STUDIES ON PAN-CAKE BAKING. II. EFFECT OF LIPIDS ON PAN-CAKE QUALITIES

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ABSTRACT

Cereal Chem. 54(4): 918–926

When pan-cake baking tests were carried out with flour extracted with ethyl ether, cake volume was smaller and cake cells were finer than those obtained with the normal flour. Normal cake characteristics were completely restored when 0.2% flour lipids extracted with ethyl ether or water saturated 1-butanol (WSB) were added to the extracted flour. Flour lipids extracted with WSB were fractionated into polar (62%) and nonpolar (38%) fractions by silicic acid column chromatography. Each lipid fraction was added in turn to the extracted flour. Results of the pan-cake baking test showed that 0.2% polar lipid fraction restored cake volume and cell structure, while the nonpolar lipid fraction did not. Addition of fatty acid sucrose ester to the extracted flour also restored cake volume and cell structure, but the addition of acetylated sucrose fatty acid ester or lard shortening had no effect on this restoration. These facts indicated that hydrophilic groups in lipids are necessary for good quality in pan-cakes.

The importance of wheat flour lipids in bread-baking has been recognized for many years in spite of their low content in wheat flour (1). Recent reviews (2–6) show that polar wheat lipids, particularly glycolipids, are effective in improving bread-baking (7–9). The effects of wheat lipids on soft wheat baking quality were tested using the cookie spread method (10,11), but the role of wheat flour lipids in cake baking quality is not known, in part, because the common cake mix formula contains fatty materials which obscure the function of lipids in cake baking. The present study was designed to show the contribution of flour lipid fractions to the baking quality of soft wheat flour through a pan-cake baking test.

MATERIALS AND METHODS

Wheat Flour and Surfactants

Wheat flour used in this study was milled by Nitto Milling Co., Ltd., from western white wheat. Flour was bleached with 0.06 g chlorine gas per 100 g flour. The protein concentration was 7.2%, and ash 0.39%, at 12.8% moisture basis. The fatty acid ester of sucrose employed was a product of Nitto Ester (Dai-Nippon Sugar Mfg., Ltd.) with HLB (Hydrophil lipophil balance) value of 14–15. The lard shortening was Taiyo Yushi Lard Shortening No. 6780 (Taiyo Yushi Co., Ltd.) with a complete mp of 36.0°C.

Preparation of Defatted Flour and Extraction of Lipids

Flour was extracted separately with ethyl ether and WSB. Ethyl ether extraction was performed in a Soxhlet apparatus for 16 hr at 50°C. The WSB extraction was performed three times successively with 6.7, 3.3, and 3.3 volumes of WSB to flour for 4 min, 2 min, and 2 min, respectively, in a Homomixer at room temperature. Lipids extracted with ethyl ether were filtered, evaporated to near dryness under vacuum at 25°C, and kept under vacuum in a dark desiccator at −20°C until used. Extracts from WSB were filtered and evaporated to a small volume at 40° C. In order to exclude nonlipid materials, this condensate was further extracted with ethyl ether, and the ethyl ether layer was evaporated to syrup, as described above. Lipids extracted with WSB were fractionated into polar and nonpolar lipid fractions by the method of Daftary and Pomeranz (12), with slight modification.

Pan-Cake Baking Test

The baking tests were performed on a laboratory scale. The basic formula was composed of 100 g wheat flour, 20 g powdered sugar, 1.6 g sodium bicarbonate, and 2.3 g sodium acid pyrophosphate, unless otherwise stated. The ingredients were sifted into a bowl and then 110 ml water at 24° C was added to the mixture and blended for 30 sec in a Kitchen Aid Mixer (The Hobart Mfg. Co., Model K45) using a flat beater at 112 rpm. The batter (200 g) was placed in an iron pan whose diameter, depth, and thickness were 25 cm, 2.5 cm, and 0.5 mm, respectively, and which had been greased with vegetable oil. The cake was baked in an electric oven at 170°−180° C for 10 min before turning, and then for an additional 3 min. The cake was removed from the pan and cooled for 5 min at room temperature. Cake volume was measured twice by the rapeseed displacement method. Duplicate bakes were made, and repeated again if the volume difference was more than 2%. The standard deviation of cake volume was 3.69 cc with this method. After measuring volume, the cake was halved vertically

TABLE I
Effects of Various Levels of Ethyl Ether Extracted, WSB Extracted, Polar, and Nonpolar Lipids on Pan-Cake Volume

