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Research Article

Stress Relaxation Behavior of Gluten and Bread Dough with Medium-Chain Triacylglycerols (MCT): Comparison with Long-Chain Triacylglycerols (LCT) and Butter

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Abstract: This study investigates the stress relaxation behavior of gluten and bread dough with Medium-Chain Triacylglycerols (MCT), also, comparison with Long-Chain Triacylglycerols (LCT) and Butter. Dough and guten obtained from strong with LCT and Butter, there had a higher G (t) and H (τ) over the whole relaxation time than those from the MCT dough. This indicates that it has a stronger network structure. He stress relaxation curves of gluten with MCT, which effect of temperature was not observed most of the time. On the other hand, in the case of butter and LCT, changes were observed in the relaxation curve temperature rises both. Results from these, it has a useful functionality to network formation of gluten has been clarified that MCT.

Keywords: Butter, Dough, Gluten, Long-Chain Triacylglycerols (LCT), Medium-Chain Triacylglycerols (MCT), stress relaxation

INTRODUCTION

Medium-Chain Triacylglycerols (MCT) composed exclusively of medium chain fatty acids (C8 and C10) were first used in the 1950s for dietary treatment of malabsorption syndromes caused by rapid absorption. Since then, they have been widely studied. Although a large number of excellent reports have been published, most of these focus on clinical nutritional or biochemical standpoints (Seaton *et al*., 1986; Lavau and Hashim, 1978; Gelebter *et al*., 1983; Chanez *et al*., 1991; Kris-Etherton and Yu, 1997; Kritchevsky and Tepper, 1965; Leveilie *et al*., 1967; Ecelbarger *et al*., 1991; Papamandjaris *et al*., 1998). In contrast, very few studies have been conducted from a food science standpoint.

Wheat gluten proteins mainly comprise gliadin and glutenin (Schofield, 1986). During dough mixing; gluten proteins are hydrated and form a three-dimensional network. Which is responsible for the unique viscoelastic property. One of the factors that determine the quality of the bread is gluten formation degree. It is considered sufficiently likely during gluten formation in the gliad in and gluten in, lipids are involved particularly large. However, it is not understood in this regard. We have previously reported (Toyosaki *et al*., 2010, 2013), MCT has been implicated as an important factor that influences this phenomenon. Already, MCT has reported that it has the function of excellent properties for the dough. However, it is not clear with respect to the mechanism of action for the dough or gluten and MCT. It is determined that possible by the means clarify this problem, the physical theory techniques, to measure the stress relaxation primarily.

The objective of this study was to investigate the effects of MCT on the bread dough, gluten, stress relaxation behavior, also, comparison with Long-Chain Triacylglycerols (LCT) and Butter.

MATERIALS AND METHODS

Materials: Materials were purchased from the following sources. Medium-Chain Triacylglycerols (MCT) and Long-Chain Triacylglycerols (LCT) were a kind gift from Nisshin OilliO Group Ltd., (Kanagawa, Japan). Spring wheat flour (Super King; 13.8 proteins, 0.42 ash, 14% water) was obtained from Nisshin Flour Milling Inc. (Chiyoda, Tokyo, Japan). The contents of protein, ash, lipid and water were 13.1% (Kjeldahl, N×6.25), 0.4, and 1.8 and 15.0%, respectively. More than 95% of the flour granules were sifted though the sieve of 132-mm mesh. Dried yeast (*Saccharomyces cerevisias*) was purchased from S.I. Lesaffre (Marcq-en-Baroeul, France). Other reagents were of special grade and were obtained from Nakarai Tesque, Inc. (Kyoto, Japan).

Preparation of bread dough samples: Bread dough was prepared using commercially available ingredients

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for preparing bread dough and by employing the straight dough method. More specifically, dough was prepared using ingredients for preparing a loaf of bread, i.e., lipid, strong flour, live yeast, water, sugar, salt and skimmed milk powder. The lipids used in this experiment were MCT, LCT and butter. The added lipid content was 10%. Dough temperature at the completion of mixing was 26°C and the dough was fermented for 90 min at a temperature of 28 to 30°C. The dough was then molded and the molded pieces were subjected to final fermentation for 60 to 70 min at a temperature of 36°C and a humidity of 75%, followed by baking for 35 to 40 min at temperatures of 230°C (top of oven) to 210°C (bottom of oven). Dough subjected to only primary fermentation was also used in this experiment.

