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Farinographic Studies of Mozzarella Cheese at Optimized Conditions

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Abstract.- The basic demand of food industry is reproducible and reliable characteristics for quality and processing of foods. The instrument most often used in baking industry for the determination of mixing characteristics and water absorption of flour is Brabender Farinograph. The Farinograph®-E utilizes the same measuring mixers (300-g and 50-g) as the Farinograph® plus the small 10-g mixer. The previously used mechanical balance system is now replaced with a modern electronic system. To learn about new trends and develop new methods for quality assurance of cheese and to measure rheology of cheeses by using Farinograph-E was the major objective of the present study. Commercially availableMozzarella cheeses of brands Equality and No Name of different fat percentages and moisture contents were included in this study and Farinograph®-E was used as a tool to measure their rheology. Analysis of variance showed that two brands (Equality and No Name) differed significantly ($P<0.01$) in their torque values. Low fat brand (18%) had higher value of torques compared to full fat brands (28%). Full fat and low fat differences were also found significant within the brands. The value of torque was the lowest at 20 and 30°C and the highest at 40°C in the case of high fat brands, whereas for low fats the trend was 20, 30, 40 and then 50°C respectively. It was revealed that Equality brand had higher values of torque compared with No Name brand cheese.

Key words: Farinograph-E, optimized conditions, cheese, Mozzarella, brand equality, brand no name.

INTRODUCTION

Mozzarella cheese is considered as the most famous and economically important among all varieties of pasta-filata. The distinctive properties of this cheese family are plasticization and stretching (Kindstedt *et al.*, 2004). Italian immigrants had introduced Mozzarella cheese in United States in the beginning of 20th century and the fortune of this traditional cheese had greatly changed (Bruno, 1999).

The physical characteristics of Mozzarella cheese consists of elasticity, stretchability, meltability; browning and free oil formation in melt form and shreddability in the solid (Kindstedt, 1991, 1993; McMahon *et al.*, 1993). U.S standards specify four types of Mozzarella cheeses according to their moisture and fat contents, and the greatest proportion covers by low-moisture, part-skim Mozzarella cheese which is mainly used as a topping on pizza.

Rheology is measuring those properties of materials that control their deformation and flow behaviour when subjected to external forces such as strain, stress, and time (Gunasekaran and Ak, 2003). Rheology has list of applications in the field of food acceptability, processing, handling, and their relationship with consumer preferences (Bourne, 1982).

To study rheology of cheese, only a small number of successful attempts had been found for the evaluation of cheese rheological characteristics using objective measurements (Cavella *et al.*, 1992; Hiçeşsaşsmaz *et al.*, 2004). No rheological physical method has yet been invented for characterization of cheese stretchability. Few studies had been carried out with Farinograph-E, using its bowl as a mixing chamber only for manufacturing imitation cheeses (Noronha *et al.*, 2008a,b; El-Bakry *et al.*, 2010, 2011). The Farinograph-E is a computer controlled system which is used for measuring the mixing characteristics of dough for its quality and processing. Farinograph-E uses same mixers (300 g,

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50 g and 10 g) like Farinograph®. Keeping in view the above facts the following study has been conducted with the same objectives by using Farinograph-E® as a major tool to measure rheology of cheese, especially Mozzarella which is a Pizza cheese.

The objective was to observe and verify visible changes in the torque values (curves) and the products texture at elevated temperatures.

MATERIALS AND METHODS

In this experiment Mozzarella cheese (brand Equality™) was selected and compared for rheological characteristics with its sister brand No Name for better approach and reproducibility.

Brabender Farinograph-E

Brabender Farinograph-E (Model: FR1 2008, No. 082160, GmbH & Co. KG, Duisburg, Germany), fitted with 50 g mixing bowl was used to measure the resistance of cheese against the blades, which depends on the cheese dough viscosity. The results were obtained through Farinograph in the form of graphs.

