Advance Journal of Food Science and Technology 12(9): 498-502, 2016
DOI:10.19026/ajfst.12.3060
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: December 17, 2015 Accepted: March 1, 2016 Published: November 25, 2016

Research Article

Relationship between Maillard Reaction during Bread Baking and Medium-Chain Triacylglycerols (MCTs)

[1]Toshiyuki Toyosaki, [2]Michio Kasai and [1]Yasuhide Sakane
[1]Department of Foods and Nutrition, Koran Women's Junior College Fukuoka, 811-1311, Japan
[2]Central Research Laboratory of the Nisshin OilliO Group LTD 1-Banchi, Shinmei-Cho, Yokosuka Kanagawa, 239-0832, Japan

Abstract: The Maillard reaction during the baking of bread forms (AGEs)**.** The present research confirmed an inhibitory effect on the Maillard reaction for Medium-Chain Triacylglycerols (MCTs)-based fat sources, compared to those for Long-Chain Triacylglycerols (LCTs)-based fat sources. This phenomenon is thought to offer new evidence concerning the manufacture of bread. The C8 and C10 saturated medium-chain fatty acids, which are MCT constituent fatty acids, appeared to be involved in inducing the Maillard reaction during baking, and consequently led to confirmation of new evidence of their inhibitory effect on the Maillard reaction. Investigation of the changes in the physical properties of bread revealed the favorable effects of MCTs and MCT-based fat sources on the hardness and adhesion of bread.

Keywords: Dough, fatty acids, long-chain triacylglycerols, maillard reaction, medium-chain triacylglycerols, physical properties

INTRODUCTION

Research into Medium-Chain Triacylglycerol (MCTs), constituted solely of the medium-chain fatty acids (C8 and C10), was initiated in 1950 through their use in the dietary therapy of malabsorption syndrome induced by rapid absorption. Since then, numerous reports have been made, although most research has been focused on the fields of clinical nutrition or biochemistry (Seaton *et al*., 1986; Lavau and Hashim, 1978; Geliebter *et al*., 1983; Chanez *et al*., 1991; Kris-Etherton and Yu, 1997; Kritchevsky and Tepper, 1965; Leveille *et al*., 1967; Ecelbarger *et al*., 1991; Papamandjaris *et al*., 1998; Toyosaki *et al*., 2008, 2013, 2015a, 2015b). However, little research has been conducted from the field of food science and few research reports were found at this time. Investigation from this discipline is urgent and indispensable.

All foods, incidentally, are inevitably eaten (consumed orally). In this context, even if the effect on the body of a certain food has been shown to have outstanding results in an *in vitro* system, the effect is completely meaningless, unless the outstanding effect is proven for an *in vivo* system. Moreover, foods must be palatable in order to be readily consumed. Once such factors are fully satisfied, then the superior functional characteristics of a food can be exploited. The authors previously identified the inhibition of the Maillard reaction during the baking of bread; however, the mechanism involving MCTs in the Maillard reaction during baking has not yet been clarified. The Maillard reaction is considered to be a large factor in not only the final baked product, but also in the flavor and texture of the bread. The principal purpose of this research, therefore, was to investigate the detailed mechanism of MCTs with respect to the Maillard reaction during bread baking. A number of observations were obtained as a result, which are described here.

MATERIALS AND METHODS

Materials: Medium-Chain Triacylglycerols (MCTs) and Long-Chain Triacylglycerols (LCTs) were a kind gift from Nisshin OilliO Group Ltd. (Kanagawa, Japan). Spring wheat flour (Super King; 13.8% protein, 0.42% ash, 14% water) was obtained from Nisshin Flour Milling Inc. (Chiyoda-ku, Tokyo, Japan). The contents of protein, ash, lipid and water were 13.1% (Kjeldahl, Nx6.25), 0.4, 1.8 and 15.0%, respectively. More than 95% of flour granules were sifted through a 132 mm mesh sieve. Dry yeast (*Saccharomyces cerevisiae*) was purchased from S. I. Lesaffre (Marcq-

Corresponding Author: Toshiyuki Toyosaki, Department of Foods and Nutrition, Koran Women's Junior College Fukuoka, 811-1311, Japan, Tel.: +81-92-581-1538; Fax: +81-92-581-2200

en-Baroeul, France). Other reagents were of special grade and were obtained from Nacalai Tesque, Inc. (Kyoto, Japan).

