Food Chemistry **25** (1987) 241–249

The Effect of Soluble Pentosans Isolated from Rye Grain on Staling of Bread

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(Received 7 May 1986; revised version accepted 2 December 1986)

ABSTRACT

The water-soluble pentosans isolated from rye grain were added to wheat dough. Their effect on staling of bread was evaluated on the basis of the changes in bread crumb compressibility as well as in the contents of water-extractable sugars and resistance of the starch system to alpha-amylase during 6 days storing of the bread.

In the presence of water-soluble pentosans the process of starch retrogradation was much slower. The digestibility of starch in bread crumb by alpha-amylase was lower also.

In the case of bread containing the increased pentosan contents, i.e. rye and wheat–rye breads, the enzymatic method should not be applied for studying the staling process.

The interaction of starch and pentosans plays an important role in retarding the starch retrogradation process.

INTRODUCTION

During recent years the number of publications devoted to the cereal soluble pentosans has been evidently increasing. The role of these substances in the formation of the dough system, as well as their effect on the sensoric properties of bread (D'Appolonia & Gilles, 1971; Jelaca & Hlynka, 1972; Pomeranz, 1974 and Jankiewicz, 1975) has been satisfactorily documented. In most physico-chemical and technological investigations of changes in starch and protein complexes during the preparation of dough, the baking

Food Chemistry 0308-8146/87/$03·50

process and storing of bread, the wheat dough has been used as a model system (D'Appolonia & Gilles, 1971; Galal & Johnson, 1976; Kim & D'Appolonia, 1977). Usage of rye dough for such purposes has been far more limited. There are only a few publications dealing with either wheat–rye or rye dough (Holas & Hampl, 1973; Jankiewicz & Michniewicz, 1976; Jankiewicz *et al.*, 1979). Introduction of rye flour to the dough in high quantities (50% or more), markedly changes the ratio of pentosan to protein in the system and affects water binding by its main constituents (Bushuk, 1969). Unlike wheat dough, there was more modification of the protein and starch complexes (Golenkow, 1965; Neukom, 1972; Pomeranz, 1974 and Jankiewicz & Michniewicz, 1976) in wheat–rye dough. Interactions of pentosans with the gluten complex of dough have been the subject of detailed studies in our Institute (Jankiewicz, 1975; Jankiewicz & Michniewicz, 1976; Jankiewicz *et al.*, 1979). High reactivity of pentosan substances was reported (Golenkow, 1965; Morita *et al.*, 1974; Patil *et al.*, 1975; Jankiewicz *et al.*, 1979). In our study their role in modifying the technological properties of gelatinized starch in bread crumb was established. The changes induced in starch complexes of wheat bread crumb by addition to the dough of the soluble pentosan preparation in amounts similar to those typical for mixed bread containing 40% or 60% rye flour (wheat–rye; rye–wheat breads) were examined. To do this, technological tests, chemical and enzymatic methods were applied.

MATERIAL AND METHODS

The laboratory flours used in the experiments corresponded to Mironowska wheat and Pancerne rye. The technological characterization of the flours included determinations of water, total nitrogen (semi-micro method) (Jankowski & Jankiewicz, 1960) and pentosan (Cerning & Guilbot, 1973) components. The soluble pentosan preparation was isolated from the rye flour (Jankiewicz & Michniewicz, 1976). In the preparation, the pentosan (Cerning & Guilbot, 1973) and protein (Jankowski & Jankiewicz, 1960) contents were determined.

The model dough was prepared by using the Brabender Farinograph bowl. The consistency of the dough equalled 500 Brabender units. The pentosan preparation was added to the samples of the dough in proportions of 1·5% and 3·0% of the flour, respectively. The baking test was done according to the method of the Research Institute of Baking Industry (Warszawa, Poland). The first stage of dough fermentation lasted 30 min at 30°C and 80% humidity. For final fermentation the specimens were transferred to cans (75 × 45 mm). After baking, the bread samples were cut at the top level of the cans. The cans were closed mechanically. The bread samples were stored at 4 and 20°C, for 1, 3, 4 and 6 days, respectively. The bread containing no pentosan addition, stored 1 day, was treated as a control. The compression of bread crumb using a Baker compressimeter (Szcześniak, 1972; Pomeranz, 1974; Knorr *et al.*, 1976) and the content of water-extractable sugars (Dubois *et al.*, 1956) were determined. The resistance of starch to alpha-amylase was established by means of a modified ICC—Standard No. 108 method. Ten-millilitre volumes of 0·5% alpha-amylase solution in 0·2% calcium chloride were added to 10-ml portions of a 2·0% suspension of bread crumb in distilled water at 30°C. After 5 and 15 min the samples were immediately filtered at room temperature and 10-ml aliquots added to 50 ml volumes of iodine solution. Further operations were performed according to the ICC-Standard method. The results were expressed as an enzyme activity index, being a function of alpha-amylase concentration and of the velocity constant for the hydrolytic degradation of starch and limit dextrin. Under the experimental conditions, the enzyme activity index was dependent on the accessibility of soluble starch and limit dextrins to alpha-amylase of constant activity. Retrogradation of the starch complex in crumb during storing of bread caused the changes measured as a presumptive decrease of the determined enzyme activity.