Raw materials

For this experiment Mozzarella cheese of brand No Name (low fat, full-fat) and brand Equality (low fat, full-fat) were procured from the local shop situated in Guelph, Ontario, Canada and tested through Farinograph-E. Brand No Name cheese bars were manufactured at Toronto, Canada and brand Equality™ prepared for A&P Canada Co., Toronto, Canada M5W 1A6 were brought to the laboratory and their fat and moisture contents of these brands are shown in Table I.

Methodology

The cheese bars (520 g) were grated first to attain uniform sample and then shifted into air tight containers. Water bath was adjusted at 20, 30, 40 and 50°C temperatures. Grated cheese was weighed (50.55 g) in a beaker and loaded on Farinograph-E bowl, lid was closed and speed of paddles fixed at 63 rpm for 35 minutes. The results were recorded in the form of graphs. All tests were recorded in duplicates.

Mathematical model

$$Y_{ijklm} = \mu + Time_{I} + Brand_{j} + Fat_{k} + Brand \times Fat_{jk} + Temperature_{l} + Brand \times Temperature_{jl} + Fat \times Temperature_{kl} + Brand \times Fat \times Temperature_{jkl} + e_{ijklm}$$

Where, Y_{ijklm}, observations; μ, Mean; time $_{i}$, ith time interval (5,10, 15, 20, 25, 30, 35 minutes); $Brand_{j}$, jth brands of Mozzarella cheese (equality, no name); Fat_{k}, kth fat % (18%, 28%); Brand x Fat_{jk}, interaction of brand and fat; $Temperature_{l}$, temperature (20, 30, 40, 50ºC); Brand x $Temperature_{jl}$, interaction of brand and temperature; Fat x $Temperature_{kl}$, interaction of fat and temperature; Brand x Fat x $Temperature_{jkl}$, interaction of brand, fat and temperature; e_{ijklm}, Random error associated with each observation.

RESULTS

Torque versus time graph was plotted from the data obtained through Farinograph (Figs. 1, 2). The graph figures showed four zones denoted as 1-4 stages depending upon fat % in cheese and the time of mixing. 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 nearly 10 minutes for low fat cheese mixed at 20 and 30ºC, but decreases to minimum at higher temperature in low fat Mozzarella cheese of Equality brand.

For brand No name low fat and full fat Mozzarella cheeses, the trends are slightly different (Fig. 2A). Stage 2 prolongs up to 20 minutes at lower temperature 20ºC for low fat and then slope is quite sharp and torque increases and stabilizes at a higher value, for 30ºC stage 2 prolongs for 25 minutes. For higher temperature gradually decline in stage 2, after getting peak within a few minutes, is quite obvious from (Fig. 2A). For full fat, brand No name this peak is attained sharply and then torque remains nearly stable at high temperature. At low temperature, the torque remains minimum (approaching zero) soon after running the machine (Fig. 2B).

Table I.- Fat and moisture % of Mozzarella cheese brands (No name and Equality).

Cheese kind	Brand name	Fat%	Moisture%	Weight
Mozzarella low fat	No name	18%	48%	520g
Mozzarella full-fat	No name	28%	42%	520g
Mozzarella low fat	Equality	18%	45%	520g
Mozzarella full-fat	Equality	28%	42%	520g