Flour Treatment	Cake Volume cc
Original	472.0
Extracted with WSB	335.0
+ 1.36 g WSB-extracted lipid	320.0
Extracted with ethyl ether	380.0
+ 0.1 g ether-extracted lipid	390.0
0.2	467.5
0.3	470.0
0.4	470.0
0.05 g WSB-extracted lipid	372.5
0.1	397.5
0.2	486.3
0.4	483.8
0.05 g polar lipid	370.0
0.1	370.0
0.2	470.0
0.4	470.0
0.1 g nonpolar lipid	370.0
0.2	370.0
0.4	378.0
0.6	375.0

and the cell structure of each part was recorded and assessed by photograph or by Xerox. The addition of lipids, when necessary, was made by dissolving them in a few ml of chloroform. Chloroform had no effect on pan-cake quality. Two g of lard shortening was added to ethyl ether extracted wheat flour.

RESULTS AND DISCUSSION

Effect of Polar and Nonpolar Lipid in Flour

The lipid contents of wheat flour extracted with ethyl ether and WSB were 0.95% and 1.2%, respectively. WSB extracted more total lipids than ethyl ether, since the 'bound' lipids are more soluble in a polar solvent than in a nonpolar solvent (12).

The WSB extracted flour lipids (13.6 g) were fractionated into polar and nonpolar fractions by silicic acid column chromatography. The nonpolar lipid fraction was eluted with chloroform and the polar lipid fraction was eluted with methanol. The amounts of nonpolar and polar lipids obtained from 13.6 g of WSB extracted lipids were 4.25 g and 6.48 g, respectively, with 78.9% recovery. The elution pattern was checked by TLC. (Solvent system= chloroform:methanol:water, 65:25:4, v/v/v.)

A pan-cake baked from flour extracted with WSB or ethyl ether had significantly smaller volume and finer grain of crumb cells than a pan-cake baked from the control flour. Addition of 1.36 g of WSB lipids to WSB extracted flour did not restore the original baking potential (Table I, Fig. 1). However, addition of 0.2 g of WSB lipids or ethyl ether lipids to ethyl ether extracted flour returned the baking potential completely to the control (Table I, Fig. 2a and b).

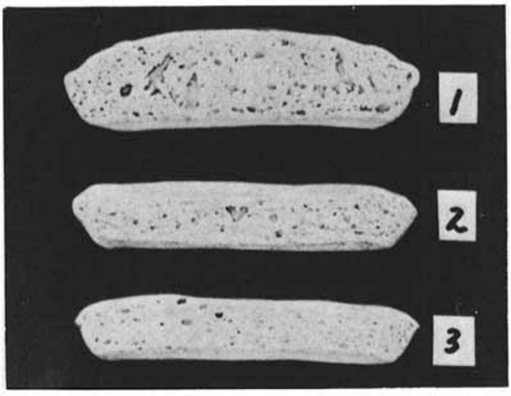


Fig. 1. Pan-cake baked with 1) original flour, 2) flour extracted with WSB, and 3) flour extracted with WSB plus 1.36 g WSB extracted lipid.

