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Flour milling and baking

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Non-starch polysaccharides affect flour quality

It is well known that non-starch polysaccharides influence the physical properties of dough and the baking performance of flour, although they only represent a minor component of wheat flour. Their exact role is not fully understood. However, reports suggest that they interact with other flour components. Some workers even reported that non-starch polysaccharides (NSPs) interact with gluten to make doughs more resistant to extension, thus decreasing their extensibility.

The term, non-starch polysaccharides, encompasses a variety of polysaccharides that are composed of pentoses (monosaccharides containing five carbon atoms) and hexoses (monosaccharides containing six carbon atoms). These polysaccharides are frequently branched as well as having linear chains. They originate from the endosperm cell wall and make up 2-3% of dry flour. Some NSPs are water-soluble and some are water-insoluble. Many researchers believe that the importance of NSPs in wheat quality, flour processing and their affects on baking quality have been somewhat overlooked. Investigations of how NSPs affect flour quality during milling may show ways to increase the value and quality of the product. This bulletin outlines the current knowledge of NSPs and their functionality in flour.

The polysaccharides:

The dominant polysaccharide in wheat flour is arabino-xylan (AX) which is well studied and consists predominantly of the pentoses arabinose and xylose. Hence it is often referred to as pentosan. In chemical terms, the backbone of the AX is essentially 1->4 linked β-D-xylopyranose with substituents of mainly arabinose on the 0-2 and /or 0-3 position of the xylose residue. Fig 1. shows a typical structure of wheat flour arabino-xylan. It has been reported that the structure of wheat AX exhibits small variations which affect its physico-chemical properties.

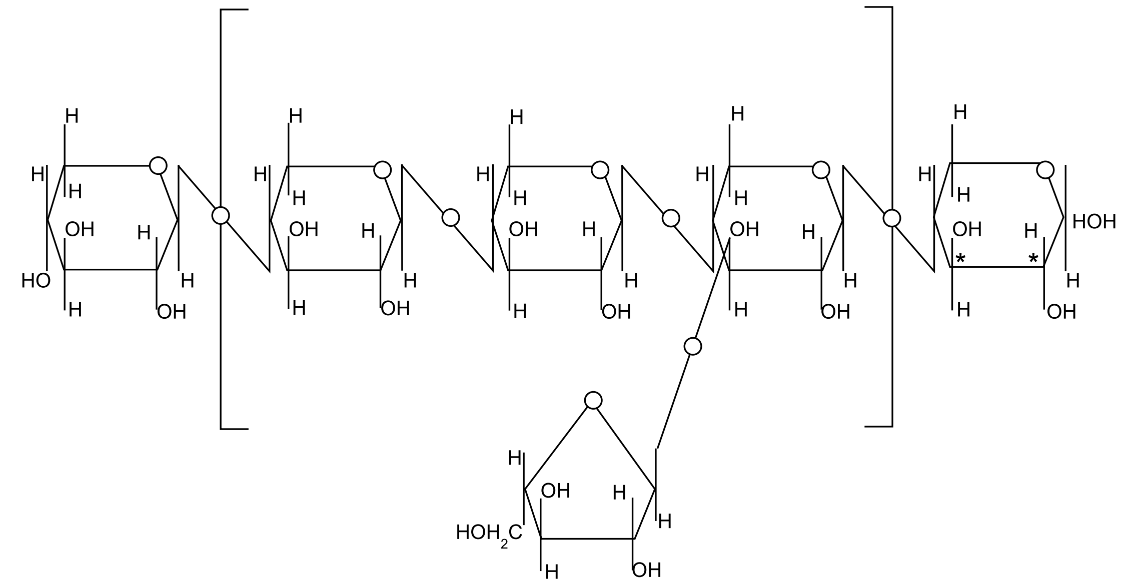

Figure 1: Typical structure of a water-soluble wheat endosperm pentosan; n indicates a finite number of polymer units; * indicates (C_2 and C_3) at which branching ocurs.

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Proceedings of conferences:

are available at $100.00 each.

Nutrition and Food Trade Conference April 1999.

42nd RACI Cereal Chemistry Conference 7-11 Sept 1992

Managing Water Activity in Baked Products 28 May 1998

Mechanical Dough Developments 26-27 May 1998

International Baking Course 7-8 Oct 1996

'Frozen Dough Technology' AACC Short Course 18-19 September 1995

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Arabino-galactan, (AG), which is the second largest polysaccharide in wheat flour, consists of a β 1–>3 linked galactose substituted by arabinose on the 0-6 position. This polysaccharide was found to be associated with protein. Some reports show that AG occurs in the same quantities as AX in some wheat varieties. Other polysaccharides, such as β-glucan, are present in minor quantities, while a few researchers found traces of mannan and fructan.

