in a Petri dish, is heated in an oven set at 232°C for 5 min. The melted cheese is cooled for 30 min, and the largest diameter of spread is taken as an estimate of its meltability. Park et al. (8) compared two traditional cheese meltability tests, the Schreiber and Arnott, on various cheeses and found a marked lack of correlation between the Schreiber and Arnott results.

Two major problems with the Schreiber test (J. J. Yee, 1997, personal communication. Schreiber Foods, Green Bay, WI) are 1) noncircular cheese spread and 2) scorching of the outer edges of the spread (Figure 1). These problems induce errors in this test, which is already very empirical, making the test results inconsistent. However, because of its simplicity, the Schreiber test is still very popular. We think that, with some modifications, the consistency of the Schreiber test results can be improved. The noncircular spread of the melted cheese can be accounted for by measuring the spread area instead of the diameter, and scorching of the cheese can be avoided by evaluating meltability at a temperature lower than the current 232°C. Thermal and surface tension properties of the heating surface may also contribute to the sample scorching and the extent of spread. We have determined that full fat cheeses soften and flow in the temperature range of 50 to 60°C (6). Thus, the 232°C setting is excessive. Even in applications, such as baking pizza, the cheese temperature does not reach above 100°C (5) during heating. Therefore, the cheese need not be heated above 100°C for meltability evaluation.

Our objective was to investigate the effect of the following factors on cheese meltability evaluation: 1) oven temperatures in the range of 60 to 232°C; 2) three heating surfaces, namely, glass Petri dish, aluminum plate, and stainless steel; and 3) measuring the area of melted cheese rather than its maximum diameter.

MATERIALS AND METHODS

Five shredded Mozzarella cheeses supplied by a commercial manufacturer were used. Because of the proprietary nature, the origin and manufacturing procedures for these cheeses were not available for publication. The chemical composition of these cheeses was determined by published methods and is presented in Table 1. In addition to the glass Petri

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TABLE 1. Chemical composition of shredded Mozzarella cheeses.

Sample	pH[1]	Fat[2]	Moisture[3]	Salt[4]
		(%)		
A	5.16	22.0	46.8	1.44
B	4.96	25.0	52.4	1.84
C	5.14	24.3	48.2	1.18
D	5.11	23.0	48.8	1.60
E	5.01	21.5	49.8	1.72

[1]Gold electrode-quinhydrone method (11).

[2]Babcock method (2).

[3]Vacuum oven method (10).

[4]Coulometrical method using a chloride analyzer (3).

dish, a 0.7 mm thick stainless steel plate and a 2.5 mm thick aluminum plate were selected as surfaces over which the cheese plug would be heated and allowed to flow. The rationale behind the selection of these test surfaces was that the surfaces would have different heat transfer characteristics that might influence the properties of cheese melt and flow. To test the effect of test surface and oven temperature on heat transfer characteristics of cheeses, the center temperature of the specimens was measured as a function of time during each test for each sample. The temperature of the cheese during heating was monitored by a copper-constantan thermocouple that was 0.13 mm in diameter (Omega Engineering, Inc., Stamford, CT). For this test, two oven temperatures (90 and 232°C) and two different test surfaces (aluminum plate and glass Petri dish) were selected. The preset oven temperatures imposed different heating rates. The test was repeated three times, and the mean cheese temperature was used in the data presentation.

For meltability evaluation, four oven temperatures (60, 70, 90, and 232°C) were selected. These temperatures ranged from 60°C, which is just over the softening point of cheese, to the current Schreiber test setting of 232°C. Because our preliminary tests indicated that temperatures of 100°C and above led to the scorching of the melted cheese, we did not include other temperatures over 90°C. For each test, 5 g of cheese, formed into a 35 mm in diameter, 21-mm high disc, were heated in a forced-air convection oven (Blue-M forced air convection oven, model No. OV-490A-2; Blue-M Electric Company, Blue Island, IL) for 5 min. The sample discs were formed by placing the shredded cheese in a stainless steel ring (35-mm i.d. and 25-mm high) and compressing the sample with a plunger (34 mm in diameter) to a constant distance (4 mm) so that the compressed cheese sample was a disk of 35 mm in diameter and 21 mm in height. The samples were heated without the steel ring around them.