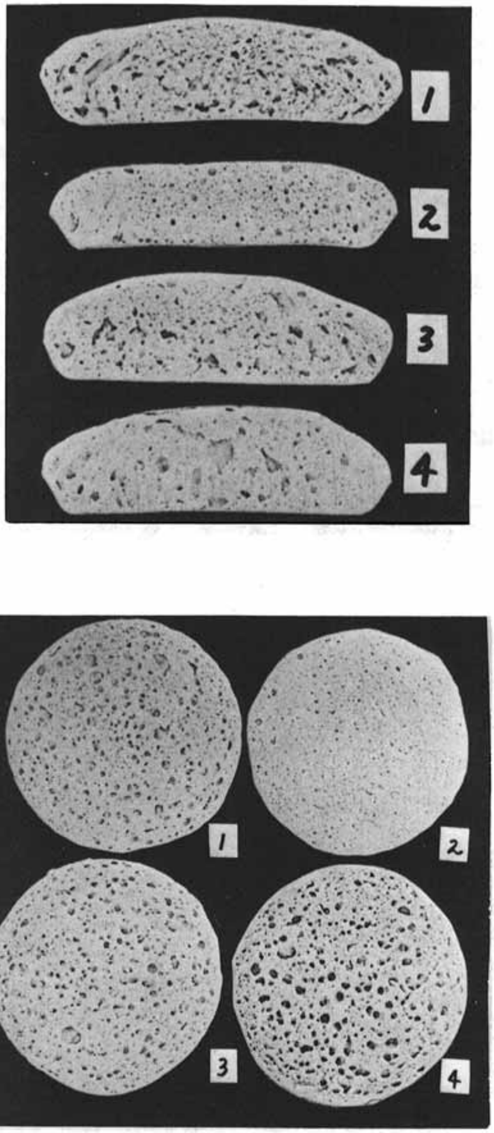
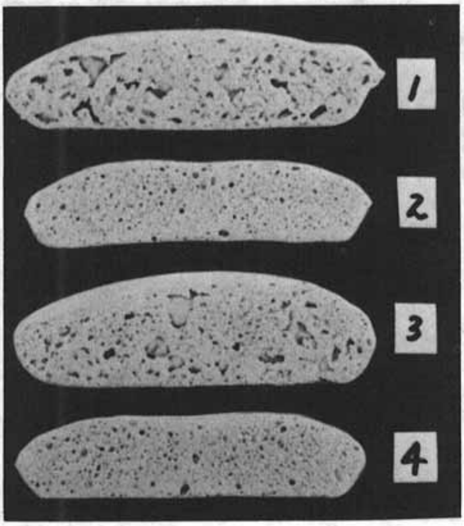


Fig. 2a, b. Pan-cake baked with 1) original flour, 2) ethyl ether extracted flour, 3) ethyl ether extracted flour plus 0.2 g ethyl ether extracted lipid, and 4) ethyl ether extracted flour plus 0.2 g WSB extracted lipid.



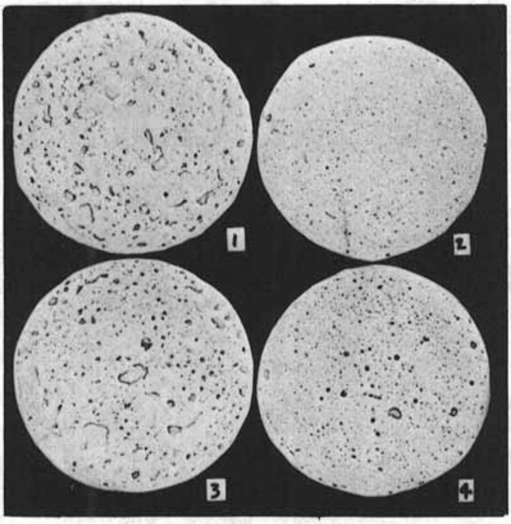


Fig. 3a, b. Pan-cake baked with 1) original flour, 2) ethyl ether extracted flour, 3) ethyl ether extracted flour plus 0.2 g of polar lipid, and 4) ethyl ether extracted flour plus 0.2 g of nonpolar lipid.

Baking tests conducted after the addition of polar or nonpolar lipids to ethyl ether extracted flour indicated that polar lipids restored the baking properties, while nonpolar lipids did not (Table I, Fig. 3).

The effect of incremental additions of WSB extracted lipids, and polar and nonpolar flour lipids on pan-cake volume (Table I) and internal cell structure (Figs. 4, 5a and b, 6a and b, respectively) are readily apparent.

Complete restoration of volume was affected by the addition of 0.2 g WSB or polar lipids per 100 g ethyl ether extracted flour, but nonpolar lipids failed to function similarly. It was unclear why cake volume and cell structure were suddenly restored when 0.2 g of WSB or polar lipids was added to ethyl ether extracted flour, and the addition of more than 0.2 g of lipids did not further increase the cake volume. The effects of sucrose fatty acid ester and lard shortening on pan-cake quality are shown in Table II. The addition of 2 g of sucrose fatty acid ester to ethyl ether extracted flour restored the cake volume and quality. Sucrose fatty acid ester contains two opposing solvent characteristics, hydrophilic and hydrophobic, of which the hydrophilic character is presumed to have a relation to cake volume and quality. In order to block the hydrophilic character of sucrose fatty acid ester, the compound was acetylated (13). Addition of the treated ester to ethyl ether extracted flour showed that the ester had lost its functionality in restoring cake volume (Table II) or cell structure. Addition of 2 g of the nonpolar lard shortening to ethyl ether extracted flour also failed to restore cake volume (Table II) or cell structure.

