Toast Bread from Defatted Wheat Flour[1]

Y. POMERANZ,[2] A. W. EL-BAYA,[3] W. SEIBEL,[3] and H. STEPHAN[3]

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ABSTRACT

Toast bread was baked from nondefatted and from petroleum-ether defatted flour of medium protein content and strength. The formulation included 5% peanut oil or fat, 0.2–0.4% diacetyltartaric acid esters or lecithin, 0.1–0.2% polar wheat flour or wheat gluten lipids, 0.55% nonpolar wheat flour or wheat gluten lipids, and combinations of 5% fat or oil and emulsifiers or wheat flour lipids. Whereas peanut oil and fat were equally effective in increasing loaf volume, bread baked with fat had significantly superior crumb characteristics. Diacetyltartaric acid esters were more effective than lecithin in increasing loaf volume and in improving crumb characteristics. Polar wheat flour lipids had an intermediate effect. Oil, in combination with emulsifiers or wheat flour polar lipids, improved loaf volume and crumb characteristics. Surfactants, alone or in combination with 5% oil or fat, had a more pronounced effect when added to defatted rather than to nondefatted flour. Increasing the amounts of surfactants within the limits used in this study increased loaf volume and usually improved bread crumb characteristics. When added to defatted flour, wheat flour polar lipids were more effective than nonpolar lipids, which were more detrimental than corresponding lipids extracted from vital commercial gluten. The difference is related to the composition of the extracted and fractionated lipids. Baking scores and softness retention were usually positively related to loaf volume.

The effects of wheat flour lipids in breadmaking have been studied extensively. Since the reports by Pomeranz et al in 1965 and Daftary et al in 1968, several investigators have confirmed that wheat flour polar lipids generally improve loaf volume and bread characteristics and that wheat flour nonpolar lipids impair them (Chung and Pomeranz 1977, 1981; Chung et al 1978; Mecham 1971; Morrison 1978; Pomeranz 1971). Most investigations were conducted with strong flours that were relatively high in protein. The effects of lipids on flours that were relatively low in protein were studied little. The reports on the effects of wheat flour lipids on bread baked from defatted and from nondefatted flours conflict. Little is known about the effects of lipids on shelf life of bread, and there are few comparisons on the effects of wheat flour lipids and commercial emulsifiers. In addition, we are not aware of comparisons of the effects in breadmaking of lipids extracted from gluten and wheat flour. Such comparisons and determinations were made in this study. We recently compared the effects of commercial emulsifiers on products baked with various levels of oil and fat or their combinations (Pomeranz et al 1983). Acceptable bread could be produced with commercial oil in place of fat if commercial emulsifiers were added. The present study also compares the effects of wheat flour lipid fractions on loaf volume and bread characteristics of toast bread baked with or without 5% peanut oil or peanut fat. Toast bread is defined as a baked product containing a maximum of 11% nongrain ingredients (fat, sugars, or both, flour basis) and produced from at least 90% flour (generally wheat) and a maximum of 10% meal. Toast bread contains about 5% fat (Seibel et al 1977).

MATERIALS AND METHODS

Wheat Flour

The commercial wheat flour used in this study had a moisture content of 14.8%. On a dry basis, ash was 0.52%, maltose 2.0%, and protein (N × 5.7) 12.3%. Wheat gluten was 27.7%, sedimentation value 32, and Falling Number 286 sec (all on an as-is moisture basis). Farinogram characteristics were: dough development time, 1.5 min; dough stability, 0.5 min; resistance, 2.0 min; and consistency fall (mixing-tolerance index), 70 units. Extensigram characteristics (after 135 min) were: extensibility, 135 mm; resistance, 590 units; and area under the curve, 130 cm^2. The flour was defatted in 50-kg batches with petroleum ether.

