Steamed Bread. III. Role of Lipids[1]

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ABSTRACT

The effects on volume, compressibility (softness), and overall score of Chinese steamed bread of flour lipids, shortening and vegetable oils, and emulsifiers (hydroxylated lecithin, distilled monoglycerides, and ethoxylated monoglycerides [EMG]) added to an untreated and a petroleum ether defatted soft white wheat flour were determined. Defatting significantly reduced volume and softness of steamed bread. The control, defatted, and reconstituted flours showed a shortening response. Doubling the amount of added free lipids (from 0.86 to 1.72%) had no additional restoring effect beyond that from reconstituting the defatted flour to the original level of free lipids. Shortening at the 2% level provided the best steamed bread; replacing shortening by soybean or corn oil produced comparable breads. In defatted flour, 0.1% EMG and especially 0.2% hydroxylated lecithin, alone or in combination with 2% shortening, increased volume and improved softness; each was superior to shortening alone. Adding 0.1% EMG and especially 0.2% lecithin to defatted flour baked with 1 or 2% corn oil increased volume and softness of steamed bread. None of the combinations among lecithin, EMG, or distilled monoglycerides was superior to any of the single emulsifiers.

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Steamed bread is an important item in the diet of consumers in many Southeast Asian countries. The formula for steamed bread is flour, water, salt, and yeast; it may sometimes include sugar and/or shortening. In rural China, the bread is produced from a starter "mother dough," in place of the yeast. Commercial steamed bread is commonly made in a sponge and dough system with fermentation times of 3-4 hr.

A study by Faridi and Rubenthaler (1983) found significant differences in suitability to produce acceptable Chinese steamed bread among Pacific Northwest (United States) soft white and club wheats of medium to low flour strengths. Generally, the higher the protein within a cultivar, the better the steamed bread quality. Preston et al (1986) studied the effects of flour extraction rates of Canadian wheats on the performance of steamed bread. Rather stiff doughs were rested for 30 min and proofed for 30 min before steaming.

Lukow et al (1990) studied the potential of high-protein wheats (average flour protein of 13.2%) from Canada and the People's Republic of China for producing pan bread and steamed bread. The pan bread was prepared using a relatively rich formula from doughs mixed to optimum with optimum water absorption. The steamed bread was made from lean (1% sugar), stiff doughs (50%

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water absorption) mixed for a fixed time. The authors concluded that similar factors govern quality of pan and steamed bread: high protein and high gluten strength. In contrast, McMaster and Moss (1989) reported that wheat flour of medium to low strength with a protein content of 9.5–11% yielded the best steamed bread. Optimization and evaluation of Chinese steamed bread were described by Shi et al (1990a,b). Best results were obtained from flours in which the ash content was below 0.65%, the protein around 10.7%, and the falling number above 250.

Rubenthaler et al (1990) studied the characteristics of traditional soft Chinese steamed bread, using combinations of formula ingredients and fermentation and proofing procedures. Properties sought in the finished steamed bread were a large volume with a soft, moist, and uniformly fine-textured crumb and a smooth, semiglossy and white surface. These properties were affected by dough water absorption and mixing time, sugar-yeast combinations, and corresponding fermentation and proof times. A response surface methodology program determined an optimum formula with 8% sugar and either 1.0% instant active dry yeast or 1.5% fresh baker's yeast with 3.5 hr of fermentation, 58 min of proof, and 10 min of steaming. Wheat cultivar, class, and year or location influenced steamed bread quality. Breads of satisfactory quality were made by using either a sponge and dough or a straight dough procedure.

In a study by Addo et al (1991), flours from hard and soft wheats were compared in making pan bread and steamed bread under optimized conditions. Protein content was important in the production of acceptable steamed bread (especially from low-protein soft wheat flours). High flour strength, as determined by physical dough tests, was desirable in production of pan bread (especially from high-protein hard wheat flours) and detrimental in production of steamed bread.