Preparation and baking of dough: For the preparation of bread dough, commercially available materials were used by the direct kneading method. The dough was made from loaf-bread ingredients (fat, bread flour, fresh yeast, water, sugar, salt, skimmed-milk powder). For the tests, MCTs, LCTs (liquid), and MCT- or LCT-based fat sources were used as the fat component. The added fat content was set at 10%. The bread was kneaded at 26°C, and was allowed to rise for 90 min (28° to 30°C). The final rising was conducted for 60 to 70 min (36°C, RH 75%) after shaping, followed by baking for 35 to 40 min (oven temp.: upper 230°C, lower 210°C). In order to study the effect of fatty acids on bread baking, C8:0, C12:0, C16:0, and C18:0 saturated fatty acids, and C18:1, C18:2, C20:4, and C22:6 unsaturated fatty acids were used in the tests. The added content of fatty acids was set at 2% in the preparation of bread dough.

Measurement of physical properties of baked bread: The hardness and adhesion of baked bread was measured using a rheometer (TPU-25; Yamaden).

Analysis of maillard reaction product: Changes in Browning Products (AGEs) were analyzed by measuring their absorption at 420 nm (brown color development).

Statistical analysis: All data were expressed as the mean ± standard deviation. Statistical analysis was performed using the unpaired student's *t*-test (Kaleida Graph, Ver. 4.0; Synergy software, PA, USA). Differences in mean values among groups were assessed using the Tukey-Kramer multiple comparison test (Instat Ver. 3.0; GraphPad software, Inc., CA, USA). The level of significance was set at $p<0.05$ for all statistical tests.

RESULTS AND DISCUSSION

AGEs of the Maillard reaction during baking: The results of studying the changes in AGEs formed by the Maillard reaction during bread baking are shown in Fig. 1. Compared to LCTs and LCT-based fat sources, MCTs and MCT-based fat sources, consisting of liquid oil, showed a lower trend at 420 nm (formation quantity of AGEs). This result was thought to indicate Maillard reaction inhibition during baking by MCTs and MCT-based fat sources. Wu *et al.* (2011) introduced the principal AGEs in a recent report concerning AGEs. This research, however, did not clarify the structures of AGEs formed during baking. Consequently, future research investigating differences in the characteristics

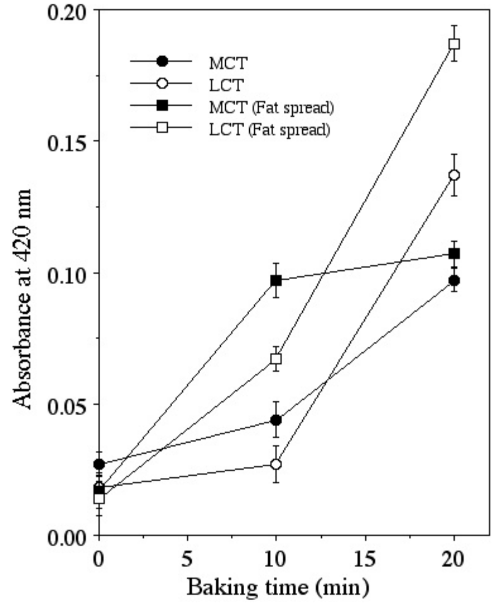

Fig. 1: Changes in the content of AGEs by Maillard reaction during the baking of bread dough