Flour Lipids, Peanut Fat and Oil, and Emulsifiers

For analytical determinations and characterization, flour lipids were extracted in the laboratory, in batches, with petroleum ether. The original free lipid content of the flour (as-is basis) was 0.78% and was reduced in the flour by large-scale extraction to 0.24%. The extracted flour was aerated in thin layers on metal sheets below 40°C until no petroleum ether odor was detected. Lipids were also extracted in the laboratory from commercial vital gluten (Fa. Crespel and Deiters, Ibbenburen, Westfalia) with a 2:1 chloroform-methanol mixture as described by Nierle et al (1981). The peanut oil and fat (hydrogenated peanut oil) were commercial products. The sample of diacetyltartaric acid esters (DAWE) was from Chemische Fabrik Grunau, Illertissen. The soybean lecithin was from Lucas Meyer Co., Hamburg, West Germany. DAWE and lecithin contained 80 and 50% active matter (emulsifier), respectively (manufacturers' data). Added levels are denoted in this report as active matter. The flour lipids and emulsifiers for each bake were thoroughly mixed into 100 g of flour and then blended with the rest of the flour.

Baking Procedure

The toast bread was baked on a laboratory scale from 700 g of flour, 14 g of sucrose, 28 g of bakers' yeast, and 14 g of sodium chloride. Water absorption was optimized by an experienced baker and confirmed by farinograph absorption (centered around the 400-unit line). The dough was mixed in a Stephan mixer (1,400 rpm) for 1 min and allowed to rest at 27°C for 10 min. Then, two equal pieces were scaled and rounded manually, fermented 15 min, shaped by a mechanical molder and panned, proofed at 32°C and 80% rh for 65 min (controls) to 85 min (doughs containing fat emulsifier) and baked for 35 min at 220°C with small amounts of steam. The bread was kept in a constant-temperature-humidity cabinet, and its loaf volume (by the dwarf rapeseed-displacement method), crumb grain, and texture were determined 24 hr after baking. Loaf volume is reported for 100 g of flour (14% mb). For determination of bread softness, the bread was placed into polyethylene bags 60 min after baking and stored for 48 hr in a temperature-humidity-controlled cabinet.

Analytical Methods

Analytical determinations were made according to Standard-Methoden fur Getreide, Mehl, und Brot (1978). Baking scores are calculated on the basis of several loaf volume factor and crumb grain scores. In calculating overall scores, in addition to the baking score, crumb texture, uniformity, and especially elasticity are taken into account. Bread softness was determined by the penetrometer method as described by Maleki and Seibel (1972). All baking tests

[1]Mention of firm names or trade products does not imply that they are endorsed or recommended by the U.S. Department of Agriculture over other firms or similar products not mentioned.

[2]U.S. Grain Marketing Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Manhattan, KS 66502.
[3]Federal Research Center of Grain and Potato Processing, Detmold, West Germany.

were made in duplicate. Loaf volume differences (for 100 g of flour) of at least 30 ml were significant at $P = 0.05$.

Fractionation and Characterization of Lipids

Extracted lipids were fractionated by silicic-acid column chromatography. The silicic acid (Kieselgel 60, Merck Co., Darmstadt, 0.063–0.100 mm) was slurried in chloroform and poured into a glass column. About 100 g of silicic acid was used to separate 4 g of lipids. The lipids were dispersed in chloroform and placed on top of the column. Nonpolar lipids were eluted with chloroform and polar lipids with methanol. Characterization of lipids was made by thin-layer chromatography (TLC) on silica gel G plates with a developing system of chloroform–methanol–water (65:25:4) (Nierle et al 1981). The fractionated lipids were made visible by iodine vapors in the chamber.

RESULTS AND DISCUSSION

TLC of Lipids

Lipids isolated in the laboratory from the nondefatted and defatted flours are shown in Fig. 1 and are compared with lipids that were extracted commercially from the nondefatted flour. Lipids extracted commercially from the nondefatted flour and fractionated in the laboratory by silicic-acid chromatography into nonpolar and polar fractions are also compared (Fig. 2). The presence of some nonpolar lipids is indicated in the polar lipid fraction.