The role of wheat flour lipids in yeast-raised bread has been the subject of many investigations (Pomeranz 1985, 1987, 1988). Defatting of wheat flour impaired loaf volume and crumb grain of bread baked from the flour (Chung et al 1980, 1982). Whereas the addition of nonpolar lipids further damaged the quality of defatted flour, the addition of polar lipids increased loaf volume and improved texture. Glycolipids were more beneficial than phospholipids. Shortening, fat, or a combination of vegetable oil and emulsifiers is an essential ingredient in breadmaking. In commercial bakeries, these are added to facilitate dough handling and processing, to improve loaf volume and crumb grain, and to prolong shelf life. The term "shortening effect" is used to describe an increase in loaf volume and an improvement of crumb grain from the addition of 0.7–3.0% shortening or hardened vegetable fat. In defatted flour, however, shortening has a detrimental effect on loaf volume and crumb grain (Chung et al 1980). The detrimental effect is related to the amount of polar lipids removed from the flour during defatting.

We know of no published studies on the role of wheat flour lipids, shortening, or emulsifiers on the quality of Chinese steamed bread. Such an investigation is the subject of this study.

MATERIALS AND METHODS

The commercial soft wheat flour (160 g, 8.3% protein, 0.41% ash, 14% mb), 1% instant active dry yeast, 8% sucrose, 1 g of salt, and 0–2% shortening were mixed for 2.7 min (optimum for control flour) with 54.5% water. The dough was fermented 3.5 hr at 300°C, proofed 58 min, steamed 10 min, and evaluated as described previously (Rubenthaler et al 1990).

Free lipids (0.86%) were extracted from the flour with petroleum ether, bp 38–57°C, by a Soxhlet for 24 hr. The defatted flour was air dried at room temperature in a hood until solvent odors were no longer detected and was then sifted through a 100-mesh sieve (with 149-μm openings). The solvent in the petroleum ether extract was removed under vacuum in a rotary evaporator. Defatted flour was reconstituted (whenever appropriate) with lipids in a mortar. The moisture contents of the defatted or reconstituted flours were raised to about 14% by placement in a high-humidity cabinet for about 20 hr at 30°C and 98% rh.

The shortening (a vegetable product, partly hydrogenated, with a melting point of 41°C), corn oil, and soybean oil were commercial products. The emulsifiers included ethoxylated monoglycerides (EMG), sodium stearoyl lactylate, distilled monoglycerides (DM), and diacetyl tartaric acid esters of mono- and diglycerides from Grindsted Products, Inc., Industrial Airport, KS. The DM were added to the dough after hydration (in part of the water) according to the manufacturer's instruction. All the other emulsifiers were added directly at the dough mixing stage.

Ryoto sucrose fatty acid esters were obtained from Mitsubishi-Kasei Food Corporation, Tokyo, Japan. The three samples used in this study contained fatty acids derived from hydrogenated edible tallow. The stearic acid content was 70%; hydrophilic-hydrophobic balance values and monoester contents were 11 and 55%, 15 and 70%, and 16 and 75%, respectively. A total of 10 samples of lecithins (regular, deoiled, low viscosity, concentrate spray dried with milk components, and hydrophilic-water dispersible) was obtained from ADM, Decatur, IL; Central Soya, Ft. Wayne, IN; or Lucas Meyer, Decatur, IL.

Protein, ash, and moisture contents were determined by AACC methods (1976). The steamed bread was evaluated as described by Faridi and Rubenthaler (1983) and Rubenthaler et al (1990). All experiments were run at least in duplicate. Differences of 18 cm^3 in volume and of 10 g/cm^2 in compressibility of steamed bread were significant at the 5% level. Compressibility (softness) was determined by the compression test with a Fudometer on bread from which the top 1 cm was cut off; the lower the value, the softer the bread crumb. The bread was scored on a scale of 1 (best) to 10 (worst). The score was based on visual observation of the outside (shape and symmetry, smoothness, stickiness, gloss) and the inside (crumb fineness and uniformity). Overall scores were highly reproducible. Differences of 0.2 were significant at the 5% level; average scores were rounded off to whole figures. In the series of experiments on the effects of shortening, lecithin, and DM on softness retention during storage, bread was stored in closed plastic containers at room temperature (about 22°C) for 48 hr.

RESULTS AND DISCUSSION

Defatting significantly reduced volume and softness of steamed bread (Table I), indicating that wheat flour lipids are important functional components in baking Chinese steamed bread. The control, the defatted, and the reconstituted flours showed a shortening response. It would seem that, unlike its effect on regular baked bread, shortening can have a beneficial effect on volume, softness, and overall score of Chinese steamed bread independent of the presence of free flour lipids, extracted with petroleum ether.