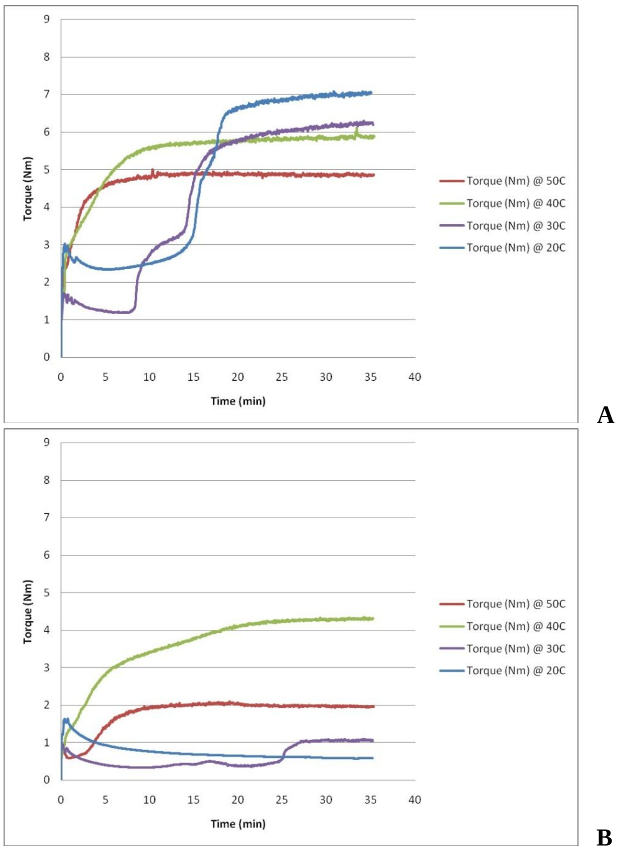

Fig. 1. Farinogram development curves for Mozzarella low fat (18%) (A), and full fat (28%) (B) brand Equality at the temperature of 20, 30, 40 and 50ºC. Results are the average of two determinations.

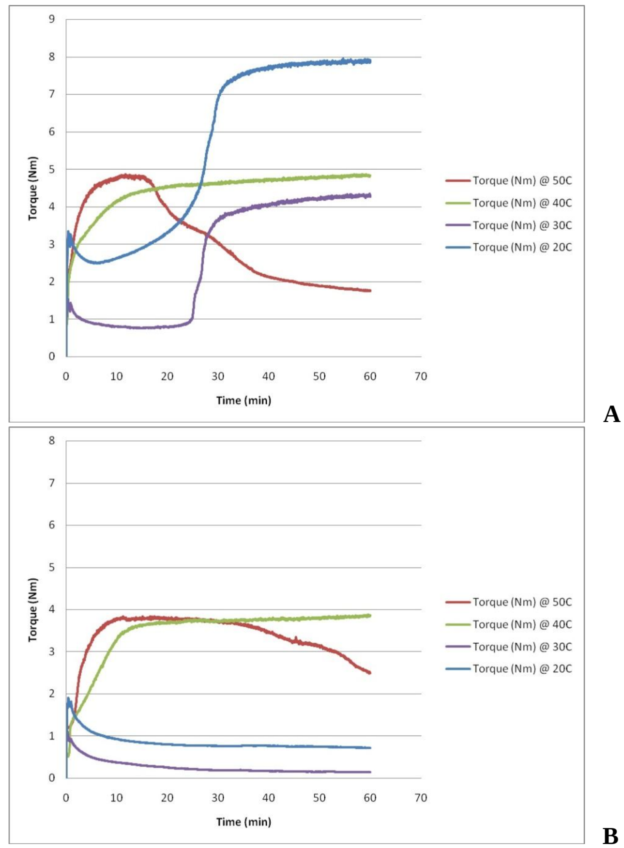

Fig. 2. Farinogram development curves for Mozzarella low fat (18%) (A), and full fat (28%) (B) brand No name at 20, 30, 40 and 50ºC.Results are the average of two determinations.

Analysis of variance revealed that two brands (Equality and No Name) differed significantly (P<0.01) in their torque values. Full fat and low fat differences were also significant within the brands (Table II). Low fat brand (18%) had higher values of torque as compared to full fat (28%) brand.

The value of torque was the lowest at 30^{o}C and the highest at 40^{o}C (Table III). The value of torque increased gradually and slowly with the passage of time and it was the highest after 35 minutes (Table IV). The brand Equality had higher value of torque as compared with brand No Name.