Nondefatted Flours

Loaf volume, crumb grain score, and overall score of nondefatted flour were improved substantially by adding 5% peanut fat or 0.3% DAWE (Table I). Peanut oil increased loaf volume more than did peanut fat, but crumb grain, baking scores, and overall scores were substantially inferior. Lecithin showed limited effectiveness, but polar flour lipids at the level of 0.15% (flour basis) provided significant improvement in all respects. As expected, the effects of total free flour lipids were intermediate between those of nonpolar and polar lipids. When DAWE, lecithin, or wheat flour lipids were added to nondefatted flour baked with 5% peanut fat, the results recorded in Table I were obtained. Only DAWE produced a loaf volume increase and overall improvement significantly above those of the control bread baked with 5% peanut fat. Breads baked from nondefatted flour with 5% peanut oil are entirely different, however (Table I). Adding peanut oil increased loaf volume, but crumb, baking scores, and overall scores were affected little. DAWE and lecithin increased loaf volume and improved crumb grain and overall scores. Flour (total free polar) lipids were highly effective improvers, and flour nonpolar lipids were much less effective. Thus, an interaction between peanut oil and emulsifiers or wheat flour lipids is clearly indicated.

Defatted Flours

The effects of added lipids were somewhat masked by the presence of native free lipids in the nondefatted flour (Table I). Consequently, the effects of added lipids could be seen more clearly in defatted flours, even though the commercially defatted flour contained a substantial amount of residual lipids.

The bread from the defatted flour without added emulsifier, fat, or oil had a slightly larger loaf volume (609 versus 585 ml) and better crumb grain than did the bread baked from the nondefatted flour (compare Table I and II). Whereas adding 5% peanut oil increased nondefatted flour loaf volume (Table I) from 585 to 703

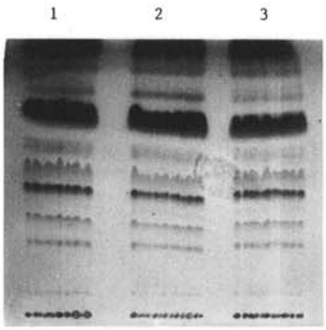

Fig. 1. Thin-layer chromatography of lipids extracted in the laboratory with petroleum-ether from: **1,** undefatted and **2,** defatted flours, and **3,** of lipids that were extracted commercially from the undefatted flour. Thin-layer chromatography separation was on Kieselgel G with chloroform-methanol-water (65:25:4) and was made visible with iodine vapor.

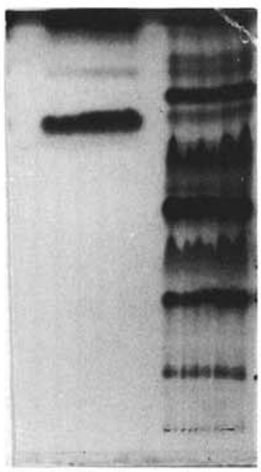

Fig. 2. Thin-layer chromatography of lipids isolated commercially from undefatted flour and fractionated in the laboratory by silicic-acid column chromatography into nonpolar and polar fractions. Thin-layer chromatography separation was on Kieselgel G with chloroform-methanol-water (65:25:4) and was made visible with iodine vapor.

TABLE I
Effects of Emulsifiers and Flour Lipids on Loaf Volume and Characteristics of Bread Baked from Nondefatted Flour

Emulsifiers and Flour Lipids (%, flour basis)	No Oil or Fat			5% Peanut Fat			5% Peanut Oil		
	Loaf Vol (cc)	Crumb Grain Score	Overall Score	Loaf Vol (cc)	Crumb Grain Score	Overall Score	Loaf Vol (cc)	Crumb Grain Score	Overall Score
None	585	5	150	719	6	243	703	4–5	180
0.3 DAWE[a]	762	6–7	243	777	6	246	813	6	266
0.3 Lecithin	608	5–6	163	737	6	235	752	6–7	255
0.15 PL[b]	646	6–7	205	738	6–7	249	817	6–7	283
0.55 NPL[c]	600	6	175	708	6–7	236	720	6	228
0.70 TL[d]	629	5–6	176	717	6–7	240	794	6–7	272

