Short Communication: Comparison of Covered and Uncovered Schreiber Test for Cheese Meltability Evaluation

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ABSTRACT

Schreiber meltability tests were performed on glass Petri dishes, with and without the Petri dish cover placed over the cheese samples, at 100, 150, and 232°C. Meltability of different process cheese and Cheddar cheese samples was determined based on the melt spread distance and area. At the test temperature of 232°C, the covered Schreiber was significantly superior to the uncovered test because of no crust formation, no browning, and a circular melting pattern, which were attributed to the barrier effect of covering the cheese samples (which inhibits moisture loss during the test). The covered Schreiber test data were statistically more robust as measured by the lower average coefficient of variation than the data from the traditional uncovered Schreiber test.

(Key words: cheese meltability, Cheddar cheese, process cheese, Schreiber test)

Abbreviation key: AI = area index, CI = circle index, COS = covered Schreiber test, CV = mean coefficient of variation, UCS = uncovered Schreiber test.

Cheese meltability is defined as the ease and extent at which cheese will flow upon heating (Gunasekaran and Ak, 2003). It is an important functional property especially for cheeses used in foods consumed after heat treatment.

Many attempts have been made to measure and control cheese meltability. As part of these efforts a battery of meltability tests has been developed, which can be divided into empirical methods and objective methods. The empirical tests depend on measuring dimensional changes in the cheese sample upon melting, such as diameter, height, etc. (Arnott et al., 1957; Kosikowski, 1977); the objective methods rely on determining intrinsic rheological properties of the cheese such as viscosity,

viscoelasticity, etc. (Wang et al., 1998; Kuo et al., 2000). Gunasekaran and Ak (2003) documented and discussed the various cheese meltability tests.

Despite being empirical, the Schreiber test (Kosikowski, 1977) is by far the most widely used in the industry perhaps because of its simplicity. According to the original Schreiber test, a cylindrical cheese specimen (41 mm in diameter, 4.8 mm in height) centered on a concentrically numbered target-type graph is heated in an oven set at 232°C for 5 min; the longest flow line from the center to the edge of the melt is used as the cheese meltability (Kosikowski, 1977). Major drawbacks of this procedure are excessive and uncontrolled heating, drying, crust formation, and browning, and inaccurate flow line measurement in case of noncircular melting (Muthukumarappan et al., 1999; Gunasekaran and Ak, 2003).

Considering its widespread use, many researchers investigated the effect of heating temperature, mode, and surface, sample geometry and dimension, and method for measuring the melting to overcome many of the inherent problems of the Schreiber test (Park et al., 1984; Muthukumarappan et al., 1999; Wang and Sun, 2001, 2002). However, the effect of moisture loss during heating has not been investigated as a potential source of error in Schreiber test meltability results. It is well known that moisture loss during heating, especially in low-fat cheeses, affects the cheese properties. The noncircular melt spread, crust formation, and scorching at elevated temperatures are some of the problems attributed to moisture loss during heating. To minimize moisture loss during heating of the cheese sample in a Petri dish, we enclosed the sample with the Petri dish cover. The results of the Schreiber meltability test with and without the Petri dish cover are presented herein.

Four process cheeses (2 high melt and 2 medium melt) and 3 Cheddar cheeses (aged, medium aged, and mild aged) were obtained from Schreiber Foods, Inc. (Green Bay, WI). The cheeses were stored at 5°C until sample preparation. Samples were cut into 5-mm-thick slices using a hand-operated slicer (model 1042, Rival Co., Kansas City, MO) and then into 41-mm-diameter

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Table 1. Chemical composition of cheese samples tested.

Cheese type	Moisture (%)	Fat (%)	Salt (%)	pH
Process cheese				
High melt A	48.8	22.3	2.00	5.99
High melt B	49.0	22.0	2.11	5.88
Medium melt A	39.8	30.5	2.32	6.17
Medium melt B	40.6	30.0	2.34	6.09
Cheddar cheese				
Aged	36.0	33.5	1.56	5.05
Medium aged	36.0	33.0	2.12	5.32
Mild aged	39.1	31.1	1.70	5.36

discs using a cork borer. Cheese specimens were kept in plastic bags at 5°C until testing.

Chemical analyses of the samples were performed according to published methods and are presented in Table 1. Moisture content was determined by the AOAC oven method at 100°C for 24 h (AOAC, 1995). Fat was determined by the Babcock method (Bradley et al., 1992), salt was determined colorimetrically (Johnson and Olson, 1985), using a Chloride Analyzer 926 (Corning, Medfield, MA), and pH was measured by pH meter (Orion 420A) with a solid RJ pH probe and Orion ATC automatic temperature compensation probe.