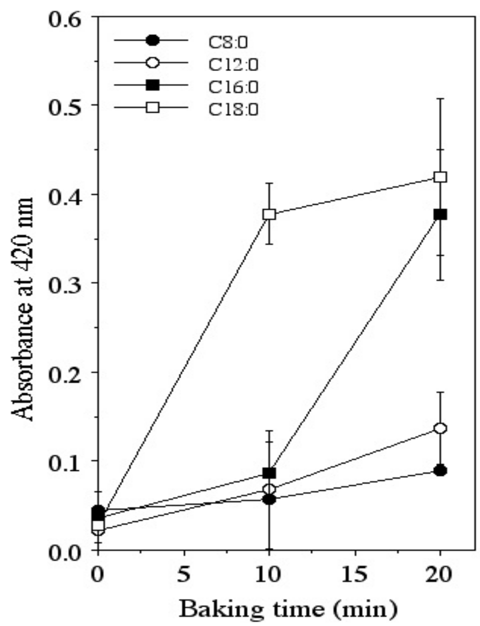

Fig. 2: Change in the browning by Maillard reaction during the baking of dough with added saturated fatty acids

of the fat component, particularly the relationship between fatty acids and the Maillard reaction is warranted.

Change in AGE levels formed by maillard reaction during baking of bough with added saturated or unsaturated fatty acids: The results of studying changes in AGEs formed by the Maillard reaction induced during the baking of bread dough supplemented with various fatty acids are shown in Fig. 2 and 3. In the cases of saturated fatty acids, the

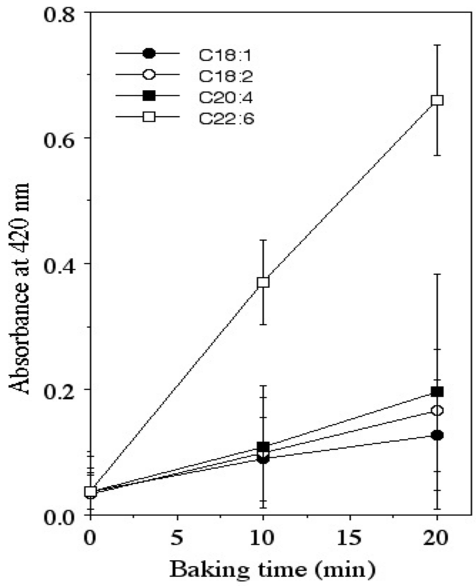

Fig. 3: Change in the browning by Maillard reaction during the baking of dough with added unsaturated fatty acids

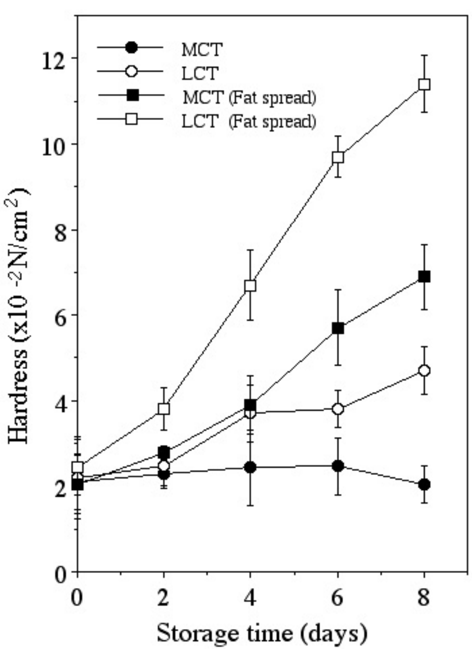

Fig. 4: Change in the hardness of baked bread during storage

quantity of AGEs formed by the Maillard reaction showed an increasing trend with baking time and a greater number of carbon atoms. In the case of dough with added unsaturated fatty acids, the quantity of AGEs formed by the Maillard reaction showed an increasing trend with baking time and greater unsaturation level. According to these phenomena, the change in the number of carbons of the fatty acid is thought to be a major factor in promoting the Maillard reaction in the case of saturated fatty acids. In the case of unsaturated acids, the change in unsaturation level of