RESULTS

The general characteristics of the laboratory flours and pentosan preparation used in the experiments are presented in Table 1. The preparation contained 85% of pentosans, 7% of proteins and 8% of other

TABLE 1
Chemical Characteristics of Laboratory Flours and Pentosan Preparation

	Flours		*Pentosan preparation*
	Mironowska wheat	*Pancerne rye*	
Extraction (%)	72	70	—
Water (%)[x a]	12·1 ± 0·08	13·8 ± 0·06	5·0 ± 0·08
Protein (%)[a]	11·9 ± 0·12	8·8 ± 0·14	7·0 ± 0·11
Pentosan (%)[a]	6·2 ± 0·35	10·2 ± 0·30	85·0 ± 0·53
Ash (%)[a]	0·6 ± 0·02	0·9 ± 0·03	—

[a] Mean value ± SD.
[x] N × 5·7.

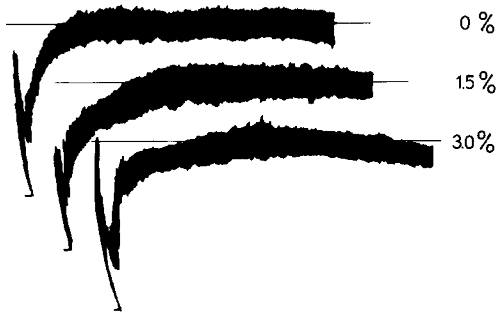

Fig. 1. The farinographic characteristics of dough.

components. The farinograms obtained for control dough and dough samples containing 1·5% and 3·0% of pentosan preparation are presented in Fig. 1.

The samples of dough containing the pentosan preparation increased their water absorption at a consistency 500 BU from 60% for the control to 66% and 80%, respectively, for additions of pentosan preparation amounting to 1·5% and 3·0% of the flour used (dry mass basis). Duration of dough development was also longer and lasted, for the dough containing 3% pentosan addition, 6 min (for control—3 min).

The results of compression measurements made for the crumb of bread stored under different conditions are presented in Fig. 2. The increasing values of force applied to reach crumb depression (described in the method) indicate the progress of staling. The greatest changes were observed for control bread stored at 20°C for 6 days. The increase reached 182% in comparison with the data obtained for bread stored 1 day. For the same

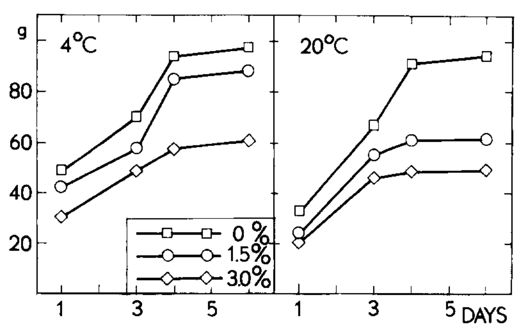

Fig. 2. The changes in compression of bread slices measured by means of Baker compressimeter. The force (*g*) acting on the plunger of Baker compressimeter causing 3 mm compression of the slice of bread.

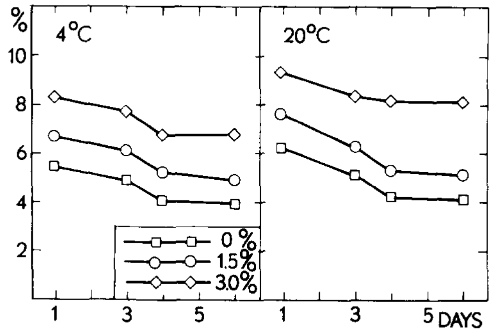

Fig. 3. The effect of pentosan addition on the changes of the contents of water-extractable sugars in the bread crumb.

bread, stored at 4°C, a lower increase, of about 100%, was observed. In the case of bread containing 3% addition of pentosan preparation these values were slightly lower. It was observed that, in the case of samples stored at 20°C, the force values were lower than for those stored at 4°C.

In Fig. 3 the contents of water-extractable sugars in the bread samples are presented. They are expressed as xylose contents calculated on the basis of dry mass of flour. The contents of extractable sugars in the bread crumb decreased in the course of the storing period. The character of the changes was similar at 4°C and 20°C. The addition of the pentosan preparation stabilized the contents of water-extractable sugars in the stored breads. The smallest changes occurred in the case of the bread samples containing 3% of the pentosan preparation and stored at 20°C. Assuming that the values determined for the bread samples stored for 1 day equalled 100%, a decrease after 6-days' storage with 3% addition of pentosan reached only 13% whereas, in the case of control bread, it amounted to 34%. Regardless of the contents of pentosan preparation in the bread samples after the same period of storing, the amounts of water-extractable sugars were found to be higher for the samples stored at 20°C than for those at 4°C.