Schreiber test was performed by heating cheese specimens on a glass Petri dish with (mass = 65.34 ± 2.17 g; diameter = 100 mm, and height = 21 mm) and without the Petri dish cover (mass = 37.41 ± 0.93 g; diameter = 94.05 mm, height = 19.41 mm) in an oven (Blue-M, model OV-490A-2, Blue-M Electric Company, Blue Island, IL) at 100, 150, and 232°C. After 5 min, cheese melts were removed from the oven, and cooled at room temperature for 30 min. The cheese flow was determined by measuring the spread diameter and area. The spread diameter was measured using concentrically numbered target-type templates placed face up at the bottom of the Petri dishes. Diameter of the innermost circle was 41 mm and the diameter of the subsequent circles increased by 2.5 mm. The circles were numbered sequentially from 0 to 10 starting from the smallest. The template was divided into 8 equal sectors according to Park et al. (1984). At the start of a melt test, a cheese specimen would fit inside the circle "0". The Schreiber test was repeated 3 times for each cheese sample taken from similar batch but different molds. The replicate samples were tested individually at different times.

Two meltability indices were calculated: circle index (CI) and area index (AI). Circle index is the average of the cheese spread circle numbers at each of the 8 sector lines (Figures 1, 2); and AI is the increase in cheese surface area upon melting as measured by a computer imaging system. The imaging system included 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 measurements were conducted in triplicate. Statistical analyses were performed by ANOVA using SPSS software (SPSS 8.0; SPSS Inc, Chicago, IL).

Figures 1 and 2 show the typical appearances of the process and Cheddar cheese melts, respectively, obtained by covered Schreiber test (COS) and uncovered Schreiber test (UCS). Apparent drying and crust formation was observed on all UCS samples melted at 100 and 150°C; neither drying nor crust formation was detected on COS samples. The UCS samples tested at

Figure 1. Melt spreads of process cheese (medium melt A) obtained at different test temperatures by covered (left) and uncovered (right) Schreiber tests.

Figure 2. Melt spreads of Cheddar cheese (medium aged) obtained at different test temperatures by covered (left) and uncovered (right) Schreiber tests.

232°C were severely scorched on the edges and on the melt surface, which was nonexistent in the COS samples. Furthermore, the COS samples were generally more circular, especially the process cheese samples tested at 232°C.

As expected, both AI and CI increased with increasing test temperature for all cheese samples (Tables 2, 3). The increase in AI was more pronounced than the increase in CI. For process cheese samples, except one sample at 100°C, COS gave significantly higher AI and CI than UCS at the same temperatures. This supported our initial hypothesis that cheese melt test results could improve if moisture loss from cheese samples was inhibited. The same trend was observed with the Cheddar cheese samples tested at 232°C. At 100°C and 150°C,

however, the test data of COS and UCS were numerically, but not statistically, different. The test temperature of 232°C is high as it can cause scorching of the samples (Muthukumarappan et al., 1999; Figure 1, 2). However, such high temperatures may be necessary for testing of some low-melt and specialty cheeses. In such cases, and for the sake of using uniform test conditions, selecting 232°C may be preferable. This is clear, judging from the current industry practice. In which case, based on our results, it would be highly desirable to perform the Schreiber tests with the glass Petri dish lid placed over the cheese samples. In addition to leaving the samples unscorched and ensuring that the melt spread is circular, the larger numerical melt spread values obtained via covered Schreiber tests may assist in discriminating samples with similar meltabilities.

The robustness of COS and UCS data was evaluated by calculating coefficient of variation (CV) of the AI and CI. The mean values presented in Table 4 indicate that the data variation decreases for both COS and UCS with increasing test temperature. Moreover, at all test temperatures, mean CV values for COS data were lower than those for UCS data. The AI values obtained with COS at 232°C were by far the most precise as observed from the low CV value, and hence became our recommended test conditions.

Measuring the melt spread area and the AI is more demanding (in terms of time and resources) for the industry than measuring the CI. Therefore, we attempted to determine the possible relationship between these 2 meltability metrics. We obtained strong linear relationships ($R^2 \geq 0.96$) between AI and CI values from both COS and UCS tests (Table 5). This correlation indicates that the industry might use CI as the preferred meltability index for routine tasks and use the AI for research and development purposes. However, neither the AI or CI values obtained by COS and UCS tests correlate ($R^2 \leq 0.52$), indicating that the COS test data indeed vary substantially from those of the traditional UCS data.

Drying, crust formation, and browning, and noncircular melting encountered in the conventional Schreiber test due to high temperature can be eliminated by conducting the tests with the glass Petri dish lid placed over the samples. The covered test performed at 232°C resulted in the largest numerical values and the smallest coefficient of variation for different process cheese and Cheddar cheese samples. Thus, we recommend performing Schreiber cheese meltability tests at 232°C in a glass Petri dish with the samples covered with the glass Petri dish lid. The measuring melt spread distance (CI) will be sufficient for routine tasks; but measuring melt spread area (AI) may be necessary for research and development purposes. Further investiga-

Table 2. Meltability of cheese samples (area index, cm²) after covered (COS) and uncovered Schreiber test (UCS).