Preparation of gluten samples: Gluten was separated from bread dough samples as follow; bread dough was then removed in a sieve and washed with distilled water for 20 min by hand until the gluten was obtained. After washing, the gluten was frozen in liquid nitrogen and freeze-dried. The freeze-dried gluten was ground and sieved using a 250 μm sieve. This sample (100 g) was defatted (four times) with 500 mL of chloroform under magnetic stirring for 20 min, filtered under vacuum, then dried in an air cupboard overnight.

Stress relaxation test: Stress relaxation test was determined according to the produce of Del Noblie *et al*. (2007). Stress relaxation behaviors samples were measured over 2000 sec at 8% strain with strain rise time 0.1 sec, at 25°C. After the sample was loaded on the rehometer (Model: RE-3305S, YAMADEN Co., Itd., Tokyo Japan), the excess sample was trimmed off with a razor blade. The dough edges were coated with a thin layer of silicone oil to prevent drying. The sample was taken. The stress relaxation curve was plotted as $G(t)$ versus test time (sec), were $G(t)$ is the relaxation modulus (stress/stain) at any time. The corresponding relaxation spectrum was calculated from the relaxation modulus by the software using Alfrey's rule (Alfrey and Doty, 1945):

$$H(\tau) = -(dG(t)/dlnt)\ lt = \tau$$

where, τ is the relaxation time and the value $H(\tau)$ in the spectrum represents the intensity of relaxation process at that particular time on a logarithmic scale. The rapid application of strain (5% with a rise time of 0.1 sec) can give rise to inertial effects such as force oscillations that can distort the data and lead to an inaccurate relaxation spectrum at short times. Data below half of the rise time (0.05 sec in this case) probably do not represent the true distribution of relaxation times (Rao *et al*., 2001). Therefore, the $G(t)$ and $H(\tau)$ at times <0.05 sec were plotted by a light line and the test time 0.05 sec was indicated by a vertical arrow at 0.05 sec in Fig. 1 to 7.