The overall quality of the defatted flour could be reconstituted, albeit incompletely, by adding the extracted lipids. Doubling the amount of free lipids from 0.86 to 1.72% added to the original or to the defatted flour, had little or no consistent effect on the volume of the steamed bread (data not shown). Doubling the amount of added free lipids made the bread crumb softer, especially if made without shortening, without consistently affecting its overall score.

The results in Table I were obtained on bread made with or without the addition of 2% shortening; that level of shortening provided the highest volume and softness (data not shown).

A comparison of the effects of shortening versus soybean oil or corn oil (in control and defatted flours) is given in Table II. In the control flour, 1 or 2% of soy or corn oil produced bread with a volume comparable to that with 2% shortening; the oil-containing bread was not significantly softer than the shortening-containing bread. No consistent and significant differences were found in volume and softness among the breads from defatted flours with shortening or oil, with the exception of the 2% shortening bread.

Sucrose fatty acid esters at levels of 0.1–0.3%, diacetyl tartaric acid esters of mono- and diglycerides at levels of 0.1–0.4%, and sodium stearoyl lactylate at levels of 0.1–0.4% had no improving effects at low levels and decreased bread volume and firmed the bread crumb at high levels of supplementation (data not shown). Hydrophilic-water dispersible lecithin, when added at levels of 0.1–0.3% to regular flour in the presence of 2% shortening, was superior to the other lecithin products. The data reported in this article are for hydroxylated lecithin, only.

DM at levels of 0.05–0.2% did not improve the softness of the freshly baked bread; they increased bread volume by 39 cm^3 and 40 cm^3 for the 0.10 and 0.15% DM additions, respectively; the increase was only 28 cm^3 for the 0.20% DM addition.

Representatives of two types of polar lipids, lecithin and EMG, were added to regular and defatted flours. With the control flour, 0.1% EMG or 0.2% lecithin had no significant effect on bread volume or softness (Table III). In defatted flour, however, 0.2% lecithin or 0.1% EMG alone (or in combination with 2% shortening) increased volume and made the crumb softer; in both respects, EMG and especially lecithin were superior to shortening alone. The results indicate that lecithin or EMG can replace, in part at least, the polar lipids that are removed by defatting with petroleum ether and that are required in production of satisfactory Chinese steamed bread. In two of the four comparisons in Table III, hydroxylated lecithin was superior to EMG. Commercial lecithins are not well defined products and vary in concentrations and composition of phospholipids; EMG is a relatively pure compound, and differences among products from various manufacturers are relatively small. The amounts of lecithin (0.2%) and EMG (0.1%) were those that gave best results in preliminary studies (data not shown).

Increasing the amount of corn oil added to the control flour from 1 to 2%, in the presence of 0.2% hydroxylated lecithin or 0.1% EMG, lowered the volume of steamed bread (Table IV). An increase in corn oil added to defatted flour increased the volume of steamed bread in the presence of 0.2% lecithin but not in the presence of 0.1% EMG. Adding 0.1% EMG and especially 0.2% lecithin to defatted flour baked with 1 or 2% corn oil increased volume and softness of steamed bread (compare Tables II and IV).

The main function of DM is to prolong shelf life and soften bread. EMG primarily strengthen the dough and increase bread volume, and lecithin improves rheological properties of the dough and crumb grain texture. None of those functions is exclusive, and an increase in one function affects the others to some extent.

In light of the differences in the mode of action of the three additives, their separate and combined effects were compared in control flour and defatted flour baked with 2% shortening. In control flour (Table V), only DM increased bread volume, and

TABLE I
Effects of Defatting and Reconstituting on Volume, Compressibility, and Overall Score of Steamed Bread

Flour	Shortening (%)	Volume (cm^3)	Compressibility (g/cm^2)	Overall Score
Control	0	835	64	5
	2	875	62	5
Defatted	0	650	110	7
	2	705	86	6
Reconstituted	0	780	103	6
	2	850	72	5

TABLE II
Effects of Shortening vs Soybean or Corn Oil on Volume, Compressibility, and Overall Score of Steamed Bread