Cheese type	100°C		150°C		232°C	
	COS	UCS	COS	UCS	COS	UCS
Process cheese						
High melt A	11.70 ± 0.2 ^a	2.10 ± 0.9 ^b	16.80 ± 1.1 ^a	8.90 ± 0.1 ^b	36.20 ± 0.6 ^a	22.40 ± 0.8 ^b
High melt B	11.40 ± 1.2 ^a	2.90 ± 1.3 ^b	23.7 ± 0.8 ^a	10.30 ± 0.2 ^b	33.90 ± 0.3 ^a	29.90 ± 0.5 ^b
Medium melt A	0.30 ± 0.3 ^a	0.60 ± 0.6 ^a	5.80 ± 0.5 ^a	0.90 ± 0.4 ^b	30.30 ± 0.4 ^a	17.50 ± 0.6 ^b
Medium melt B	4.00 ± 1.4 ^a	0.60 ± 0.5 ^b	9.50 ± 0.4 ^a	1.10 ± 0.4 ^b	17.70 ± 1.2 ^a	6.20 ± 0.4 ^b
Cheddar cheese						
Aged	0.46 ± 0.2 ^a	3.16 ± 0.9 ^b	16.46 ± 3.4 ^a	19.20 ± 2.3 ^a	32.16 ± 0.5 ^a	23.86 ± 1.0 ^b
Medium aged	5.66 ± 1.4 ^a	6.20 ± 1.7 ^a	13.03 ± 0.4 ^a	13.00 ± 0.4 ^a	18.43 ± 0.5 ^a	14.73 ± 0.7 ^b
Mild aged	7.91 ± 1.4 ^a	8.86 ± 0.5 ^a	14.81 ± 0.8 ^a	13.59 ± 1.3 ^a	18.51 ± 0.4 ^a	15.31 ± 0.2 ^b

^{a,b}Under the same temperature, means in the same row with different superscripts differ ($P < 0.05$).

Table 3. Meltability of cheese samples (circle index) after covered (COS) and uncovered Schreiber test (UCS).

Cheese type	100°C		150°C		232°C	
	COS	UCS	COS	UCS	COS	UCS
Process cheese						
High melt A	3.1 ± 0.2 ^a	0.5 ± 0.1 ^b	4.0 ± 0.10 ^a	2.5 ± 0.05 ^b	7.8 ± 0.28 ^a	4.4 ± 0.25 ^b
High melt B	3.1 ± 0.3 ^a	0.6 ± 0.1 ^b	5.0 ± 0.75 ^a	2.7 ± 0.1 ^b	7.9 ± 0.29 ^a	6.3 ± 0.20 ^b
Medium melt A	0.0 ± 0.0 ^a	0.0 ± 0.0 ^a	1.6 ± 0.03 ^a	0.0 ± 0.0 ^b	6.7 ± 0.25 ^a	4.6 ± 0.26 ^b
Medium melt B	1.0 ± 0.1 ^a	0.0 ± 0.0 ^a	2.8 ± 0.18 ^a	0.0 ± 0.0 ^b	4.2 ± 0.15 ^a	1.4 ± 0.12 ^b
Cheddar cheese						
Aged	0.0 ± 0.0 ^a	0.7 ± 0.4 ^a	4.2 ± 0.75 ^a	4.3 ± 0.28 ^a	7.6 ± 0.09 ^a	5.4 ± 0.29 ^b
Medium aged	1.4 ± 0.4 ^a	1.9 ± 0.2 ^a	3.4 ± 0.15 ^a	3.3 ± 0.01 ^a	4.8 ± 0.31 ^a	3.7 ± 0.12 ^b
Mild aged	2.0 ± 0.3 ^a	2.2 ± 0.1 ^a	3.8 ± 0.21 ^a	3.3 ± 0.23 ^a	4.7 ± 0.10 ^a	3.7 ± 0.06 ^b

^{a,b}Under the same temperature, means on the same row with different superscripts differ ($P < 0.05$).

Table 4. Average of mean coefficient of variation (CV) for the meltability indices of all cheese samples after covered (COS) and uncovered Schreiber test (UCS).

Meltability index ¹	100°C		150°C		232°C	
	CO	UCS	COS	UCS	COS	UCS
AI	27.51	39.01	6.18	12.71	2.81	4.01
CI	17.41	19.23	5.94	6.99	4.17	5.31

¹AI = Area index; CI = circle index.

Table 5. Correlation between area index (AI) and circle index (CI), and covered (COS) and uncovered Schreiber test (UCS) (Equations were forced through 0, 0).

Correlation	Test temperature (°C)					
	100		150		232	
	Equation	R ²	Equation	R ²	Equation	R ²
COS						
AI vs. CI	AI = 3.76 CI	0.996	AI = 3.96 CI	0.986	AI = 4.30 CI	0.960
UCS						
AI vs. CI	AI = 3.58 CI	0.995	AI = 4.08 CI	0.975	AI = 4.38 CI	0.971
AI						
COS vs. UCS	COS = 0.89 UCS	-0.447	COS = 1.17 UCS	-0.512	COS = 1.32 UCS	0.518
CI						
COS vs. UCS	COS = 0.82 UCS	-0.493	COS = 1.18 UCS	-0.087	COS = 1.38 UCS	0.482

tion is needed (with more cheese samples) to fully understand of how well the COS, compared with USC, differentiates these cheeses and to establish how widely the COS is applicable to other cheeses.

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