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EVALUATION OF COMMERCIALLY AVAILABLE MOZZARELLA CHEESE FOR ITS MELT AND STRETCHING BEHAVIOUR THROUGH FARINOGRAPH-E

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ABSTRACT

Rheology of the solid and melted cheese depends upon their functional properties. Farinograph is used for quality determination of wheat flour dough. Determination of the rheological properties of dough and dough like food materials from Farinograph is easy while study of cheese characteristics is very difficult and complicated. The present study is therefore designed for the possibility of qualitative profile development for studying cheese by using Farinograph. Torque (resistance against farinograph paddles) was measured along with other qualitative parameters (texture, fat globules, protein matrix) and graphs were plotted between torque and time to see changes in torques at different temperatures (20, 30, 40, 50 and 60ºC) at different intervals of time (5, 10, 15, 20, 25, 30 and 35) minutes. Analysis of Variance of data revealed that time factor showed significant effects on torque ($P<0.01$). Magnitudes of torque were significantly ($P<0.001$) different for different fat percentages. Whereas the interaction of time with fat was non-significant ($P>0.05$). It is proposed that Farinograph may be used for preparation of cheeses because it gives more control on factors affecting cheese preparation.

Keywords: Cheese, Mozzarella, Farinograph-E, Torque.

INTRODUCTION

Cheese is the most diverse, interesting and challenging food. Mozzarella cheese is the most economically important of all pasta-filata kinds of cheeses. This cheese family has its unique characteristics of stretching and plasticization, all pasta-filata varieties showed these characteristics (Kindstedt *et al*., 2004). At the start of 20th century Mozzarella cheese was introduced into the United States by Italian immigrants and it had greatly changed the fate of this traditional cheese (Bruno, 1999). Mozzarella cheese functional properties includes shred ability in its solid state whereas stretch ability, meltability, elasticity, browning and oil formation in melted cheese (Kindstedt, 1991; Kindstedt, 1993; McMahon *et al*., 1993).

Rheology of solid as well as melted cheese depends on their functional properties, which expresses expectations of consumers that how cheese will perform when used like an ingredient (Gunasekaran and Ak, 2003). Sensory tests are not capable of measuring results more accurately as compared to Instrumental tests. To study cheese properties and effects of many manufacturing factors the fundamental methods help researchers to develop cheeses with required and persistent textural and rheological properties (Gunasekaran and Ak, 2003).

Brabender Farinograph is the instrument frequently used all over the world for determining water absorption and mixing characteristics of wheat and rye flour in the baking industry as reproducible and reliable determination of food quality and its processing characteristics is a basic demand of food industry. The present study was conducted by using Farinograph-E as a major tool to measure rheological properties of Mozzarella cheese.

Use of Farinograph for studying cheese characteristics was initiated in late 1980s. In 1988, Rippe and Kindstedt worked on rheological properties of melted Mozzarella cheeses and compared Brabender Farinograph and Brookfield viscometer for Mozzarella cheese consistency and other rheological properties. Some studies have been conducted with Farinograph-E for the preparation of imitation cheeses by using it as a mixing machine. Noronha *et al.* (2008a) studied starch addition and its influence on imitation type cheeses and its functionality.

Different studies on manufacturing and rheological properties of imitation cheeses were performed by El-Bakry *et al.* in (2011), they manufactured imitation cheeses that contained 48% moisture and 0-1.5% NaCl. They investigated the effects of NaCl reduction in manufacturing of cheeses, on its functional characteristics, flowability, texture profile analysis, microscopy and dynamic rheology. For this purpose they used Farinograph and Blentech cookers. They also examine sensory attributes and microbiological stability. They reported results that decreased NaCl concentration reduces the processing time and mixing energy. It minimized cheese hardness, G´ values at 25ºC and crossover temperature whereas fat globule size was increased.

MATERIALS AND METHODS

The present study was conducted at the Department of Food Science, Ontario Agricultural College, University of Guelph, Guelph, N1G 2W1, Ontario, Canada.

Raw materials: Mozzarella cheese samples low fat and full-fat (brand Equality) were purchased from the local shop situated in Guelph, Ontario, Canada. Mozzarella low fat cheese sample (Part skim) having 18 % milk fat and 45% moisture, whereas full-fat containing 28% milk fat and 42 % moisture (A&P Canada Co., Toronto, Canada) were obtained from local shop and subjected to experimentation.

Optimization of Conditions: The objective of this study was firstly to develop an optimum procedure which gives stretching and kneading action to the hydrated casein resulting in the formation of homogeneous mass. The suitability of Farinograph was also evaluated both by the mixing action and mixing speed. The resistance of cheese against the mixing action of paddles (blades) was recorded directly in the form of graphs as resistance (torque in Nm) over mixing time (in minutes).

Sample preparation: The test was performed by cutting whole cheese bar into small pieces in order to obtain homogeneity in sample and was shifted into air tight container in order to avoid moisture loss. The cheese sample were taken in glass beakers and weighed in grams (50.55 g).