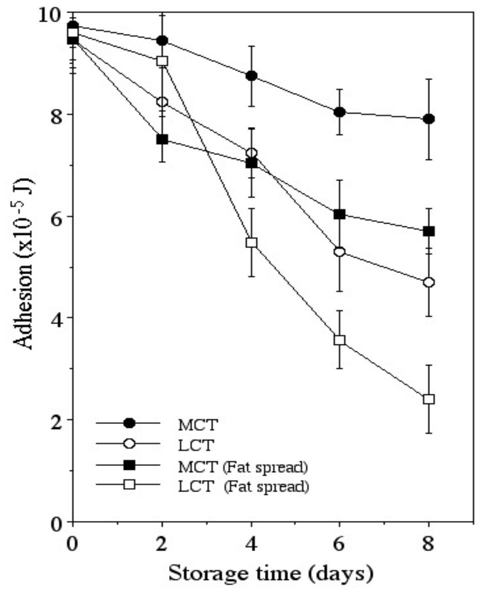

Fig. 5: Change in the adhesion of baked bread during storage

the fatty acid is presumed to be a major factor in promoting the Maillard reaction.

Influence on properties associated with storage condition of baked bread: After storing for 8 days at room temperature (temp. 20°C, RH 75%), changes to the physical properties of bread baked from dough supplemented with MCTs, LCTs, and MCT- or LCT-based fat sources were studied. The results of measuring the hardness of the breads after 8 days of storage are shown in Fig. 4. Both MCTs and LCTS that maintained a liquid form as the fat component provided softer characteristics to the breads compared to breads made with MCT- or LCT-based fat sources. In particular, minimal change in hardness was observed after storing for 8 days in the case of MCTs. Generally, baked bread ages over time", results in a stale taste. If MCTs inhibit this aging phenomenon, the results obtained in this research will be highly applicable to the food industry. Further detailed research in this area is anticipated.

The results of studying adhesion are shown in Fig. 5. Adhesion declines in a storage time-dependent manner. The level of decline, however, was confirmed to be minimal for adhesion with respect to MCTs and MCT-based fat sources, compared to LCTs and LCT-based fat sources. The inhibited aging phenomenon is assumed to have provided greater water retention, consequently further inhibits the aging phenomenon.

Relationship between fatty acids and Maillard reaction: The constituent fatty acid of the added fat content was thought to likely be a large factor in the various changes of MCTs and LCTs with respect to the

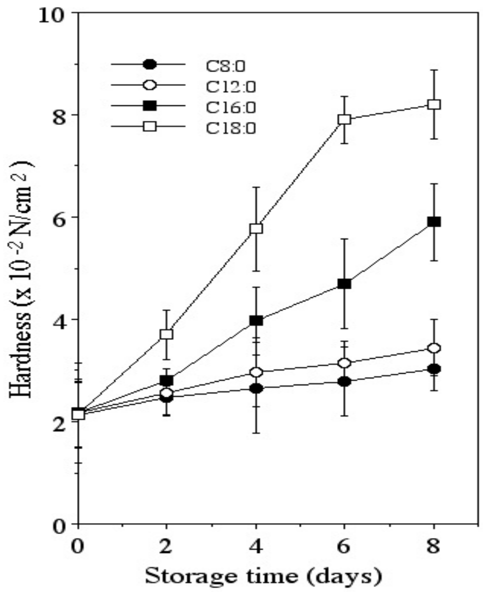

Fig. 6: Change in the hardness of bread with added saturated fat during storage

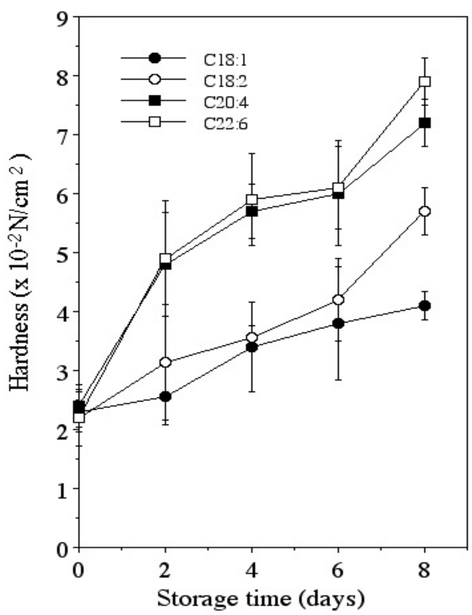

Fig. 7: Change in the hardness of bread with added unsaturated fat during storage