Interaction effects

Different brands have different percentages of fats those were significantly different from each-other. The interaction of Brand x Fat was, therefore, highly significant (P<0.01). Similarly cheese having

Table II.- Analysis of variance for torque values of Mozzarella Cheese low fat and full-fat (brands No name and Equality) at different temperatures *viz.*, 20, 30, 40 and 50ºC.

SOV	D.F	MS	F value	P value
Time	6	8.13	5.35	0.025*
Brand	1	20.22	13.33	0.010**
Error a)	6	1.52		
Fat	1	319.64	115.91	0.000**
Brand x fat	1	45.65	16.55	0.002**
Error b)	12	2.76		
Temperature	3	64.27	39.55	0.000**
Brand x temperature	3	10.31	6.35	
Fat x temperature	3	19.78	12.17	0.000**
Brand x fat x temperature	3	3.72	2.29	0.085 n.s
Error c)	72	1.63		
Error	112	0.695		

* = Significant at P < 0.05; ** = Highly significant P < 0.01; n.s = Non-significant at P > 0.05

different fat percentages behaved differently, showing highly significant interaction effects (P<0.01) as shown in Table II.

Table III.- Mean Torque values (Nm) at different temperatures.

Temperature	Mean Torque values (Nm)
20˚C	2.73±0.15 [c]
30˚C	1.82±0.15 [d]
40˚C	4.31±0.15 [a]
50˚C	3.84±0.15 [b]

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

Table IV.- Mean Torque (Nm) values at different time durations.

Time (minutes)	Mean Torque values (Nm)
5	6.08±0.19 [g]
10	-2.65±0.19 [f]
15	0.87±0.19 [e]
20	4.05±0.19 [d]
25	6.65±0.19 [c]
30	8.87±0.19 [b]
35	10.52±0.19 [a]

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

DISCUSSION

In our study, parameters for operating Farinograph-E were adjusted by standard methods, and initial trials were performed to finalize the procedure. The experiment was conducted at 20-50ºC, selected branded mozzarella cheeses Equality and No name (low fat and full fat). For the measurement of viscoelastic consistency of Mozzarella cheese, Rippe and Kindstedt (1988) studied melted Mozzarella cheese. Results of our study agreed with their approach that Farinograph showed graphical results/outputs that were the fingerprints of individual cheese viscoelastic characteristics, at selected temperatures and their curve shape was repeatable.

Olivares *et al*. (2009) selected test temperatures of 20, 30 and 40ºC, whereas Muliawan and Hatzikiriakos (2007a) preferred a range of 25-60ºC temperature and examined Mozzarella cheese rheological characteristics using parallel plate, sliding plate, extensional and capillary rheometer. They reported that at room temperature mozzarella cheese is viscoelastoplastic material, whereas at 60°C it behaves like viscoelastic.

The experiment was conducted with two brands of Mozzarella cheese (low fat and full fat). Analysis of variance showed that the two brands (Equality and No name) differed significantly (P<0.01) in their torque values. Full fat and low fat differences were also found significant within the brands. Low fat brand (18%) had higher value of torques as compared to full fat (28%) brands. The value of torque was the lowest at 20 and 30^{o}C and the highest at 40^{o}C in case of high fat brands. And in the case of low fats the trend was 20, 30, 40 and then 50ºC. It was revealed that Equality brand had higher values of torque as compared with No Name brand. The results of cheese were in agreement with Farinographic analysis.

It was found that low fat cheese brands offered more resistance against paddles as compared to high fat cheeses. Low fat cheese was more viscous at elevated temperatures, and protein matrix offered more interference in flow and processing of cheese dough. It may be due to mixing geometry of proteins and effect on fat globules size and their distribution. It is in agreement with the reports of Noronha *et al.* (2008b) and El-Bakry *et al.* (2010) about the development of congealed, cohesive protein matrix and homogeneous mass. For interaction effects it was also comparable.