Methodology developed: Cheese samples were tested for their rheological study through Brabender Farinograph-E (Model: FR1 2008, No. 082160, GmbH & Co. KG, Duisburg, Germany) by using bowl W-50. The grated cheese was filled with the help of a spatula into the Farinograph-E bowl. Water bath was adjusted at various temperatures like 20, 30, 40, 50 and 60°C. The temperature was continuously monitored through a temperature probe, inserted into the bowl containing cheese sample. The speed of paddles/ spindles was fixed in Newton meters (Nm) and was kept as constant. The lid was closed after filling the bowl and clamped in order to avoid any disturbance. The test was allowed to run for specified time 35 minutes. After completion of time duration the test was stopped automatically. All the trials/results were recorded in duplicates. The readings were recorded in the form of graphs (torque, time and temperature) of cheese resistance over mixing time.

Statistical analysis of data: Statistical analysis was performed using Factorial experiment with Randomized Complete Block Design (RCBD) Arrangement. The difference among treatment means were tested through Duncan's Multiple Range Test (Duncan, 1955).

Mathematical Model The model used was:

$$Y_{ijkl} = \mu + \text{Temperature}_i + \text{Time}_j + \text{Fat}_k + (\text{Time}^*\text{Fat})_{jk} + e_{ijkl}$$

Where as
Y_{ijkl} = Observations
μ = Mean
Temperature_i = i^{th} temperature (20, 30, 40, 50, 60ºC)
Time_j = j^{th} time interval (5, 10, 15, 20, 25, 30, 35 minutes)
Fat_k = k^{th} fat % (18%, 28%)
$\text{Time}^*\text{Fat}_{jk}$ = Interaction between time interval and fat%
e_{ijkl} = Random error associated with each observation.

RESULTS AND DISCUSSION

Mozzarella Cheese samples low fat (brand Equality; 18 % milk fat, 45% moisture), whereas full fat (brand Equality; 28% milk fat, 42 % moisture) were used for the experiment after optimization of conditions. The Farinograph data was plotted as torque (Nm) versus time (min). Depending on cheese fat percentage and temperature of mixing, the plots of torque (resistance in units of Nm) versus mixing time (minutes) have up to four zones designated stage 1, 2, 3 and 4. Stage 1 is the initial sample after the cheese is cut and loaded into the Farinograph. Stage 2 is a 'lag' phase where the cheese is being sheared, but torque remains constant or decreases. This stage is up to 10 minutes for low fat cheese mixed at 20 and 30ºC, but decreases to nil at higher temperatures like 40, 50 and 60ºC (Figure-1). During stage 3 torque increases at a rate (slope) and to a maximum value. In case of low fats at 20ºC the curve was higher with delayed response, then 30ºC, 40ºC, 50ºC and 60ºC respectively. It means the height of curve decreases with the increase in temperature, but the response to achieve curve at its maximum height was vice versa.

However, the torque profile obtained with full fat cheese (Figure-2) was flattened in case of 20 and 30ºC, whereas in case of 40ºC it went up to its maximum height started moving up rapidly and was straight. At 50ºC the curve was flattened throughout and showed its melted behavior whereas at 60ºC it started moving up slowly than 40ºC, after 25-28 minutes again showed decline trend.

Analysis of variance: By conducting Analysis of Variance, it was found that time factor showed significant effects on torque ($P<0.01$). Magnitudes of torque were significantly ($P<0.001$) different for different fat percentages. The interaction of time and fat, as expected, was found to be non-significant ($P>0.05$) (Table-1).

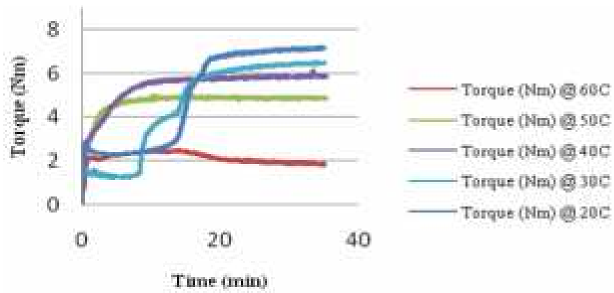

Figure-1: Farinogram development curves for Mozzarella low fat (18%) at the temperature of 20,30,40,50 and 60ºC.

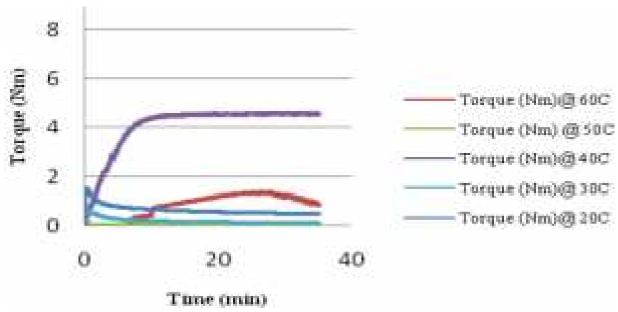

Figure-2: Farinogram development curves for Mozzarella full fat (28%) at the temperature of 20,30,40,50 and 60ºC.