The changes of the resistance of starch from the bread crumb to alpha-amylase attack are presented in Fig. 4. The activity of the enzyme preparation used in the experiments was established as a course of starch gel hydrolysis. Therefore, the changes in the action of the enzyme observed for the bread samples used as a substrate were related to resistance of the starch complex, in bread crumb, to enzymic decomposition. The values of the enzyme activity factor were higher for the samples stored at 20°C than for those stored at 4°C. Prolonged storage of the bread caused a drop in the values of the factor in all cases. The addition of pentosan preparation to the dough caused similar changes.

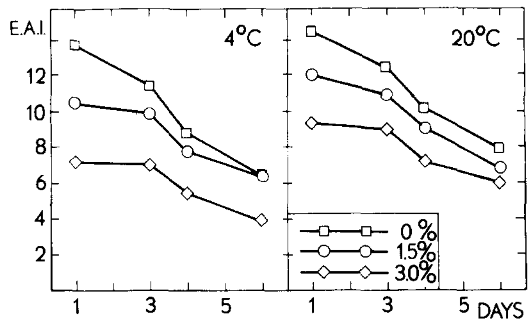

Fig. 4. The changes of the resistance of starch from the bread crumb to alpha-amylase.

After storing the control breads for 3 days, their crumb crumbled when cut, whereas no such effect took place in breads with 3% addition of pentosans, even when stored for 6 days. The bread containing the pentosan preparation showed smaller changes of sensoric properties (according to the baking test evaluation) than the control.

DISCUSSION

The role of pentosans in causing the physico-chemical properties of wheat dough is only partly understood, although their reactions with some substances in the system have been already described (D'Appolonia & Gilles, 1971; Neukom, 1972; Pomeranz, 1974; Jankiewicz & Michniewicz, 1976; Kim & D'Appolonia, 1977). In this study a special emphasis was placed on the effect of starch–pentosan interaction in bread crumb in retarding the process of starch retrogradation. The reactivity of pentosan compounds (Neukom, 1972; Patil *et al.*, 1975; Jankiewicz *et al.*, 1977) and their high ability to bind water (Golenkov, 1965; Bushuk, 1969; Jankiewicz *et al.*, 1977) became an object of our interest.

The experiments required proper selection of the conditions of bread preparation and storage. The dough was prepared in the conventional way. Baking bread in cans helped to prevent loss of water and development of microflora in stored samples. Under such conditions, changes found in the starch complex of bread could be solely related to the phenomenon of retrogradation and not to the joint effect of drying of the sample and retrogradation of the starch (Neukom, 1972). The bread samples were stored at 4°C in order to stimulate the retrogradation changes which are much slower at room temperature (Herz, 1965; Willhoft, 1973; Zobel, 1973; Galal & Johnson, 1976). Changes of technological properties of the wheat dough caused by soluble pentosans were similar to those described by other authors using flours different in respect to their technological properties (Jelaca & Hlynka, 1972; Pomeranz, 1974; Jankiewicz & Michniewicz, 1976).

The changes in stored bread containing soluble pentosans in larger quantities were less pronounced in comparison with normal bread. There was no discrepancy between the results obtained using the compressimeter and the chemical method based on measuring the decrease of water-extractable sugars in the bread crumb. The measurements of alpha-amylase starch digestibility gave different results. In the control bread the starch complex increased its resistance to alpha-amylase as retrogradation progressed. Such changes have previously been described (Neukom, 1972). Addition of the soluble pentosan preparation caused a decrease of the bread starch digestibility similar to that observed after long storing of control bread. This phenomenon underlines the risk of obtaining faulty results if the enzymic method is the only one used for characterization of the staling process.

It was evident in the experiments that the bread containing the pentosan preparation preserved its freshness and good sensoric properties much better, even when stored under unfavourable conditions. Therefore, the specific behaviour of the starch complex in the presence of soluble pentosans should be viewed in terms of starch–pentosan interactions and formation of a complex less accessible to alpha-amylase. The slight changes of starch digestibility in the bread stored for a long time indicate that the process of retrogradation is restrained by formation of the starch–pentosan complex.

The results obtained in this study show that the interactions of starch and pentosan components play a similarly important role in wheat–rye and rye–wheat breads, as has been reported in other publications on interactions of proteins and pentosans in dough (Golenkov, 1965; Neukom, 1972; Holas & Hampl, 1973; Jankiewicz & Michniewicz, 1976; Kim & D'Appolonia, 1977; Jankiewicz *et al.*, 1979).

CONCLUSIONS

(1) Prolonged shelf-life of wheat–rye bread can be explained as a result of increased contents of pentosans and the interaction of starch and pentosans.
(2) In the presence of soluble pentosans the starch gel is more resistant to retrogradation.
(3) The soluble pentosans cause a lowering of digestibility of the gelatinized starch in bread crumb by alpha-amylase.
(4) The enzymic method of studying the staling process should not be used as the sole method for breads rich in pentosan substances.

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