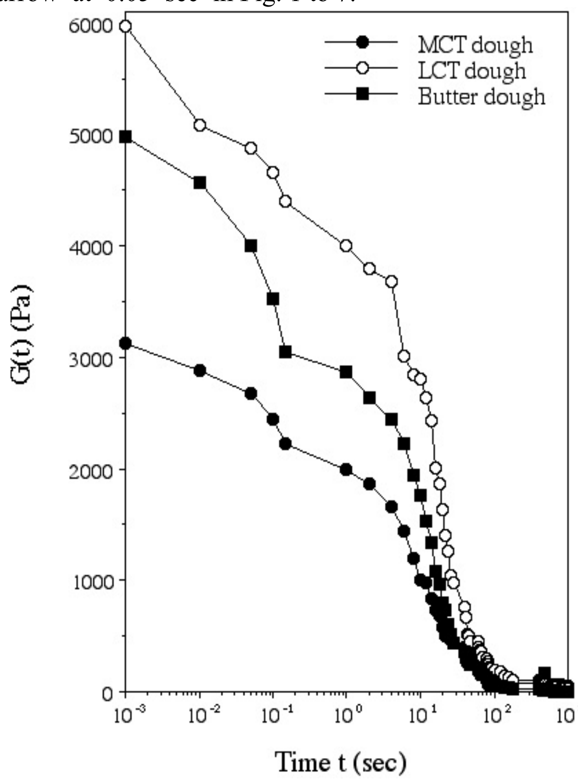

Fig. 1: Stress relaxation curves for bread dough with MCT, LCT and butter

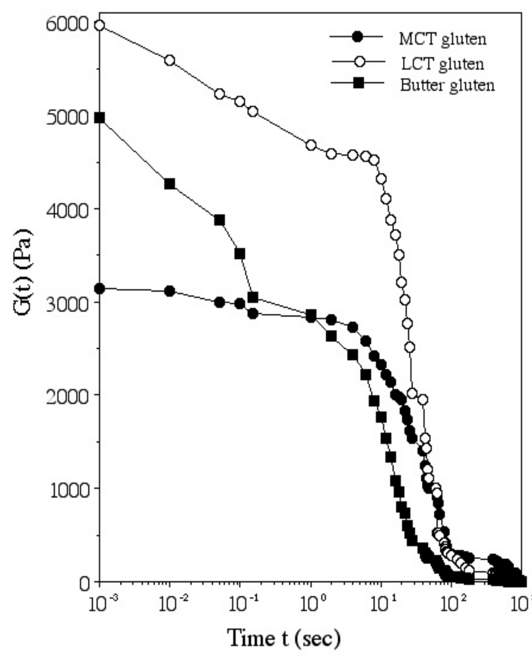

Fig. 2: Stress relaxation curves for gluten with MCT, LCT and butter

Statistical analysis: Statistical analyses were performed using GraphPad PRISM (Ver.4.0) software (GraphPad Software. Inc., California USA). Results were means of triplicate separated tests of each sample and standard deviations <10% for test time at 0.1 sec.

