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Reprinted from CEREAL CHEMISTRY, Sept. 1970, Volume 47: Number 5
Published by The American Association of Cereal Chemists, Inc.
1821 University Avenue, St. Paul, Minnesota 55104

Effects of Fumigation on Wheat in Storage. II. Physical and Eating Qualities of Breads and Rolls

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ABSTRACT

This paper reports on the effects of fumigation of wheat in storage on the physical and sensory qualities of breads and rolls. Together, storage time and treatment of wheat affected quality of the finished doughs and baked products. Baked breads and rolls increased in compressibility with storage of the wheat. For both baked products, the methyl bromide-fumigated samples were most compressible. In contrast, rolls made from phosphine-fumigated wheat were most firm. In the latter half of this research, it was evident from the Kramer shear readings that breads and rolls from phosphine-fumigated wheat were less tender than the others.

In the second and third years of storage of the wheats, loaf volume of breads made from the phosphine and the ethylene dichloride-CCl_4 fumigation treatments decreased. Volume of rolls made with flour from phosphine-fumigated wheat was consistently lower than that of the others. Some of the taste panel members detected a stale aroma in laboratory-type breads and crumbly texture in rolls made from wheats exposed to methyl bromide fumigation.

The effects of fumigation of wheat in storage on quality of bread and rolls made from the milled flour are reported in this paper. A previous paper (1) describes details of this research, a co-operative and comprehensive project of the Human Nutrition Research Division and the Market Quality Research Division of the U.S. Department of Agriculture. Research was conducted over a period of 3 years with wheat fumigated two to three times each year. The fumigants used were methyl bromide, ethylene dichloride-CCl_4 (3:1), and phosphine. Similar lots of untreated wheat were held at ambient temperatures and at 32°F. as controls. To date, only a few reports have been published on effects of fumigation of wheat on baking quality of flour (2,3,4,5,6).

MATERIALS AND METHODS

Formulations

Two types of bread were made according to the formulations and procedures described previously by Matthews et al. (7). Rolls were also made from the same flour samples with a formulation four times higher in fat and in sugar than the home-type bread formulation. For each roll, 55 g. of dough was weighed into each of 100 greased aluminum muffin pans in each mixing lot. Rolls were moulded by hand and proofed and fermented under the same controlled atmospheric conditions of temperature and humidity as described previously for the home-type breads (7).

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Rolls required 4 min. for mixing and no longer than 60 min. each for fermentation and proofing. To prevent any residue contamination of one sample by another, special care was taken to scrub tables and utensils immediately after use.

Procedures for Sampling Doughs and Baked Products

For both home-type breads and for rolls, approximately 6 kg. of dough was mixed in each lot; of this amount 3 kg. was baked as bread or rolls and 3 kg. was sampled as raw dough after the proofing step. From 3 kg. of material, 0.75 kg. was reserved for analyses of B vitamins and tocopherols, 1.0 kg. for residue analyses, and 1.25 kg. for physical and eating-quality evaluations. The 60 flour samples (12 test periods X 5 treatments) were made into home-type breads and rolls (three replications each). Laboratory-type breads made by the Market Quality Research Division procedure were used for sensory evaluations only. Three hundred sixty lots of home-type bread and roll doughs were mixed and baked for nutrient, residue, and baking-quality evaluations over the 3-year period.

Samples of dough for nutrient analyses were taken immediately after proofing. Those for residue content and Kramer shear measurements were wrapped in foil, frozen, and stored at −40°F. in sealed No. 10 cans. Bread and rolls were sampled and stored in the same manner as the doughs. Loaf breads were quartered, and individual rolls were sampled randomly. After all doughs and baked products for a test period were collected for residue analyses, cans were packed in dry ice inside specially constructed Celotex-lined plywood boxes and shipped via air express to the Savannah, Georgia, laboratory. Doughs for shear measurements were thawed at room temperature before readings were taken.

Physical Measurements of Doughs and Baked Products

Physical measurements of the doughs, baked bread, and baked rolls were made as described earlier (7). Readings included shear (Kramer) of dough, and volume, compressibility, and shear (Kramer and Warner-Bratzler) of the crumb for bread and rolls.

