Technical News Features

Recent Trends in Usage of Fats and Oils as Functional Ingredients in the Baking Industry

OKKYUNG KIM CHUNG and **YESHAJAHU POMERANZ**, USDA/ARS Grain Marketing Research Laboratory, 1515 College Ave., Manhattan, KS 66502

Throughout the history of the human race, cereal grains have been a source of staple food throughout this Earth. Except for the rice-eating countries, bread is the principal food and provides more nutrients than any other single food source. In over half of the countries around the world, bread supplies more than 50% of the total caloric intake.

Even in one of the wealthiest nations, the United States, cereal grain products supply over 25% of the food energy, ca. 20% of the proteins, 14-18% of fats, and over 40% of carbohydrates.

Cereal grain products play an important role in supplying not only the main nutrients but also the minor nutrients such as vitamins, especially B-complexes, and minerals such as iron and calcium (Table I). Therefore, grain products are an important source of essential nutrients in the U.S. diet (1).

Bakery foods are the major grain products available to consumers. Annual total bakery food production was 23 billion lb, of which 65% was breads and rolls. More than 10 billion lb of breads were produced in 1972 and ca. 11 billion lb were produced in 1977 in the United States. The annual per capita consumption of bread in 1977 was 48 lb. This is equivalent to two 1-oz slices of bread per person, per day.

TABLE I

Nutrients from Grain Products

Nutrient	% of nutrients by grain products
Vitamins	
Vitamin A	12-26
Thiamin (B_1)	48
Riboflavin (B_2)	25-38
Niacin	25-42
Vitamin B_6	13-18
Vitamin B_{12}	6-14
Minerals	
Iron	28-43
Calcium	15-26

Summarized data from Pao (1).

Fats and Oils in Bakery Foods

Various types of fats and oils are used by the baking industry. To produce a total of 23 billion lb of bakery goods, more than 1.4 billion lb of shortening were used (2). This amounts to over 33% of total shortening production.

This presentation will review the following items based on work done at various laboratories: changes in consumption of fats and oils in the United States; fatty acid composition of fats and oils; fat requirements in bakery formulation; role of bakery goods in meeting dietary goals and recommendations; and the role of breads in diet and some diseases.

Consumption

The U.S. per capita consumption of total fats and oils increased by 21% from 1965 (21.7 kg) to 1979 (26.2 kg) (Fig. 1). During that period there was a steady decrease in consumption of animal source fats: a 30% decrease in butter consumption and 64% decrease in lard consumption. Consumption of edible vegetable oils increased by 66%; shortening, 34%; and margarine, 16% (3).

During November 1981, more than 1 billion lb (480 million kg) of fats and oils were consumed in the United States. Over 91% of the total fats and oils consumed were from plant origin; 73% of the total was soybean oil.

Shortening

The raw materials for manufacturing shortening have been changing too (Fig. 2). In 1965, more than 30% of the raw

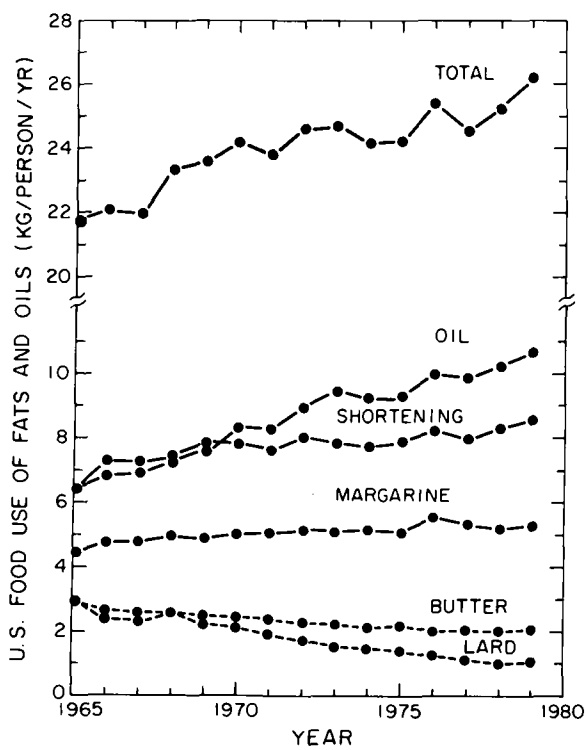

FIG. 1. The U.S. annual per capita consumption of fats and oils in food uses during 1965-79 (3).

materials for shortening production was from animal fats; in 1981, only 21% was from lard and tallow (4,5). The decline resulted primarily from reduced usage of lard.