Table 1: Mozzarella cheese low fat and full-fat (brand Equality) at different temperatures 20, 30, 40, 50 and 60ºC analysis of variance for torque values.

Source of Variation	D.F	MS	F value	P value
Temperature	4	45.72	38.87	0.000
Time	6	5.82	4.71	0.003
Error a	24	1.24		
Fat	1	420.50	262.37	0.000
Time*fat	6	3.05	1.91	0.087
Error b	105	1.603		

Significant at P < 0.05 Non-significant at P > 0.05

Comparison of means: Means were separated using DMR and their comparisons are given in Table-2, 3 and 4. Cheese containing lower fat percentage (18%) yielded greater magnitude of torques than the cheese containing full fat (28%) showing that less resistance against paddles is offered by higher fat percentages (Table-2). By increasing the temperature from 20 to 60ºC, the magnitude of torque reduced gradually but it was the highest at 40ºC and the lowest at 60ºC perhaps due to meltability (Table-3). While considering comparison of means for time, for cheese samples, the magnitude of torque gradually increased with time duration. It was lowest for 5 minutes treatment and the highest for 30 minutes treatment (Table-5). This shows cheese offers more resistance to Farinograph paddles with the passage of time due to the changes in its internal structure.

Table 2: Comparison of mean torque (Nm) values at different fat levels.

Fat %	Torque (Nm)
18%	4.59^{a}
28%	1.19^{b}

Means with different superscripts are significantly different at P < 0.05

Table 3: Mean Torque values (Nm) at different temperatures 20, 30, 40, 50 and 60ºC

Temperature	Torque values (Nm)
20ºC	2.84^{b}
30ºC	2.73^{b}
40ºC	4.97^{a}
50ºC	2.42^{b}
60ºC	1.49^{c}

Means with different superscripts are significantly different at P < 0.05 and with similar superscripts are non-significant at P > 0.05.

Table 4: Mean Torque values (Nm) at different time durations.

Time (minutes)	Mean values
5	1.923^{c}
10	2.458^{bc}
15	2.816^{ab}
20	3.235^{a}
25	3.276^{a}
30	3.277^{a}
35	3.258^{a}

Means with different superscripts are significantly different at P < 0.05 and with similar superscripts are non-significant at P > 0.05.

Farinograph-E is the most commonly used recording dough mixer, usually employed in flour industry. It is a computerized machine that has been previously used for measuring mixing characteristics of the dough for determination of its quality and processing characteristics. Now a day's various scientists prepared imitation cheeses also using Brabender Farinograph-E bowl as a mixer and studied their rheology.

In this study, parameters for operating Farinograph-E were adjusted by learning standard methods, and conducted initial trials for Mozzarella cheese in various directions to finalize the procedure. Different heat trends in ascending and descending order were organized on the basis of similar findings of (Udyarajan *et al*., 2007) to study rheological properties of part skim Mozzarella and fat-free cheeses during heating

(10-90ºC) and cooling (90-10ºC) trends. A strong association exists (Olivares *et al*., 2009), they selected test temperatures of 20, 30 and 40ºC. (Muliawan and Hatzikiriakos, 2007a) also selected a temperature range of 25-60ºC and studied the rheological properties of Mozzarella cheeses using a parallel plate, sliding plate, an extensional and a capillary rheometer. Rippe and Kindstedt (1988) studied rheology of cheeses using Farinograph and evaluated melted Mozzarella cheese properties. Minor differences has been found with El-Bakry *et al.* (2010) they observed the effect of temperature on farinograph prepared cheese from 20 to 95ºC.

In the present study Mozzarella cheese (low fat & Full fat) of Equality brand was investigated at 20 to 60^{o}C temperature for 5 to 35 minutes. Effect of temperature on torques produced by low fat and full fat Mozzarella was similar to the findings of El-Bakry *et al.* (2011). They found Farinograph is a suitable instrument for small-scale manufacture of imitation cheese and fat globule size increased by slowly increasing temperature and giving more time which produced typical changes in the graphical output.

In the light of results, Mozzarella cheese at 20ºC after working with Farinograph-E performed like hard cheese dough, expressed highest peak viscosity values and good stability time. While at 30ºC it can also be hard dough with little less peak and stability. At 40 and 50ºC it is a mixture of hard and soft dough with lesser peak and highest stability time. At 60ºC it is a soft cheese dough and showed decline trend after 15 minutes possibly due to the effect of increased temperature and casein matrix dilution with fat and water.

In case of full fat (28%), at 20 and 30ºC the torque profile obtained was flattened and shows soft dough like characteristics, in case of 40ºC it went up to its maximum height, at 50ºC started moving up rapidly but again declined and at 60ºC it is nil. It was found that time factor showed significant effects on torque ($P< 0.01$). The interaction of time and fat was found non-significant ($P> 0.05$). The results seem to be in agreement with the Farinographic analysis.

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