Maillard reaction. Thus, in order to confirm the relationship between the fatty acid and the Maillard reaction, changes in the physical properties of bread stored under constant conditions (temp. 20°C; RH 75%) for 8 days were assessed. Bread was prepared and baked using dough that employed various saturated and unsaturated fatty acids. Four types of saturated fatty acids, C8:0, C12:0, C16:0 and C18:0, were used, and the results showing the change in bread hardness are presented in Fig. 6. The tendency for hardness to increase along with an increase in carbon number was

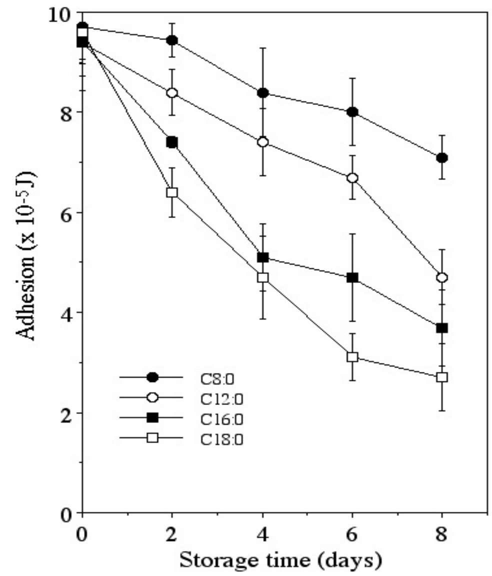

Fig. 8: Change in the adhesion of bread with added saturated fat during storage

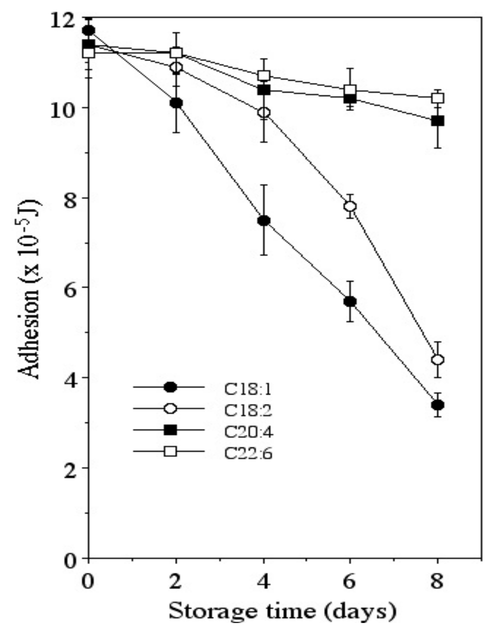

Fig. 9: Change in the adhesion of bread with added unsaturated fat during storage

confirmed. According to the results, the change in carbon number of the fatty acid was proposed to have a large influence on the bread hardness. In addition, four types of unsaturated fatty acids, C18:1, C18:2, C20:4 and C22:6, were used, and the results showing the change in bread hardness are presented in Fig. 7. The tendency for hardness to increase along with an increase in the unsaturation level was confirmed. According to the results, the change in unsaturation level was thought to be a greater factor in bread hardness than the change in the number of carbon atoms.

Next, adhesion was studied for breads with added saturated fatty acid. In Fig. 8, the respective cohesiveness showed a greater decline over the 8 days with increasing carbon number. In the cases of breads with added unsaturated fatty acid. In Fig. 9, a tendency for adhesion to decline more severely over the 8 days was confirmed as the unsaturation level of additive fatty acid declined.