Among plant oils, the use of soybean oil increased most. Cottonseed oil contributed almost 15% of raw materials in 1965, but only 4% in 1981. In 1975, an unusually large

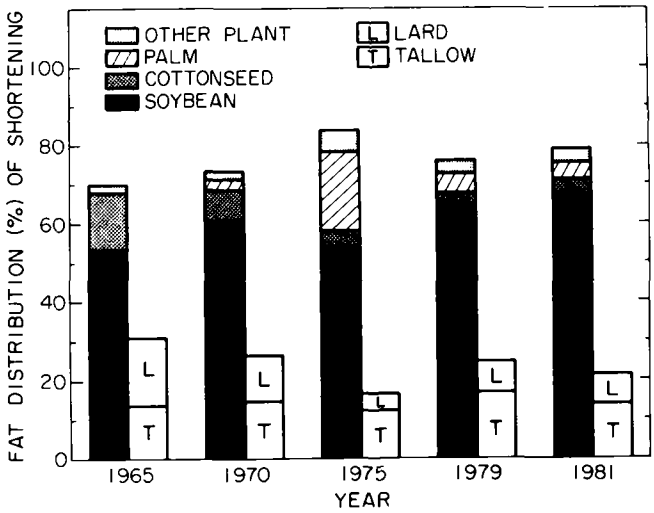

FIG. 2. Fat distribution (%) of shortening production during 1965-81 (calculated and adapted from refs. 3 and 4).

quantity of palm oil was used because of the excessively high cost of soybean oil, resulting from a shortage.

Fatty Acid Content

Although it is generally accepted that vegetable oils are mostly unsaturated, palm oil contains about equal amounts of saturated and unsaturated fatty acids. Coconut oil is nearly all saturated, and safflower or sunflower seed oils are nearly all unsaturated (6). Plant oils vary widely in fatty acid composition and in the ratio of polyunsaturated to saturated fatty acids (PUFA/SFA).

Animals fats are more saturated than most plant oils and the ratios of PUFA/SFA of animals fats are significantly lower than those of plant oils except for palm and coconut oils.

Margarine or shortening manufacturers use different proportions of various source oils and also different processing technologies. Consequently, the fatty acid composition of shortening or margarines varies widely.

Fats in Bakery Formulation

The requirement of fats and formula balance depends on the type of bakery goods (Table II) (3). There also is quite a variation among manufacturers. Pie crust formula requires fats as high as 50-70% of flour weight. Pound cake formula, on the other hand, requires 30-70% fats.

Fat requirements for crackers, rolls and doughnuts are intermediate, ca. 10% of flour weight.

Breads and pretzels require rather small amounts of fats compared to other types of baked goods. Neither sponge cake nor angel food cake requires added fats.

Although bread requires less fats than the other bakery goods, fat content in bread is nutritionally significant because bread consumption is largest of all the bakery goods.

TABLE II

Added Fat Content of Baked Goods

Type of baked goods	Added fats (% flour)
Pie crust	50-70
Pound cake	30-70
Cookies	20-60
Layer/chiffon cake	20-50
Fried pie crust	30
Waffles/pancakes	25-30
Crackers	8-15
Rolls	8-12
Doughnuts	
Yeast-raised	7-16
Cake	6

Summarized data from Chung and Pomeranz (3).

Fats in Bread

For years, the fat predominantly used in bread production was lard. Other types of shortening, such as plastic shortening, have been used to a limited extent. Fluid shortening came into use in the early 1960s (Table III) (7). At present, a third generation of fluid bread shortening is available. In each phase, more surfactants were included in shortening production. In the early 1960s, small amount of monoglycerides (MG) and diglycerides (DG) were included. In the 1970s, the amounts of MG and DG increased and ethoxylated monoglycerides (EMG) and ethoxylated diglycerides (EDG) were included. More recent types of fluid shortening include sodium stearoyl lactylate (SSL) in addition to those surfactants. Fluid shortenings have many advantages over the plastic shortening: they are liquid and therefore pumpable, and their added surfactant imparts several functional properties in addition to shortening effects. To maintain vegetable oils as functional ingredients, a small amount of surfactant is required.

In October 1980, the American Institute of Baking (AIB) conducted a survey of 313 bakeries that produce ca. 50% of U.S. commercial white pan bread. Table IV gives the average formulation ("Revised Formula") used by those bakeries compared to the formula ("Old Formula") determined in a 1964 study by the National Commission of Food Marketing (8).

The major changes in white pan bread formulae were in levels of sweeteners, fats and surfactants, and dairy-type products. Table IV shows changes in fats and surfactants.

Total fat levels dropped to 2.3% from 3.3% of flour weight and, at the same time, the total amounts of surfactants increased to 1.25% from 0.7% (an almost 80% increase). Lard consumption decreased by 80% and soybean oil replaced vegetable shortening and most of the lard in

TABLE III

Fluid Bread Shortenings

Fluid bread shortening type	Development period (year)	Fluid bread shortening composition (%)			
		MG+DG	EMG+EDG	SSL	Soybean oil
I	Early 1960s	2.2-2.8	0	0	97-98
II	Early 1970s	5.0-6.0	4.8-5.5	0	89-90
III	1977	3.4-4.7	4.3-5.8	4.3-5.8	84-88

Adapted data from Smith (7).