Sensory Evaluation of Baked Breads and Rolls

Eating quality of the baked products was evaluated the day after baking as previously described (7). Rolls were warmed for 15 min. at 350°F. before being presented to the panel. Home-type breads, rolls, and laboratory-type breads were evaluated each week for 3 consecutive weeks (three replications).

RESULTS AND DISCUSSION

Physical Measurements of Home-Type Breads and Rolls

Shear readings of bread doughs at first decreased, then increased during storage of wheats. Highest shear readings (least tender doughs) were at the initial test period and at the fourth test period (9 months after the wheat was stored). Freezing and thawing of doughs may have masked differences due to fumigation or storage time.

Kramer shear of the roll dough was highest at the initial test period, decreasing gradually after 3 months' storage of the wheat. No differences due to fumigation or storage of the wheat were evident later in the study.

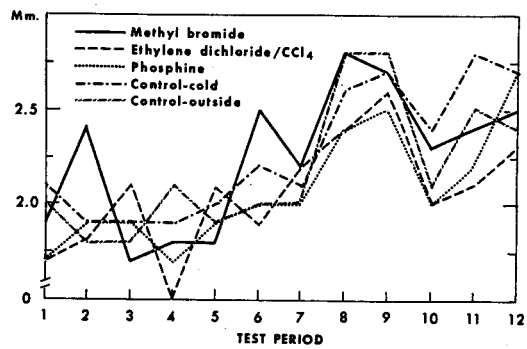

Fig. 1. Compressibility of baked bread made from flours from wheats fumigated eight times during 3 years' storage.

Bread crumb increased in compressibility during 3 years' storage of the wheat (Fig. 1). At most test periods, breads from the methyl bromide-fumigated wheat were most compressible or were among the most compressible of the five lots. Phosphine samples were usually least compressible. Compressibility of baked rolls increased gradually with storage of the wheat in about the same way as compressibility of the baked breads.

Kramer shear of baked bread increased dramatically during the last half of the project (Fig. 2). In the first year, shear readings ranged between 260 and 375 lb. of

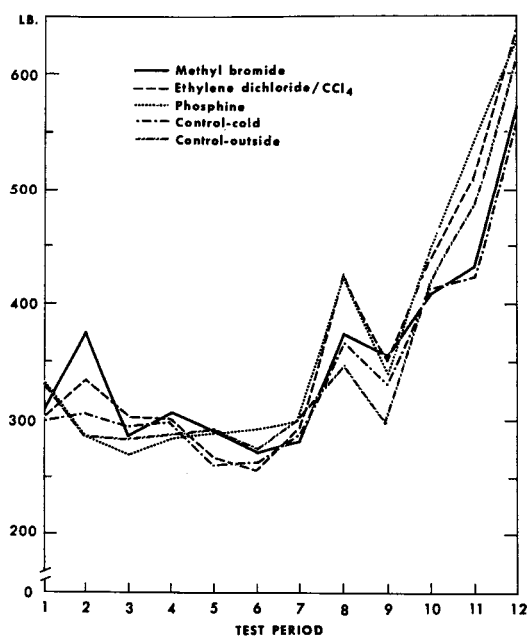

Fig. 2. Shear (Kramer) of baked bread made from flours from wheats fumigated eight times during 3 years' storage.

force and breads from the methyl bromide-fumigated wheat seemed to be less tender (higher readings) than the others. During the second and third years (test periods 6 through 12), breads from the phosphine-fumigated wheats were almost consistently least tender of the samples. Rolls made from all samples increased in tenderness during the last year and a half of storage of the wheat; those made from the phosphine-fumigated wheat were least tender. A richer formulation or the addition of crumb softeners would probably have improved the quality of breads and rolls made from these stored wheats; particular attention should be given to breadmaking quality of the phosphine-fumigated wheats.

Warner-Bratzler shear readings showed an over-all decrease in tenderness of breads and rolls with storage and fumigation of the wheat. No one fumigation treatment seemed to differ from any other. This measurement was found previously to closely correlate with tenderness of crumb as judged by a trained taste panel (8).