[a] Diacetyltartaric acid esters.
[b] Polar wheat flour lipids.
[c] Nonpolar wheat flour lipids.
[d] Total wheat flour lipids.

ml, defatted flour loaf volume did not increase (Table II). On the other hand, peanut fat was, in most respects, slightly more effective in defatted than in nondefatted flour. But the greatest improvement occurred when emulsifiers and flour lipids were added to the defatted flour. Extracting the free wheat flour lipids and adding DAWE, lecithin, and polar lipids substantially increased loaf volume and improved crumb grain and overall scores. Wheat flour nonpolar lipids were detrimental (Fig. 3). In the series baked from defatted wheat flour with 5% peanut oil (Table II, Fig. 4), DAWE and total free and polar wheat flour lipids improved loaf volume and overall quality and showed synergistic interactions with peanut oil. A similar synergistic effect was shown for polar lipids and oils in nondefatted flour (Table I). Whereas adding 5% peanut oil produced a loaf volume of 613 cc with a score of 175, and adding 0.3% DAWE increased them to 832 and 273, a combination of peanut oil and DAWE yielded a loaf volume of 891 cc and a score of 285 (Table II). The improvement is even larger for polar lipids. They increased loaf volume from 609 to 712 cc, and scores from 185 to 232, but when combined with 5% peanut oil loaf volume was 814 cc and the score 296. Nonpolar lipids were either ineffective (loaf volume) or detrimental (overall score), and total flour lipids were intermediate in their effects.

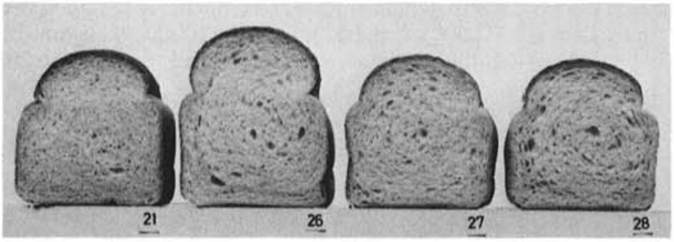

Fig. 3. Characteristics of bread baked from petroleum-ether defatted flour with no additive (No. 21), 0.15% polar wheat flour lipids (No. 26), 0.55% nonpolar wheat flour lipids (No. 27), or 0.70% total wheat flour lipids (No. 28).

Defatted Flours with Various Amounts of Lipids and Emulsifiers

The amounts of emulsifiers used were recommended by the manufacturers; the amounts of wheat flour lipids approximate those that were extracted from the flour in exhaustive extraction in the laboratory and in subsequent fractionation. For additional comparison, we determined the effects of various levels of emulsifiers or lipids; bread was baked with surfactant or lipid levels that were 50% above or below those recommended by manufacturers or present in the flour.

The comparison is given in Fig. 5 for bread baked with defatted flour with DAWE, lecithin, or polar flour lipids. As expected, an increase in emulsifier or in flour lipid level increased loaf volume. The increase was affected little by the presence of 5% peanut oil for DAWE and lecithin but was much greater in the presence of peanut oil for polar wheat flour lipids. The increase of DAWE to 0.4% lowered the overall score. Similar results were obtained for 0.4% DAWE with 5% peanut oil. The large loaf volume increase from adding DAWE was accompanied by a decrease in score, emphasizing the effects of very high loaf volumes on reducing crumb elasticity. No such effect was observed for lecithin or high polar lipid levels (Fig. 6). The high levels of lecithin and polar lipid were, of course, much less effective in increasing loaf volume than was DAWE.

Gluten Lipids versus Flour Lipids

A comparison of polar and nonpolar lipids from gluten and wheat flour on loaf volume and bread characteristics is shown in Table III. Nonpolar lipids from wheat flour affected bread quality more adversely than did nonpolar lipids from wheat gluten when baked from defatted flour. Similarly, wheat flour polar lipids were better improvers than were polar gluten lipids. TLC indicated a higher ratio of phospholipids to glycolipids in gluten than in flour polar lipids (not shown). Because glycolipids are more effective improvers than phospholipids (Daftary et al 1968) the differences in ratios may explain, in part, the difference in effectiveness between gluten and flour polar lipids.