		Oil				
Flour	Shortening (%)	Soybean (%)	Corn (%)	Volume (cm^3)	Compressibility (g/cm^2)	Overall Score
Control	0	0	0	835	64	5
	1	0	0	833	64	5
	2	0	0	875	62	5
	0	1	0	867	55	5
	0	2	0	825	56	5
	0	0	1	865	56	5
	0	0	2	848	54	6
Defatted	0	0	0	650	110	7
	1	0	0	653	108	7
	2	0	0	705	86	6
	0	1	0	655	131	7
	0	2	0	663	112	7
	0	0	1	670	92	7
	0	0	2	648	103	7

TABLE III
Effects of Hydroxylated Lecithin or Ethoxylated Monoglycerides (EMG) on Volume, Compressibility, and Overall Score of Steamed Bread

Flour	Shortening (%)	Lecithin (%)	EMG (%)	Volume (cm^3)	Compressibility (g/cm^2)	Overall Score
Control	0	0	0	835	64	5
	2	0	0	875	62	5
	0	0.2	0	845	55	5
	2	0.2	0	874	58	7
	0	0	0.1	818	64	5
	2	0	0.1	870	61	5
Defatted	0	0	0	650	110	7
	2	0	0	705	86	6
	0	0.2	0	763	74	7
	2	0.2	0	805	69	6
	0	0	0.1	755	83	7
	2	0	0.1	783	77	7

TABLE IV
Effects of Corn Oil in the Presence of 0.2% Hydroxylated Lecithin or 0.1% Ethoxylated Monoglycerides (EMG) on Volume, Compressibility, and Overall Score of Steamed Bread

Flour	Corn Oil (%)	Lecithin (%)	EMG (%)	Volume (cm^3)	Compressibility (g/cm^2)	Overall Score
Control	0	0.2	0	845	55	5
	1	0.2	0	880	53	5
	2	0.2	0	858	56	5
	0	0	0.1	818	64	5
	1	0	0.1	875	57	5
	2	0	0.1	853	57	5
Defatted	0	0.2	0	763	74	7
	1	0.2	0	753	73	7
	2	0.2	0	795	65	7
	0	0	0.1	755	83	7
	1	0	0.1	743	87	7
	2	0	0.1	733	81	6

TABLE V
Combined Effects of Monoglycerides (MG), Ethoxylated Monoglycerides (EMG), and Lecithin on Volume, Compressibility, and Overall Score of Steamed Bread from Control or Defatted Flour in the Presence of 2% Shortening

Flour	MG (%)	EMG (%)	Lecithin (%)	Volume (cm^3)	Compressibility (g/cm^2)	Overall Score
Control	0	0	0	875	62	5
	0.1	0	0	914	63	5
	0	0.1	0	870	61	5
	0	0	0.2	874	58	7
	0.1	0.1	0	825	77	5
	0.1	0	0.2	860	56	5
	0	0.1	0.2	870	55	5
Defatted	0	0	0	705	86	6
	0.2	0	0	790	67	7
	0	0.1	0	783	77	7
	0	0	0.2	805	69	7
	0.1	0.1	0	695	82	7
	0.1	0	0.2	790	67	7
	0	0.1	0.2	803	69	7

the combination of monoglycerides plus EMG was deleterious. In defatted flour, none of the combinations was superior to any of the single emulsifiers. The combination of monoglycerides plus EMG was actually detrimental.

The effects of 0.2% lecithin or 0.1% DM (alone or in combination with 2% shortening) on the quality of Chinese steamed bread stored for 48 hr in closed plastic containers at room temperature were also determined. Bread volume and compressibility were determined in the freshly steamed bread (10 min after baking), after storage for 48 hr, and after the stored bread had been resteamed for an additional 5 min. No consistent differences were found among the effects of the three additives on the volume or compressibility of the freshly made, stored, or resteamed bread (data not shown).

In summary, flour lipids are important in baking steamed bread. Unlike the situation for regular pan bread, however, a shortening response can be attained in steamed bread even in the absence of flour lipids. Surfactants that strengthen the dough, such as sodium stearoyl lactylate and sucrose fatty acid esters, may lower volume and toughen crumb. DM were not highly effective in softening the crumb of steamed bread. EMG and especially hydroxylated lecithin were effective improvers.

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