After cooling to room temperature for 5 min, the spread of the melted cheese was characterized by measuring both the maximum diameter (as per the Schreiber test) and the area. The maximum diameter of the cheese spread was measured manually using a set of concentric circles similar to industry practice. The area of spread was measured using a computer imaging system. The system was a CCD video camera (model VDC 3874; Sanyo, San Diego, CA), light source, digitizer (PC Vision Inc., Quebec, Canada), computer (model 486SX; Diversified Systems, Issaquah, WA), a 15-inch video monitor (model Ectochrome; Home Automation Systems Inc., Irvine, CA), and Optimas image processing software (Bioscan Inc., Edmonds, WA). All tests were conducted in triplicate. Statistical significance of the data was tested by multifactor analysis of variance (MANOVA) using Statgraphics software (9). The level of significance used was $P < 0.05$.

RESULTS AND DISCUSSION

The mean measured surface area of cheese spreads on three surfaces, each exposed to 60, 70, 90, and 232°C, are listed in Table 2. The corresponding results of the maximum diameter measurements are

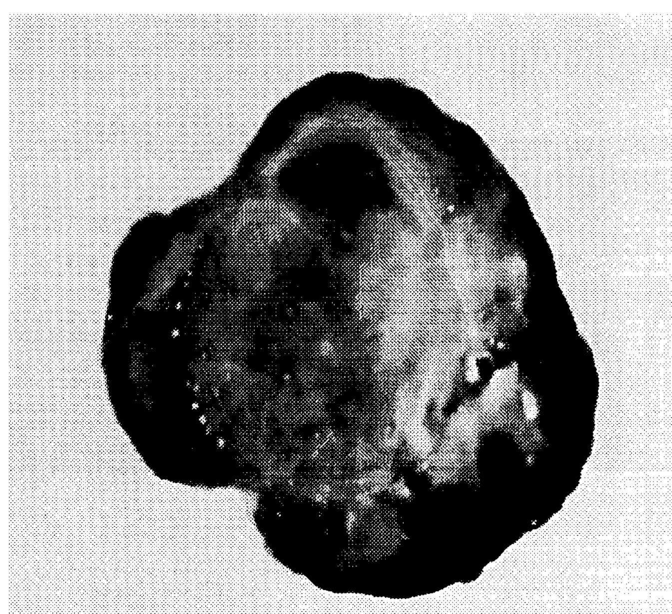

Figure 1. Picture of a melted cheese using traditional Schreiber test.

TABLE 2. Results of the Schreiber tests as measured by the surface area (centimeters squared) of cheese spread on stainless steel (SS), aluminum plate (AP), or Petri dish (PD) at 60, 70, 90, and 232°C.

	60°C				70°C		
Sample	SS	AP	PD	Sample	SS	AP	PD
A	12.3^{ab}	13.3^{bc}	12.5^{a}	A	13.0^{b}	15.3^{b}	12.9^{b}
B	12.5^{ab}	14.1^{ab}	11.9^{a}	B	15.2^{a}	16.1^{ab}	14.0^{a}
C	11.6^{b}	12.9^{c}	11.8^{a}	C	12.1^{b}	13.0^{c}	12.3^{b}
D	11.7^{b}	12.6^{c}	12.0^{a}	D	12.8^{b}	13.9^{c}	12.8^{b}
E	13.0^{a}	14.4^{a}	12.5^{a}	E	14.7^{a}	16.5^{a}	14.3^{a}
	90°C				232°C		
A	16.5^{b}	17.1^{b}	15.9^{c}	A	19.2^{c}	27.4^{c}	22.3^{c}
B	19.3^{a}	20.1^{a}	17.9^{b}	B	24.3^{b}	36.5^{b}	25.6^{b}
C	15.9^{bc}	16.9^{b}	14.7^{c}	C	22.7^{bc}	34.0^{b}	25.0^{b}
D	14.9^{c}	15.6^{c}	14.6^{c}	D	20.9^{bc}	24.8^{c}	22.1^{c}
E	18.9^{a}	20.5^{a}	19.7^{a}	E	30.9^{a}	42.9^{a}	30.3^{a}

[a,b,c,d]Within each column, means without a common superscript differ ($P < 0.05$).

reported in Table 3. The surface area of the cheese spreads and maximum diameter increased as temperature increased. Based on a multiple range analysis, the five samples could only be grouped reliably into two or three distinct meltability groups, depending on temperature used. Among four temperatures tested, use of the Petri dish and stainless steel placed the five samples into two separate groups at 60 and 70°C and into three separate groups at 90 and 232°C. The aluminum plate distinguished all five samples into three separate groups at all temperatures, which shows that all the three surfaces can be used in evaluating the sample meltability at 90°C or above. However, temperatures greater than 100°C led to charring of the outer edges of the spread cheese and contributed to some loss of accuracy of measurement for all heating surfaces (Table 4). Therefore, it appears that temperatures over 90°C are not necessary for evaluating the meltability of Mozzarella cheese.