Loaf volume of bread decreased, then increased with storage of wheat (Fig. 3). Breads made from the refrigerated control were usually highest in volume at most test periods. In the first year (test periods 1 through 5), loaf volume of breads varied little according to treatment. In the second and third years, the wheats fumigated with phosphine and with ethylene dichloride-CCl_4 made breads that were among the lowest in volume. Baked rolls (10 rolls at a time) decreased in volume during storage of the wheat. Rolls made with the phosphine-fumigated wheat were usually lowest in volume of the five samples.

Sensory Evaluation of Baked Products

During the course of this research the only significant differences in palatability factors detected by the trained taste panel that were related to storage time and fumigation of the wheat were tenderness of rolls and aroma of laboratory-type breads. Rolls became more crumbly in texture, which was particularly evident in the methyl bromide-fumigated sample. Bread aroma was scored lower (slight off-odor) with storage of wheat up to 3 years. Laboratory-type breads made with flour from methyl bromide-fumigated wheat were often described as "stale" in aroma.

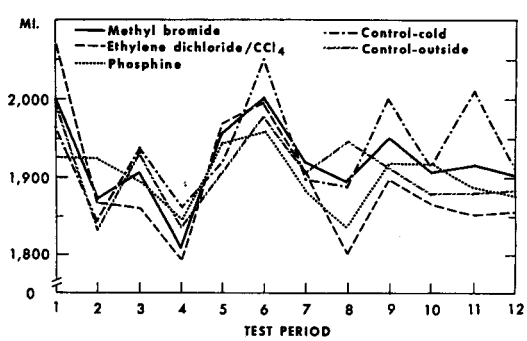

Fig. 3. Volume of baked bread made from flours from wheats fumigated eight times during 3 years' storage.

CONCLUSIONS

Repeated phosphine fumigations of the wheat had a detrimental effect on the tenderness and compressibility of baked breads and rolls. The inferior physical qualities of these baked products made from flours milled from phosphine-fumigated wheat were particularly evident by the second and third years of storage and were also reflected in the volume of the baked products. Some taste-panel members detected a crumbly texture of rolls and a stale odor in laboratory-type breads made with flours milled from methyl bromide-fumigated wheats. Some changes in formulations for breads and rolls may be necessary in general practice to offset the detrimental effects of these two treatments.

Acknowledgments

The authors wish to thank Elinora J. Sharpe (retired) and Willa M. Clark of the Human Nutrition Research Division for preparation and physical measurements of home-type breads and rolls; and Dorothy Humphrey of the Market Quality Research Division for preparation of laboratory-type breads.

Literature Cited

1. MATTHEWS, RUTH H., FIFIELD, C. C., HARTSING, T. F., STOREY, C. L., and DENNIS, N. M. Effects of fumigation on wheat in storage. I. Physical measurements of flour. Cereal Chem. 47: 579 (1970).
2. DEAN, G. A., and SWANSON, C. O. Effect of common mill fumigants on the baking qualities of wheat flour. Kan. State Exp. Sta. Bull. No. 178, pp. 155–208 (1911).
3. SMITH, H. S., and STATEN, H. W. The effects of carbon disulphide upon germination and baking quality of wheat. Okla. Agr. Mech. Coll. Agr. Exp. Sta. Tech. Bull. No. T.14 (1942).
4. YOUNG, H. D., and BAYFIELD, E. G. Effect of hydrocyanic acid on the baking quality of flour. Cereal Chem. 21: 149 (1944).
5. HERMITTE, R. J. J., and SHELLENBERGER, J. A. Effect of excessive methyl bromide fumigation on flour. Cereal Chem. 24: 449 (1947).
6. LINDGREN, D. L., VINCENT, L. E., and STRONG, R. G. Studies on hydrogen phosphide as a fumigant. J. Econ. Entomol. 51: 900 (1958).
7. MATTHEWS, RUTH H., FIFIELD, C. C., and HARTSING, T. F. Assessing wheat quality with breads prepared by two formulations. Cereal Chem. 45: 133 (1968).
8. MATTHEWS, RUTH H., and DAWSON, ELSIE H. Performance of fats in white cake. Cereal Chem. 43: 538 (1966).

[Received October 20, 1969. Accepted February 27, 1970]