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

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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-
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°C 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 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
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 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.

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 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 Maillard 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.

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**REFERENCES**