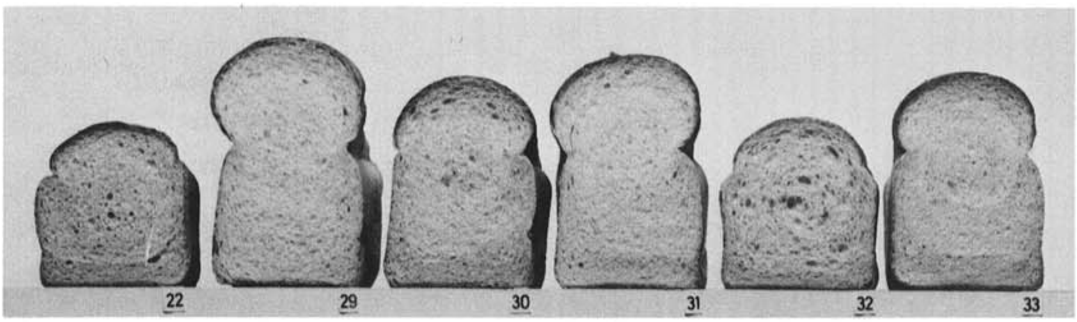

Fig. 4. Characteristics of bread baked from petroleum-ether defatted flour with 5% peanut oil alone (No. 22) plus 0.3% diacetyltartaric acid esters (DAWE) (No. 23), or plus 0.3% lecithin (No. 30) or 0.15% polar wheat flour lipids (No. 31), or plus 0.55% nonpolar wheat flour lipids (No. 32), or plus 0.70% total wheat flour lipids (No. 33).

TABLE II
Effects of Emulsifiers and Flour Lipids on Loaf Volume and Characteristics of Bread Baked from Partially Defatted Flour

Emulsifiers and Flour Lipids (%, flour basis)	No Oil or Fat			5% Peanut Fat			5% Peanut Oil		
	Loaf Vol (cc)	Crumb Grain Score	Overall Score	Loaf Vol (cc)	Crumb Grain Score	Overall Score	Loaf Vol (cc)	Crumb Grain Score	Overall Score
None	609	6–7	185	745	6–7	261	613	6–7	175
0.3 DAWE[a]	832	6	273	823	6	270	891	6	285
0.3 Lecithin	734	5–6	227	771	6	255	720	5–6	210
0.15 PL[b]	712	6–7	232	737	7	262	814	6–7	296
0.55 NPL[c]	577	6	155	730	7	259	620	5	157
0.70 TL[d]	597	5–6	159	734	7	260	774	6–7	255

[a]Diacetyltartaric acid esters.
[b]Polar wheat flour lipids.
[c]Nonpolar wheat flour lipids.
[d]Total wheat flour lipids.

Crumb Softness

Defatting the flour had no significant or consistent effects on softness retention. Generally, as loaf volume increased, softness retention 48 hr after baking increased (Fig. 7). The correlation (0.871) was highly significant at $P = 0.01$. Some simple correlation coefficients were computed between loaf volume, baking and/or overall scores, and penetrometer values (Table IV). The interrelations among the bread parameters indicate that an increase in loaf volume is accompanied by an increase in baking score; that correlation may be reduced if crumb elasticity is also considered (as in the overall score). Similarly, the correlation between penetrometer value is highest with loaf volume and lowest with overall score. The correlation between baking and overall scores is high because both are affected by similar sets of bread parameters (loaf volume and crumb score) that are important in computing the scores.

