BREAD STALING STUDIES. III. EFFECT OF PENTOSANS ON DOUGH, BREAD, AND BREAD STALING RATE[1]

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ABSTRACT

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The effect of pentosans (water-soluble and water-insoluble) on loaf volume and bread staling rate was investigated. The water-binding capacity of pentosans was determined using the farinograph. The water-soluble pentosans absorbed 4.4 times their weight of water and the water-insoluble pentosans 9.9 times their weight. The loaf volume was not affected by adding water-soluble pentosans, but was slightly decreased with the incorporation of water-insoluble pentosans. Pentosans decreased the bread staling rate, and the effect exerted by the water-insoluble pentosans was more pronounced than that exerted by the water-soluble pentosans. Kinetic studies indicated that pentosans simply reduce the amount of starch components available for crystallization, thus decreasing the bread staling rate.

Studies on the effect of pentosans on baking properties have been reviewed by D'Appolonia (1). Little information, however, is available concerning their effect on bread staling.

Gilles *et al.* (2) reported that the water-soluble pentosans present in the "soluble starch" extracted from fresh bread crumb inhibited the retrogradation of amylose (0.2% aqueous solution). However, the pentosan-rich water-solubles of wheat flour, although they affected the properties of baked bread, did not affect the staling rate.

Bechtel and Meisner (3) and Prentice *et al.* (4) showed that the tailings had no effect on crumb firming rate. Recent studies (5,6) have reported that the addition of the water-insoluble pentosans resulted in a remarkable increase in loaf volume and retardation of bread staling.

Pentosans have been shown (7) to have a definite effect in retarding the retrogradation of starch gels upon aging. The main purpose of this study was to investigate the effect of pentosans on bread staling rate. Concomitantly, water-binding capacity of pentosans was determined and their effect on loaf volume noted.

MATERIALS AND METHODS

The flour used for baking and isolating pentosans was described previously (8). It contained 13.9% protein on a 14% moisture basis.

Both water-soluble and water-insoluble pentosan-containing material was isolated according to the procedure of Medcalf *et al.* (9), with modifications as described previously (10).

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The water-binding capacity of the pentosans was determined using the farinograph (11). The baking formula and method used to measure bread staling rate have been reported previously (8). The concentration of pentosans used to measure water-binding capacity and for baking was 1% based on flour weight.

RESULTS AND DISCUSSION

Effect of Pentosans on Farinograms

Pentosans extracted from wheat flour (water-soluble or water-insoluble) are extremely hydrophilic (1). Data on the effect of pentosans on farinograms (Table I) clearly show this phenomenon. The water-soluble pentosans absorbed 4.4 and the water-insoluble pentosans 9.9 times their weight of water, respectively. Using the constant-flour farinograph method, Kulp (12) reported that the water-soluble pentosans absorb 11 times their weight of water and water-insoluble pentosans 10 times their weight. Using the same technique, Jelaca and Hlynka (13) showed that the water-soluble pentosans absorb 9.2 times and the water-insoluble pentosans 8.0 times their weight of water.

The water absorption capacity for the water-insoluble pentosans is in good agreement with that reported by Kulp (12) and Jelaca and Hlynka (13). The difference observed with the water-soluble pentosans may be due, in part, to the method of isolation and purification employed in the present investigation.

The dough development time of the pentosan-containing doughs was only slightly lower than that of the control (Table I). These results agree with the observations of Kulp (12). Jelaca and Hlynka (13), however, reported that pentosans at constant dough consistency increased dough development time.

The stability of the pentosan-containing doughs decreased compared to the control, while the mechanical tolerance index increased (Table I).