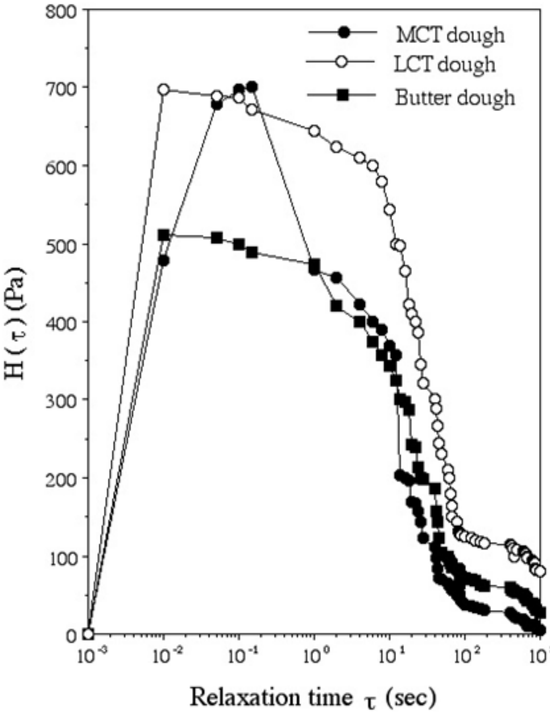

Fig. 3: Stress relaxation spectra for bread dough with MCT, LCT and butter

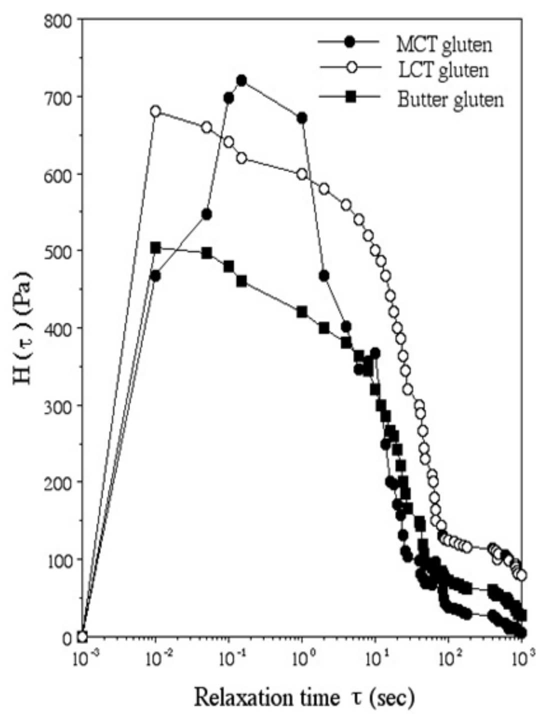

Fig. 4: Stress relaxation spectra for gluten with MCT, LCT and butter

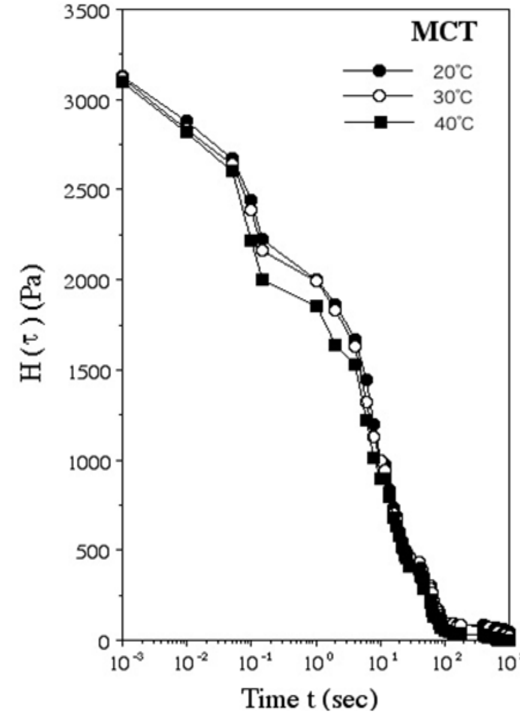

Fig. 5: Effects of temperature on the stress relaxation of gluten with MCT

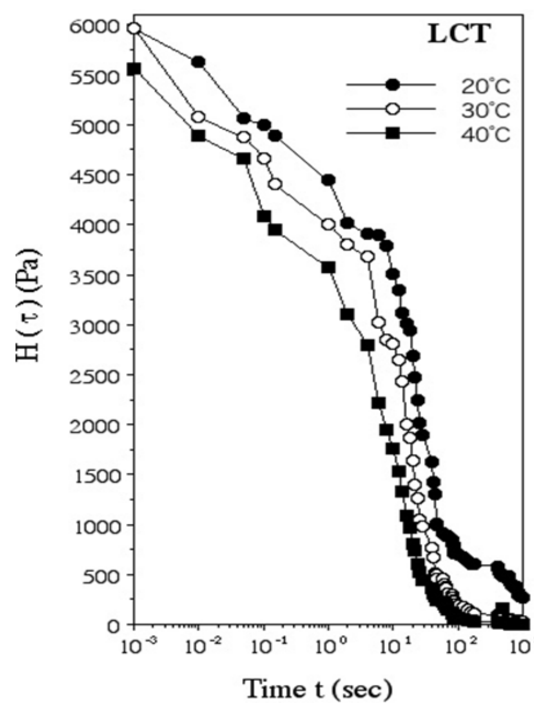

Fig. 6: Effects of temperature on the stress relaxation of gluten with LCT

RESULTS AND DISCUSSION

Stress relaxation of bread dough and gluten: The stress relaxation curves of bread dough and gluten with