Adding DAWE had a substantially larger effect on softness retention than did adding lecithin or polar flour lipids (Table V). Oil alone, especially in bread from defatted flour, was less effective

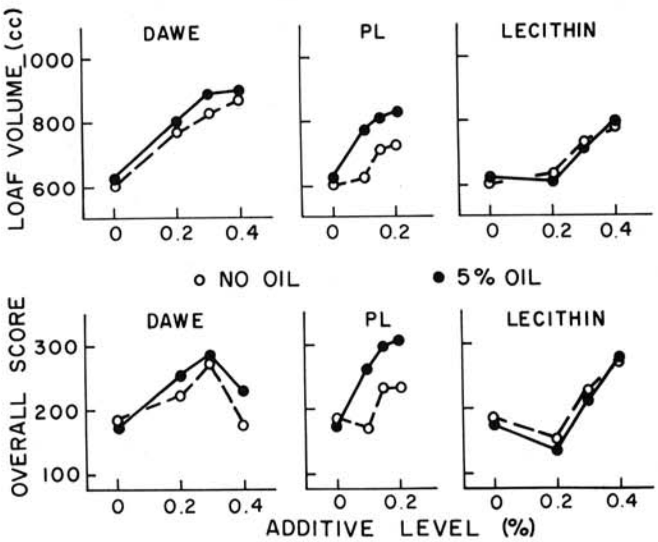

Fig. 5. Effects of increasing diacetyltartic acid esters (DAWE), lecithin, or free wheat flour polar lipid (PL) levels on loaf volume and overall scores of bread baked from defatted wheat flour with or without 5% peanut oil.

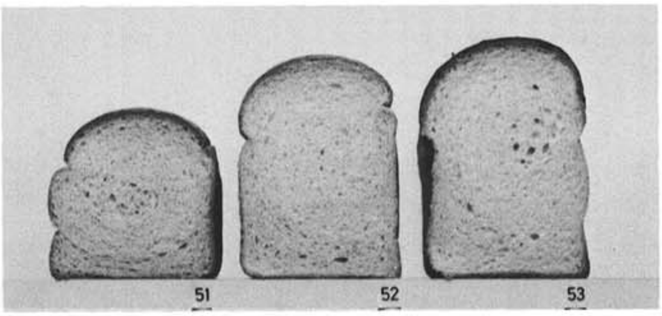

Fig. 6. Characteristics of bread baked from petroleum-ether defatted flour with 5% peanut oil alone (No. 51), plus 0.1% (No. 52) or 0.2% polar wheat flour lipids (No. 53).

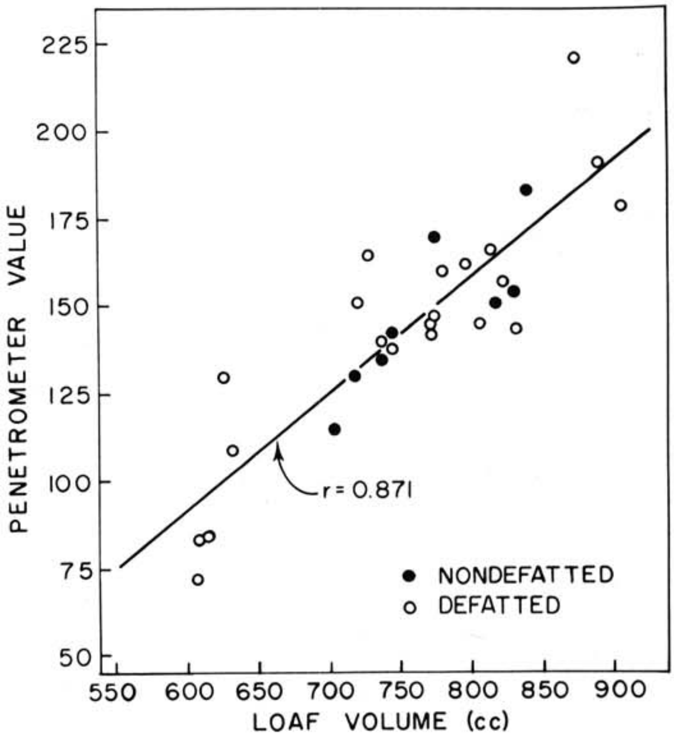

Fig. 7. Correlation between loaf volume and penetrometer values.