These results clearly indicated that an amount of polar lipids was necessary to form complete cake volume and cell structure with the ethyl ether extracted

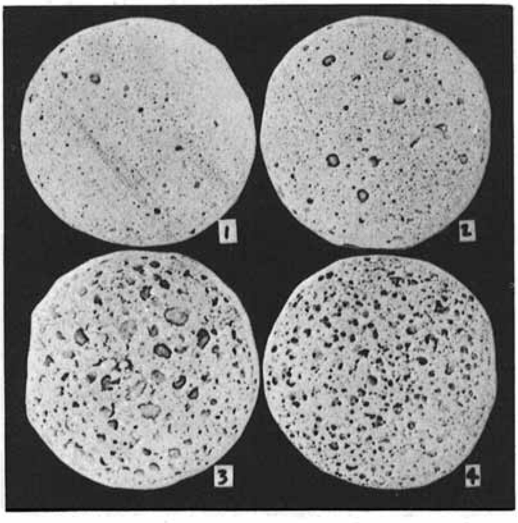
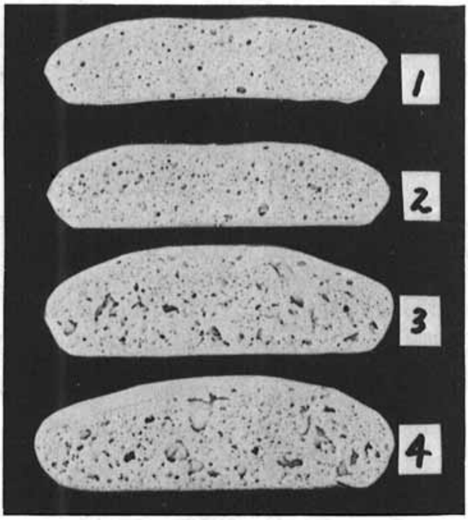


Fig. 4. Pan-cake baked with ethyl ether extracted flour plus 1) 0.05 g, 2) 0.1 g, 3) 0.2 g, and 4) 0.4 g of WSB extracted lipid.

flour, but not with the WSB extracted flour. The original cake volume did not increase even if wheat lipids were added to nondefatted wheat flour (data were not shown here); it was suggested that the amount of lipids which were necessary to cake formation are contained in wheat flour. In case of breadmaking,



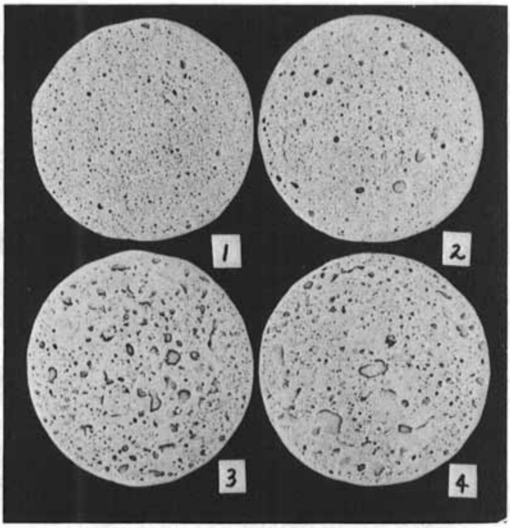
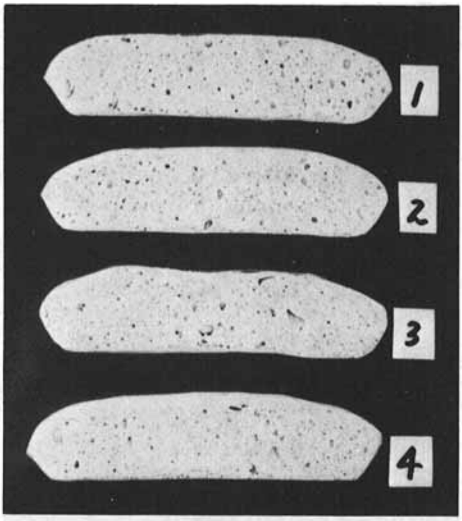


Fig. 5a, b. Pan-cake baked with ethyl ether extracted flour plus 1) 0.05 g, 2) 0.1 g, 3) 0.2 g, and 4) 0.4 g of polar lipid.