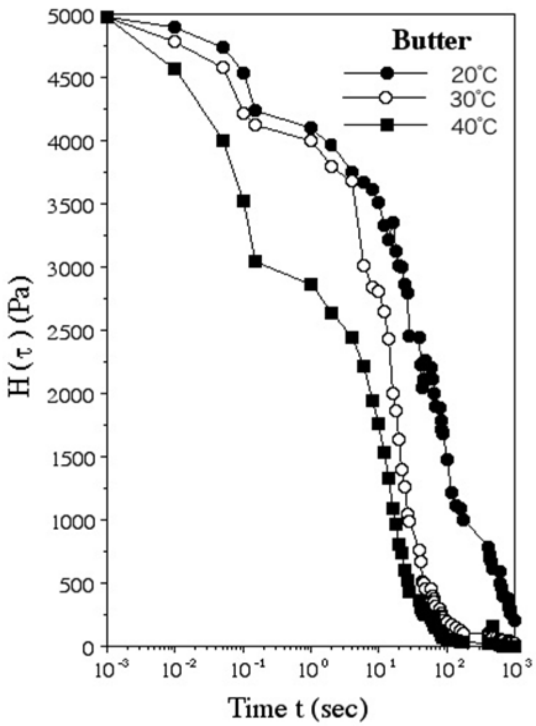

Fig. 7: Effects of temperature on the stress relaxation of gluten with butter

MCT, LCT and Butter, plotted as relaxation moduli *G* (*t*) versus time (sec) are shown in Fig. 1 and 2 and the corresponding relaxation plotted are shown in Fig. 3 and 4. From the relaxation curves and relaxation plots for these MCT, LCT and Butter doughs, three relaxation processes were distinguished over the whole relaxation time: one occurring at short relaxation times and another occurring the longer relaxation times from 10^0 to 10^3 sec. Respectively, which is typical relaxation behavior for polymer with a broad molecular size distribution and network structure. Dough obtained from strong with LCT and Butter, there had a higher *G* (*t*) and *H* (*τ*) over the whole relaxation time than those from the MCT dough. This indicates that it has a stronger network structure.

From the results shown the relaxation behavior of bread dough and gluten shows two relaxation processes that occurred at short relaxation times and the longer relaxation times from 10^0 to 10^3 sec, respectively, which is typical relaxation behavior for polymers with a broad molecular size distribution and network structure. As molecules that powerful this network structure, the possibility that fatty acids are involved deeply can be considered. Probably, it is presumed from the ratio of unsaturated fatty acid is a constituent fatty acid of LCT often. The relationship between the network structure and fatty acid composition under consideration.

Effects of temperature on the stress relaxation of gluten: Figure 5 to 7 shows the effects of temperature at 20, 30 and 40°C, respectively for stress relaxation of gluten. The stress relaxation curves of gluten with MCT, which effect of temperature was not observed most of the time. This phenomenon is presumed that for saturated fatty acids, it has a high melting point is not observed change in the relaxation curve constituent fatty acids of the MCT. Therefore, in the case of MCT, the influence of temperature was concluded that little stability of the network structure of the gluten. On the other hand, in the case of butter and LCT, changes were observed in the relaxation curve temperature rises both. That is, the tendency of the network structure of gluten is unstable with increasing temperature was observed. This phenomenon suggests that the network structure of gluten becomes unstable due to the temperature change. Since the proportion of unsaturated fatty acids in many cases, the melting point of unsaturated fatty acids is low together, the fatty acid composition of LCT, which then significantly affected the temperature of the gluten network. That the relaxation curve of LCT is highly dependent on temperature can be considered from this. As for the mild curve about the butter, a difference was not confirmed at 20 and 30°C, but a change was confirmed in a mild curve at 40°C. The unsaturated fatty acid, which is a constitution fatty acid of the butter, is big and this phenomenon is more likely to participate. Because LCT is oil and the butter is fats, a grand total with saturated fatty acid and the unsaturated fatty acid of the fatty acid composition has a difference. The fatty acid composition of the butter is considered as ratio one caused by there being relatively many it of the saturated fatty acid. In addition, it stops in a level of the reasoning to the last because I do not measure fatty acid composition. In all, it is guessed that probably constitution fatty acid composition is more likely to greatly influence it. As a result, it is considered that it is a cross-linked structure of the glutelin and gliadin (Schofield, 1986), gluten formation, that the fatty acid plays an important role in this cross-link formation. Be concluded from this result is not possible that the fatty acid is involved in the formation of the gluten network. I would like an exercise for the future.

CONCLUSION

There is a main purpose of this research in solving the food study functional characteristic of MCT. This time, the relation between cloth and gluten formation and MCT was considered by measuring a stress relaxation curve as a means to solve the interaction of gluten and MCT.

LCT and butter were used as a candidate for comparison. As for the bread dough and the stress relaxation test result of gluten containing MCT, the very good result was obtained as compared with LCT and the stress relaxation test result of butter. It has checked that MCT was the lipid excellent in network formation of gluten as one of the reasons the good result was obtained. A possibility of being a factor with fat composition major probably was able to be considered. From now on, it will pursue about a relation with fatty acid composition.

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