TABLE IV

White Bread Pan Formulae

Ingredient	Formula	
	Old	Revised
Flour	100	100
Fats		
Lard	2.6	0.6
Shortening (vegetable)	0.7	0
Soybean oil	0	1.7
Surfactants		
Emulsifier/dough strengthener	0.35	0.75
Miscellaneous dough conditioner	0.35	0.50

Adapted data from Schnake (8).

the white pan bread formula.

Changes in formula altered the total fat content of bread and the PUFA/SFA ratio of bread. As bread formulations are relatively lean, native flour lipids contribute substantially to bread lipids. Flour lipids contributed up to 31% of lipids in bread baked by the old formula and up to 39% of bread lipids by the revised formula. Flour lipids have a high PUFA/SFA ratio and are a good source of polyunsaturated fats.

Soybean oil contains substantially more PUFA than shortening or lard, consequently, 100 g of revised formula bread contains 1.1 g PUFA, whereas 100 g of old formula bread contains only 0.8 g PUFA. According to Davidson and coworkers in England, daily requirement of essential fatty acid is ca. 1 g (9). Therefore, three slices of revised formula bread would contain the daily requirement, assuming PUFA were all in the *cis* form.

The fatty acid balance in wheat or other grain lipids is governed by genetic factors, environmental conditions and cultural practices. The fatty acid balance of fats in baked goods, however, can be controlled more easily by processing ingredients. The balance depends primarily on selecting the right type of fat that has a combination of desirable functional and nutritional characteristics.

Table V (3) shows how different types of fats affect the nutritional quality of whole wheat bread. Three types of fats were selected: no. 1 was a general baking shortening with a low PUFA/SFA ratio (0.4); no. 2 was a fluid shortening for bread baking with a 1.9 ratio; and no. 3 was soybean oil with a 3.8 ratio. When equal amount of fats are added, the PUFA/SFA ratio of bread no. 3 is about three times as high as in bread no. 1.

To supply 1 g of essential fatty acid, three slices of bread no. 1 are required, but only 1.5 slices of bread no. 3 are needed.

TABLE V

PUFA/SFA Ratio in Whole Wheat Formulae

Lipid source and bread type	Total lipids (g/100 g bread)	PUFA/SFA
Whole wheat flour	1.6	3.5
Added fat		
#1 Shortening (general baking)	2.4	0.4
#2 Shortening (fluid baking)	2.4	1.9
#3 Soybean oil	2.4	3.8
Whole wheat bread		
#1	4.0	1.3
#2	4.0	2.7
#3	4.0	3.7

Summarized data from Chung and Pomeranz (3).

Nutrition

Two of the six dietary goals recommended for the United States are to reduce overall fat consumption and to achieve a balance of dietary fats: ca. 30% of food energy should be supplied by fats, of which one-third each should be saturated, monounsaturated and polyunsaturated. About 12% of total food energy should be supplied by proteins and 50% by carbohydrates: 43% should be from complex carbohydrates (such as starch) and 15% from refined carbohydrates (such as sugar).

Among baked goods, bread is uniquely suited to meet such dietary goals. Proteins supply 13 or 15% of bread energy, which is the recommended range. Total carbohydrates comprise 70-77% of bread energy; this is higher than the recommended range, but as refined sugar supplies only ca. 5% of bread energy (lower than the recommended level), complex carbohydrates comprise ca. 70% of bread calories. Fats comprise only 10 or 15% of bread calories. As "man does not live by bread alone," a bread-rich diet can be easily supplemented by foods such as meat, dairy products, eggs, etc., which may be high in saturated fat or cholesterol, and other foods that are high in fat and sugar.

Other baked goods are, in general, excellent sources of energy and fats. In baked goods that require high fat levels, levels and types of fats may govern nutritional characteristics.

Recently, Lorenz (10) reviewed the role of breads in diet and disease. High consumption of regular white pan or high-fiber breads (about 8-10 slices a day) by 20 subjects in Giessen, Germany, resulted in an average weight reduction of 6 kg (13.3 lb) over a four-week period (11). At Michigan State University, seven college men lost an average of 6.3 kg (almost 14 lb) after eating 12 slices of white pan bread daily, and six men lost an average of 8.8 kg (19.4 lb) after eating reduced-calorie high-fiber breads for eight weeks (12).

In 1978, Miranda and Horwitz (13) reported that high-fiber bread diet lowered plasma glucose content. Both Michigan and Giessen studies observed no decrease in plasma glucose with nondiabetic subjects.