Pomeranz (3) reported that the addition of vegetable shortening or wheat lipids to nondefatted or defatted flour was effective on bread volume and quality, and Daftary *et al.* (5) reported that the effects of lipids on breadmaking might be dependent on interaction with wheat protein. In pan-cake baking, however,



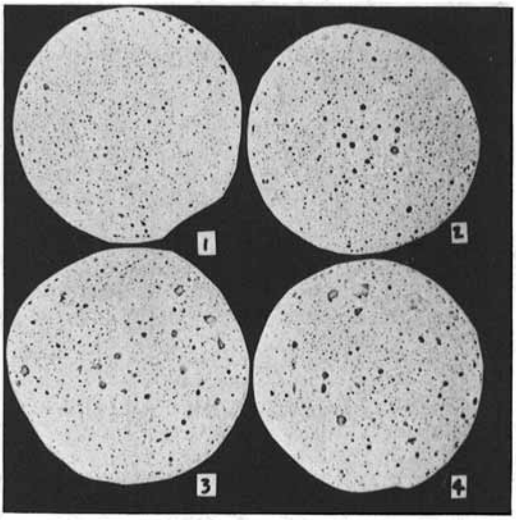


Fig. 6a, b. Pan-cake baked with ethyl ether extracted flour plus 1) 0.1 g, 2) 0.2 g, 3) 0.4 g, and 4) 0.6 g of nonpolar lipid.

TABLE II
Effects of Sucrose Fatty Acid Ester, Sucrose Fatty Acid Ester Acetate, and Lard Shortening on Pan-Cake Volume

Flour Treatment	Cake Volume cc
Original	472.0
Extracted with ethyl ether	380.0
+ 2 g sucrose fatty acid ester	485.0
+ 2 g sucrose fatty acid ester acetate	382.5
+ 2 g lard shortening	370.0

polar lipids might have a much greater effect on starch gelatinization properties than on flour protein, and thus, account for the different response of pan-cakes and bread to lipids.

Acknowledgments

We are grateful to M. A. Rashid in our laboratory for help in the preparation of this manuscript, and to W. T. Yamazaki and L. T. Kissell for many helpful criticisms and suggestions.

Literature Cited

1. MACMURRAY, T. A., and MORRISON, W. R. Composition of wheat flour lipids. J. Sci. Food Agr. 21: 520 (1970).
2. MECHAM, D. K., and PENCE, J. W. Flour lipids: An unappreciated factor governing flour quality. Baker's Dig. 31(1): 40 (1957).
3. POMERANZ, Y. A review of recent studies of wheat flour lipids in breadmaking. Baker's Dig. 40(6): 44 (1966).
4. POMERANZ, Y., SHOGREN, M., and FINNEY, K. F. Functional breadmaking properties of wheat flour lipids. I. Reconstitution studies and properties of defatted flours. Food Technol. 22: 324 (1968).
5. DAFTARY, R. D., POMERANZ, Y., SHOGREN, M., and FINNEY, K. F. Functional breadmaking properties of wheat flour lipids. II. The role of flour lipid fractions in breadmaking. Food Technol. 22: 327 (1968).
6. POMERANZ, Y., FINNEY, K. F., and HOSENEY, R. C. Molecular approach to breadmaking. Baker's Dig. 44(3): 22 (1970).
7. POMERANZ, Y., SHOGREN, M. D., and FINNEY, K. F. Improving breadmaking properties with glycolipids. I. Improving soy products with sucroesters. Cereal Chem. 46: 503 (1969).
8. POMERANZ, Y., SHOGREN, M. D., and FINNEY, K. F. Improving breadmaking properties with glycolipids. II. Improving various protein-enriched products. Cereal Chem. 46: 512 (1969).
9. POMERANZ, Y. Glycolipid-protein interaction in breadmaking. Baker's Dig. 45(1): 26 (1971).
10. COLE, E. W., MECHAM, D. K., and PENCE, J. W. Effect of flour lipids and some lipid derivatives on cookie baking characteristics of lipid-free flours. Cereal Chem. 37: 109 (1960).
11. KISSELL, L. T., POMERANZ, Y., and YAMAZAKI, W. T. Effects of flour lipids on cookie quality. Cereal Chem. 48: 655 (1971).
12. DAFTARY, R. D., and POMERANZ, Y. Changes in lipid composition in maturing wheat. J. Food Sci. 30: 577 (1965).
13. INOUYE, Y., ONODERA, K., KITAOKA, S., and HIRANO, S. Some fatty acid derivatives of D-glucosamine. J. Am. Chem. Soc. 78: 4722 (1956).

[Received November 22, 1976. Accepted March 23, 1977]