According to these phenomena, the level of saturation or unsaturation of the constituent fatty acids in the fat component was assumed to likely be a large factor in the physical properties of baked bread.

CONCLUSION

There is a main purpose of this research in the relationship between the Maillrad reaction during bread baking and Medium-Chain Triacylglycerols (MCTs). Maillard reactions with at bread baking became clear that acts as a major factor constituting fatty acid composition (saturated and unsaturated degree). In addition, the constituent fatty acid composition, it became clear that you have a major impact on the physical properties after bread baking.

ACKNOWLEDGMENT

This works was supported by a The Tojuro Iijima Foudation for Food Science and Technology to which we are grateful.

REFERENCES

Chanez, M., B. Bois-Joyeux, M.J. Arnaud and J. Peret, 1991. Metabolic effects in rats of a diet with a moderate level of medium-chain triglycerides. J. Nutr., 121(5): 585-594.

Ecelbarger, G.L., J.B. Lasekan and D.M. Ney, 1991. In vivo triglyceride secretion and hepatic and plasma lipids in rats fed medium-chain triglycerides, tripelargonin, or corn oil. J. Nutr. Biochem., 2: 260-266.

Geliebter, A., N. Torbay, E.F. Bracco, S.A. Hashim and T.B. Van Itallie, 1983. Overfeeding with medium-chain triglyceride diet results in diminished deposition of fat. Am. J. Clin. Nutr., 37(1): 1-4.

Kris-Etherton, P.M. and S. Yu, 1997. Individual fatty acid effects on plasma lipids and lipoproteins: Human studies. Am. J. Clin. Nutr., 65(5 Suppl): 1628S-1644S.

Kritchevsky, D. and S.A. Tepper, 1965. Influence of Medium-Chain Triglyceride (MCT) on cholesterol metabolism in rats. J. Nutr., 86: 67-72.

Lavau, M.M. and S.A. Hashim, 1978. Effect of medium chain triglyceride on lipogenesis and body fat in the rat. J. Nutr., 108(4): 613-620.

Leveille, G.A., R.S. Pardini and J.A. Tillotson, 1967. Influence of medium-chain triglycerides on lipid metabolism in the rat. Lipids, 2(4): 287-294.

Papamandjaris, A.A., D.E. Macdougall and P.J. Jones, 1998. Medium chain fatty acid metabolism and energy expenditure: Obesity treatment implications. Life Sci., 62(14): 1203-1215.

Seaton, T.B., S.L. Welle, M.K. Warenko and R.G. Campbell, 1986. Thermic effect of medium-chain and long-chain triglycerides in man. Am. J. Clin. Nutr., 44(5): 630-634.

Toyosaki, T., Y. Sakane and M. Kasai, 2008. Oxidative stability, *trans*, *trans*-2,4-decadienals, and tocopherol contents during storage of dough fried in soybean oil with added medium-chain triacylglycerols (MCT). Food Res. Int., 41(3): 318-324.

Toyosaki, T., Y. Sakane and M. Kasai, 2013. Effects of medium-chain triacylglycerols (MCT) on the maillard reaction. J. Food Process. Technol., 4(4): 224-228.

Toyosaki, T., Y. Sakane and M. Kasai, 2015a. Stress relaxation behavior of gluten and bread dough with medium-chain triacylglycerols (MCT): Comparison with long-chain triacylglycerols (LCT) and butter. Adv. J. Food Sci. Technol., 7(9): 676-680.

Toyosaki, T., M. Kasai, Y. Konishi and Y. Sakane, 2015b. Microstructure formation and rheological properties of bread containing medium-chain triacylglycerols (MCT) and its comparison with long-chain triacylglycerols (LCT) and butter containing bread. Afr. J. Food Sci., 9(5): 342-346.

Wu, C.H., S.M. Huang, J.A. Lin and G.C. Yen, 2011. Inhibition of advanced glycation endproduct formation by foodstuffs. Food Funct., 2(5): 224-234.