Among the surfaces tested, the surface area and maximum diameter of cheese melt on the aluminum plate was the highest and was significantly different ($P < 0.05$) from the Petri dish and the stainless steel at all temperatures tested ($P < 0.05$). This phenomenon could be due to a higher heat transfer rate from the aluminum plate (Figure 2). However, the meltability differences between the Petri dish and stainless steel surface were not statistically significant ($P < 0.05$). Also, when variation between samples was considered in terms of coefficient of variation, the aluminum plate had less variation ($P < 0.05$) than did the Petri dish and stainless steel, both when

TABLE 3. Results of the Schreiber tests as measured by the maximum diameter (centimeters) of cheese spread on stainless steel (SS), aluminum plate (AP), or Petri dish (PD) at 60, 70, 90, 232°C.

	60°C				70°C		
Sample	SS	AP	PD	Sample	SS	AP	PD
A	2.08^{b}	2.50^{b}	2.25^{a}	A	2.08^{b}	2.75^{b}	2.17^{a}
B	2.17^{b}	2.50^{b}	2.00^{a}	B	2.92^{a}	3.00^{a}	2.42^{a}
C	2.00^{b}	2.08^{c}	2.00^{a}	C	2.08^{b}	2.17^{d}	2.00^{a}
D	2.00^{b}	2.08^{c}	2.17^{a}	D	2.25^{b}	2.42^{c}	2.33^{a}
E	2.33^{a}	2.83^{a}	2.00^{a}	E	2.75^{a}	3.17^{a}	2.50^{a}
	90°C				232°C[1]		
A	3.08^{b}	3.33^{b}	2.92^{bc}	A	4.42^{c}	5.33^{c}	4.33^{c}
B	4.08^{a}	4.17^{a}	3.33^{ab}	B	5.17^{b}	7.25^{b}	4.92^{b}
C	3.17^{b}	3.25^{bc}	3.00^{bc}	C	4.58^{c}	6.92^{b}	4.83^{b}
D	2.83^{b}	3.08^{c}	2.42^{c}	D	4.17^{c}	4.83^{c}	4.25^{c}
E	3.83^{a}	3.92^{a}	3.67^{a}	E	6.58^{a}	8.75^{a}	5.83^{a}

[a,b,c,d]Within each column, means without a common superscript differ ($P < 0.05$).

[1]Data in PD column were obtained as per the actual Schreiber test protocol.

TABLE 4. Mean coefficient of variation (CV, %)[1] of the spread area (centimeters squared) and maximum diameter of spread (centimeters) of melted cheese on different surfaces heated at 60, 70, 90, and 232°C.

	Stainless Steel Plate		Aluminum Plate		Petri dish	
Sample	Area	Diameter	Area	Diameter	Area	Diameter
60	2.8[b]	5.4[a]	1.8[c]	4.5[a]	2.0[c]	4.0[a]
70	3.5[c]	6.4[a]	2.5[d]	5.7[b]	3.4[c]	7.1[a]
90	2.3[e]	5.7[b]	2.3[e]	5.2[c]	2.6[d]	8.5[a]
232	4.5[d]	8.3[b]	3.5[e]	7.2[c]	4.9[d]	10.4[a]

[a,b,c,d,e]Within each row, means without a common superscript differ ($P < 0.05$).

[1]CV = 100 × (standard deviation/mean).

diameter and spread area were determined (Table 4). The tests on aluminum plate also tended to group samples fairly well according to their meltability. The meltability ranking of the samples in each group varied slightly, depending on the surface and temperature used. There was no single criterion that could be used in selecting a suitable surface to evaluate cheese meltability. Thus, some knowledge and understanding of the cheese chemistry and manufacturing procedure should be used in conjunction with these test results when choosing the most suitable combination of surface and temperature. In general, tests on the aluminum plate tended to provide larger spread areas and lower variation between samples compared with results using other surfaces.