Effect of Pentosans on Baking

Table II shows the effect of pentosans on baking absorption, mixing time and specific loaf volume. Pentosans increased the baking absorption, and the effect exerted by the water-insoluble pentosans was more pronounced than that exerted by the water-soluble pentosans, confirming the farinograph data (Table I). The mixing time of the doughs decreased with the incorporation of the

TABLE I
Effect of Pentosans on Farinograms

Source	Absorption at 500 BU %	Dough Development Time min	Stability min	MTI[a] BU
Control	63.6	8.0	12.5	10
With 1.0% soluble pentosans	68.0	7.0	8.0	30
With 1.0% insoluble pentosans	73.5	7.0	8.0	20

[a]Mechanical tolerance index (difference in BU from the top of the curve at the peak to the top of the curve measured 5 min after the peak).

pentosan material. Inclusion of pentosans produced more relaxed doughs than those of the control after mixing.

The addition of the water-soluble pentosans had no effect on loaf volume, while the water-insoluble pentosans slightly decreased it. Pence *et al.* (14) attributed the slight loaf volume increase with the addition of water-soluble pentosans in their baking experiments to the small amounts of protein remaining in their pentosan preparations. Using a gluten-starch baking system, D'Appolonia *et al.* (15) reported that the slight increase in loaf volume of the gluten-starch loaves was due to the protein or to a protein-carbohydrate complex, and not to the pentosans themselves.

Kulp and Bechtel (16,17) reported that bread with added water-insoluble pentosans had lower loaf volume than that of the control, supporting the results of the present study. However, Casier (6) and Casier *et al.* (5) showed a beneficial effect on loaf volume with the incorporation of water-insoluble pentosans. On the other hand, Jelaca and Hlynka (18) observed either a beneficial or detrimental effect on loaf volume with the addition of water-insoluble pentosans, depending on the source of the material.

Effect of Pentosans on the Staling Rate of Bread

Data on the Avrami exponent and the time constant of bread stored at 21°C are presented in Table III. Pentosans increased the time constant of the bread, and the effect exerted by the water-insoluble pentosans was more pronounced

TABLE II
Effect of Pentosans on Baking[a]

Dough	Baking Absorption %	Mixing Time min	Specific Loaf Volume g/cc
Control	63.0	3.50	5.16
With 1.0% soluble pentosans	68.0	2.50	5.13
With 1.0% insoluble pentosans	71.0	2.25	5.05

[a]Results reported are an average of triplicate loaves.

TABLE III
Effect of Pentosans on the Avrami Exponent and the Time Constant of Bread Stored at 21°C

Bread	Avrami Exponent	Overall Time Constant	Time Constant over the First Day of Storage
Control	0.92	5.44	4.80
With 1.0% soluble pentosans	0.73	6.53	4.23
With 1.0% insoluble pentosans	0.77	8.54	5.88

than that exerted by the water-soluble pentosans. These results are in good agreement with those obtained with the starch gels (7).

The slower staling rate of the bread containing the water-insoluble pentosans supports the observations of Casier (6) and Casier *et al.* (5), who reported that the addition of the water-insoluble pentosans retarded staling. Prentice *et al.* (4), however, reported that the tailings had no effect on crumb firming rate but decreased the crumb firmness, probably due to its relatively high hydration capacity. No differences in staling rate, determined by a sensory panel, were observed when bread with or without tailings was tested at the same moisture level (3).

The time constant of bread containing pentosans over the first day of storage was considerably different from the overall time constant (Table III), indicating that bread containing pentosans aged at a faster rate over the first day. These results confirm the earlier observations with starch gels containing pentosans (7). The Avrami exponents of bread containing pentosans remained close to unity, indicating that the basic mechanism of bread staling, as far as starch crystallization is concerned, was not changed by the presence of pentosans. The results in Table III thus suggest that pentosans increase the time constant or decrease the staling rate simply by reducing the amount of starch components available for crystallization.

In studies of a possible association of pentosans with starch, it was demonstrated (7) that the water-soluble pentosans slowed down the rate of retrogradation by affecting the amylopectin fraction of starch, while the water-insoluble pentosans retarded the extent of retrogradation by affecting both amylose and amylopectin. It remains to be discovered whether pentosans retard the starch retrogradation during bread staling in a manner similar to that observed with starch gels.

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