TABLE III
Comparison of the Effects of Polar and Nonpolar Wheat Flour and Gluten Lipids on Loaf Volume and Characteristics of Bread Baked from Partially Defatted Flour

Additive (%)	Loaf Vol (cc)	Crumb Grain Score	Baking Score	Overall Score
None	609	6–7	185	185
0.15 Gluten PL[a]	677	6	191	206
0.15 Flour PL[a]	712	6–7	212	232
0.55 Gluten NPL[b]	607	6	163	173
0.55 Flour NPL[b]	577	6	155	155

[a]Polar lipids.
[b]Nonpolar lipids.

TABLE IV
Simple Linear Correlation Coefficients for Some Bread Parameters

Bread Parameters	Nondefatted Flour		Defatted Flour		Total Sum	
	N[a]	r[b]	N[a]	r[b]	N[a]	r[b]
Loaf volume versus						
Baking score	18	0.934***	32	0.926***	50	0.928***
Overall score	18	0.920***	32	0.774***	50	0.813***
Penetrometer value versus						
Loaf volume	8	0.839***	21	0.875***	29	0.871***
Baking score	8	0.685*	21	0.750***	29	0.742***
Overall score	8	0.698*	21	0.514**	29	0.536***
Baking score versus						
Overall score	18	0.968***	32	0.919***	50	0.931***

[a]N = number of samples.
[b]r = simple linear correlation coefficient. * = significant at $P = 0.01$, ** = significant at $P = 0.05$, and *** = significant at $P = 0.01$.

TABLE V
Penetrometer Values of 48-Hr-Old Bread Baked with Oil or Fat and Emulsifiers (% flour basis)

Emulsifier and Level (%)	Flour Type	Penetrometer Units of Bread Baked with: 5% Oil	5% Fat
None	Nondefatted	115	129
	Defatted	84	137
0.3 DAWE[a]	Nondefatted	182	164
	Defatted	191	157
0.3 Lecithin	Nondefatted	171	140
	Defatted	151	142
0.15 PL[b]	Nondefatted	151	135
	Defatted	166	140

[a]Diacetyltartaric acid esters.
[b]Polar wheat flour lipids.

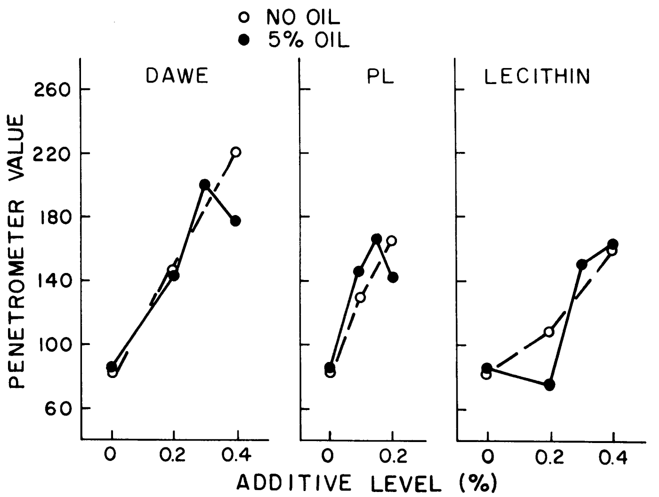

Fig. 8. Effects of increasing diacetyltartaric acid esters (DAWE), lecithin, or wheat flour polar lipid (PL) level on penetrometer values.

in retaining softness than was fat. When emulsifiers were used, bread baked with 5% oil was somewhat softer after 48 hr than bread baked with 5% fat (Table V). Increasing the level of emulsifier in bread baked from defatted flour increased softness in bread baked with or without oil (Fig. 8).

This study confirms that wheat flour polar lipids effectively improve toast bread produced from medium-low protein wheat flours baked with 5% oil or fat. The effects of wheat flour polar lipids are comparable to those of synthetic emulsifiers such as DAWE. The improving interaction of wheat flour polar lipids or emulsifiers with oil is of interest. Whereas fat is effective because of its physical characteristics, such as melting point, oil is effective if its physical and chemical properties are modified by surface-active agents in the form of wheat lipids or synthetic emulsifier. Finally, loaf volume, baking scores, overall scores, and softness retention in toast bread are highly correlated.

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