Large consumption of breads, especially high-fiber breads, lowered serum cholesterol content: an average 23% drop in the Michigan study (12) and 15% drop in the Giessen study (14). In the Giessen study, there was also a 38% decrease in serum triglycerides (11,14).

Consumption of high-fiber breads by patients with colonic disease was effective in controlling the symptoms (15-17).

Formulations and processing conditions for preparing special dietary breads are available. They include: special breads made with liquid fat composed of saturated fatty acids of C_6-C_{10} chain length for patients with fat malabsorption syndromes (18); low-sodium bread with less than 10 mg of Na/100 g or bread containing other salts as a partial replacer for Na salt for patients with edematous conditions (18,19); bread with hydrolyzed lactose for people with lactose intolerance (20,21); high-fiber bread (22-24); and gluten-free bread with rice or buckwheat flour for patients with celiac disease, nongluten-enteropathy (20,25).

In summary, cereal grains in general and wheat in particular provide an excellent basis for the production of delectable and relatively inexpensive foods. Although general consumption of fats and oils has increased, recent trends in baking industry are to reduce total usage of fats and oils and to replace plastic fats with liquid vegetable oils. To maintain vegetable oils as functional ingredients in baked goods, a small amount of surfactant is required.

Therefore, the recent trends in usage of fats can facilitate tailoring bakery goods to have the right balance of nutrients. implement dietary recommendations, and increase levels of some components such as fiber, essential fatty acids, medium-chain triglycerides, monoglycerides rather than triglycerides, or decrease levels of some components such as salt and milk for people who need special diets for either preventive or therapeutic reasons.

To accomplish those objectives, much interdisciplinary research involving nutritionists, lipid chemists, medical doctors, food scientists and technologists would be required.

REFERENCES

1. Pao, E.M., Food Technol. 35:45 (1981).
2. Jackel, S.S., Baker's Dig. 54:32 (1980).
3. Chung, O.K., and Y. Pomeranz, Advances in Modern Human Nutrition, Vol. III, Roles of Lipids in Health and Diseases, edited by J.J. Kabara, Chem-Orbital Publ. Co., Park Forest South, IL, in press, 1983.
4. U.S. Department of Agriculture, Agricultural Statistics 1980, U.S. Government Printing Office, Washington, DC, 1980.
5. U.S. Department of Commerce, Current Industrial Reports, November, 1981, U.S. Government Printing Office, Washington, DC, 1981.
6. Weihrauch, J.L., C.A. Brignoli, J.B. Reeves, III, and J.L. Iverson, Food Technol. 31:80 (1977).
7. Smith, W.M., Baker's Dig. 53:8 (1979).
8. Schnake, L.D., Wheat Outlook and Situation, November, 1981, 11-14, Economic Research Service, U.S. Department of Agriculture, 1981.
9. Davidson, S., R. Passmore, J.F. Brock and A.S. Truswell, Human Nutrition and Dietetics, 6th edn., Churchill Livingstone, Edinburgh, London and New York, 1975.
10. Lorenz, K., Variety Breads in the United States, edited by B.S. Miller, Am. Assoc. Cereal Chem., St. Paul, MN, 1981.
11. Menden, E., W. Aign and I. Elmadfa, Baker's Dig. 51:43 (1977).
12. Mickelsen, O., D.D. Makdani, R.H. Cotton, S.T. Titcomb, J.C. Colmey and R. Gatty, Am. J. Clin. Nutr. 32:1703 (1979).
13. Miranda, P.M., and D.L. Horwitz, Ann. Int. Med. 88:482 (1978).
14. Steller, W., Baker's Dig. 53:20 (1979).
15. Lorenz, K., and V.A. Lee, Crit. Rev. Food Sci. Nutr. 8:383 (1977).
16. Goldstein, F., J. Am. Diet. Assoc. 60:449 (1972).
17. Kelsay, J.L., Am. J. Clin. Nutr. 31:142 (1978).
18. Lorenz, K., F. Bowman and J. Maga, Baker's Dig. 45:34(1971).
19. Salovaara, H., Cereal Chem. 59:427 (1982).
20. Bowman, F., W. Dilsaver and K. Lorenz, Baker's Dig. 47:15 (1973).
21. Shogren, M.D., Y. Pomeranz and K.F. Finney, Cereal Chem. 56:465 (1979).
22. Prentice, N., and B.L. D'Appolonia, Ibid. 54:1084 (1977).
23. Dubois, D.K., Baker's Dig. 52:30 (1978).
24. Shogren, M.D., Y. Pomeranz and K.F. Finney, Cereal Chem. 58:142 (1981).
25. Nishita, K.D., R.L. Roberts, M.M. Bean and B.M. Kennedy, Ibid. 53:626 (1976).