Large fat globules offered resistance at higher temperatures against Farinograph paddles. Therefore, the curve exhibited rising trend in full fat cheese at higher temperatures, whereas low fat cheese showed this trend after some time. The study was conducted on such features that were formerly not investigated, so little information was available in literature and comparison became difficult.

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REFERENCES

BOURNE, M.C., 1982. *Food texture and viscosity: Concept and measurement*. Academic Press, New York.

BRUNO, P., 1999. A slice of pizza history. *Hemispheres,* **10**:128-134.

CAVELLA, S., CHEMIN, S. AND MASI, P., 1992. Objective measurement of the stretchability of mozzarella cheese. *J. Text. Stud*., **23**: 185-194.

EL-BAKRY, M., DUGGAN, E., O'RIORDAN, E.D. AND O'SULLIVAN, M., 2010. Small Scale Imitation Cheese Manufacture Using a Farinograph. *LWT-Fd. Sci. Tech.*, **43**:1079-1087.

EL-BAKRY, M., BENINATIA, F., DUGGAN, E., O'RIORDAN E.D. AND O'SULLIVAN, M., 2011. Reducing salt in imitation cheese: effects on manufacture and functional properties. *Fd. Res. Int*. **44**: 589-596.

GUNASEKARAN, S. AND AK, M.M., 2003. *Cheese rheology and texture*. CRC Press, Boca Raton, FL. pp. 132, 185, 214, 247.

HIÇEŞSAŞSMAZ, Z., SHIPPELT, L. AND RIZVI, S.S.H., 2004. Evaluation of Mozzarella cheese stretchability by the ring-and-ball method. *J. Dairy Sci*., **87**:1993-1998.

KINDSTEDT, P.S., 1991. Functional properties of Mozzarella cheese on pizza: A review. *Cul. Dairy Prod. J*., **26**:27-31.

KINDSTEDT, P.S., 1993. Effect of manufacturing factors, Composition and proteolysis on the functional characteristics of Mozzarella cheese. *CRC Fd. Sci. Nutr.*, **33**:167-187.

KINDSTEDT, P.S., CARIC, M. AND MILANOVIC, S., 2004. *Pasta-Filata cheeses. Cheese chemistry, physics and microbiology,* 3rd edition, Vol 2, Major Cheese Groups. (eds. P.F. Fox, P.H.F. McSweeney, T.M. Cogan and T.M. Guinee), Elsevier Academic Press, California, USA. pp. 251-277.

MCMAHON D., OBERG, C. AND MCMANUS, W., 1993. Functionality of Mozzarella cheese. *Aust. J Dairy Tech*., **48**:99-104.

MULIAWAN, E.B. AND HATZIKIRIAKOS, S.G., 2007a. Rheology of Mozzarella cheese. *Int. Dairy J*., **17**:1063-1072.

NORONHA, N., DUGGAN, E., ZIEGLER, G.R., O'RIORDAN, G.D. AND O'SULLIVAN, M., 2008a. Inclusion of starch in imitation cheese: Its influence on water mobility and cheese functionality. *Fd. Hydrocolloids*, **22**:1612-1621.

NORONHA, N., DUGGAN, E., ZIEGLER, G.R., O'RIORDAN, E.D. AND O'SULLIVAN, M., 2008b. Investigation of imitation cheese matrix development using light microscopy and NMR relaxometry. *Int. Dairy J*. **18**:641-648.

OLIVARES, M.L., ZORRILLA S.E. AND RUBIOLO, A. C. 2009. Rheological properties of Mozzarella cheese determined by creep/recovery tests: Effect of sampling direction, test temperature and ripening time. *J. Text. Stud*., **40**:300-318.

RIPPE, J.K. AND KINDSTEDT, P.S., 1988. *Preliminary evaluation of objective methods for measuring rheological properties of melted Mozzarella cheese*. *J. Dairy Sci*., **71**:436-458.

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