The coefficient of variation was much worse when diameter was measured than when the spread area was measured (Table 4). Moreover, surface area measurements discriminated samples according to their meltability fairly well compared with maximum diameter measurements (Tables 2 and 3). These results suggested that the measurements of spread area are more accurate and consistent for cheese meltability determinations. However, quick and easy measurements of spread area would require a computer imaging system such as the one we used.

The protocols tested in this study are only valid for the regular fat cheeses, and we did not evaluate the meltability of reduced fat cheese. In conclusion, the Schreiber test for evaluation of Mozzarella cheese meltability should be modified such that the tests are performed at a lower temperature (90°C) on an aluminum plate and the area of the melted cheese should be measured as an indicator of cheese meltability.

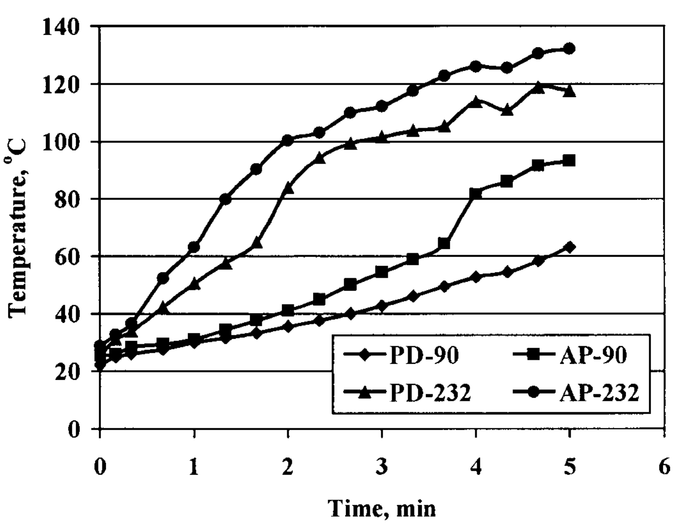

Figure 2. Effect of surface and oven temperature on the temperatures in the centers of the cheese samples during a melt test. AP-90 = Aluminum plate at 90°C, AP-232 = aluminum plate at 232°C, PD-90 = glass Petri dish at 90°C, and PD-232 = glass Petri dish at 232°C.

REFERENCES

1 Arnott, D. R., H. A. Morris, and C. A. Combos. 1957. Effect of certain chemical factors on the melting quality of process cheese. J. Dairy Sci. 40:957–959.

2 Bradley, R. L., Jr., Arnold, E., Jr., and D. M. Barbano. 1992. Pages 433–531 *in* Standard Methods for the Examination of Dairy Products. 16th ed. R. T. Marshall, ed. Am. Publ. Health Assoc., Washington, DC.

3 Johnson, M. E., and N. F. Olson. 1985. A comparison of available methods for determining salt levels in cheese. J. Dairy Sci. 68:1020–1024.

4 Kosikowski, F. 1977. Pages 337–340 *in* Cheese and Fermented Milk Foods. F. V. Kosikowski & Assoc., Brooktondale, NY.

5 Muthukumarappan, K., and S. Gunasekaran. 1997. Research Summary. Department of Biological Systems Engineering, Univ. Wisconsin-Madison, Madison.

6 Muthukumarappan, K., Y.-C. Wang, and S. Gunasekaran. 1996. Estimating softening point of cheeses. Page 205 *in* 1996 IFT Annu. Mtg: Book of Abstracts. Inst. of Food Technol., Chicago, IL.

7 Olson, N. F., and W. V. Price. 1958. A melting test for pasteurized process cheese spreads. J. Dairy Sci. 41:999–1000.

8 Park, J., J. R. Rosenau, and M. Peleg. 1984. Comparison of four procedures of cheese meltability evaluation. J. Food Sci. 49: 1158–1162, 1170.

9 Statgraphics Plus User Manual. Version 6.0. 1992. STSC, Inc., Rockville, MD.

10 Vanderwarn, M. A. 1989. Analysis of cheese and cheese products for moisture. M.S. Thesis, Univ. Wisconsin-Madison, Madison.

11 Van Slyke, L. L., and W. V. Price. 1979. Pages 4760–4786 *in* Cheese. Ridgeview Publ. Co., Atascadero, CA.