Table 1 is a typical analysis of the chemical composition of NSP from wheat.

Water Absorption

Present knowledge indicates that NSPs in flour play an important role in the "water balance" in dough and thus affect its rheological properties. It has been estimated that NSPs absorb almost 1/3 of the total water which emphasises their extremely high affinity for water and the general importance of these rather minor flour components.

Table 2 clearly shows that the highest water binding capacity was found for pentosans from no. 5 wheat flour and the lowest for those from Canada Western amber durum (CWAD). It is estimated that the water-soluble pentosan from Canadian Hard red spring (CHRS) wheat flour absorbs 6.3 times its weight of water, while the insoluble fraction absorbs 6.7 times its weight (dry basis). To put it another way, on a 14% moisture basis, they absorb 5.3 g water per gram for soluble and 6.1 g water per gram for insoluble pentosans or NSP. When pentosans were added to flour the dough development time (DDT) at a consistency of 500 B.U. was 2 - 3.5 min. longer than for the control dough.

Table 1: Distribution of the NSP monosaccharide units in wheat flour fractions.

Flour fraction	Arabinose	Xylose	Mannose	Galactose	Glucose[1]	Total g/100 g of flour (d.b.)
Water-insoluble polysaccharides	0.668	0.976	0.077	tr.	0.700	2.520
Water soluble polysaccharides	0.395	0.302	tr.	0.242	---	0.930
Sum	1.063	1.278	0.077	0.242	0.700	3.450

1Derived from β-glucans only

Table 2: Farinograph data for 1% added pentosan fractions (at consistency of 500 B.U. by the constant dough method).

Dough	Absorption % (14% m.b.)	Water binding capacity g water/g pentosan		DDT min.	Stability min.
		14% m.b.	Dry basis		
Control	61.7	-	-	6.5	17
Soluble pentosans CHRS	66.4	5.3	6.3	10	13
Insoluble pentosans CHRS	66.8	6.1	6.7	8	17
Soluble pentosans no. 5	67.9	5.9	7.0	10.5	10
Insoluble penotsans no. 5	67.6	5.6	6.6	11	16
Soluble pentosans CWAD	65.6	3.8	4.5	11	17
Insoluble pentosans CWAD	66.7	4.8	5.5	11	17

Despite the similarities in chemical composition, the water-soluble and water-insoluble fractions of NSPs seem to affect the properties of dough, and probably of bread, differently, as is demonstrated by Table 2.

Non-starch polysaccharides affect Farinograms:

Many workers in the past two decades have investigated the effect of NSPs on Farinograph mixing characteristics. Typical results obtained by the constant dough Farinograph method are shown in Fig. 2. The effect of adding pentosans is shown clearly by the marked increase in dough consistency. The top trace is the control while the centre contains 1% added water-soluble pentosans. The lower trace contains 1% water-insoluble pentosans which increased dough consistency more.

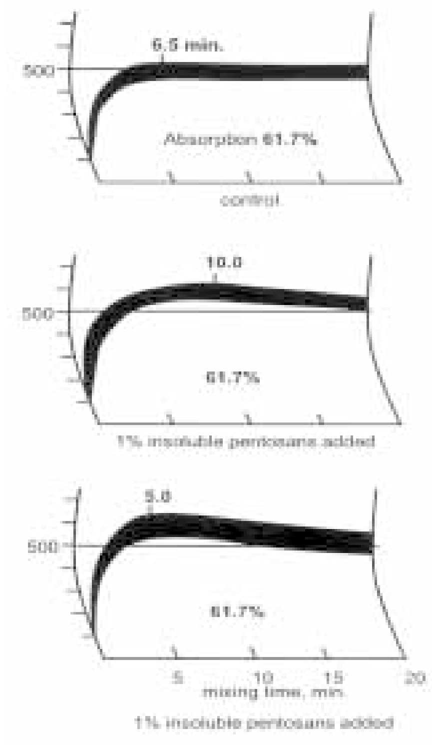

Figure 2: Farinograms showing changes in consistency for control dough (top, with 1% water-soluble pentosans added (centre), and with 1% water-insoluble pentosans added (bottom). (Figs. 2 and 3 were adapted from Jelaca and Hlynka.)

Fig. 3 shows the results of Farinographs of dough with different amounts of added pentosans, which clearly indicate that, at constant absorption, dough consistency increased markedly with increasing amounts of pentosan. As well as higher consistencies, these doughs also had longer development times and greater stability.

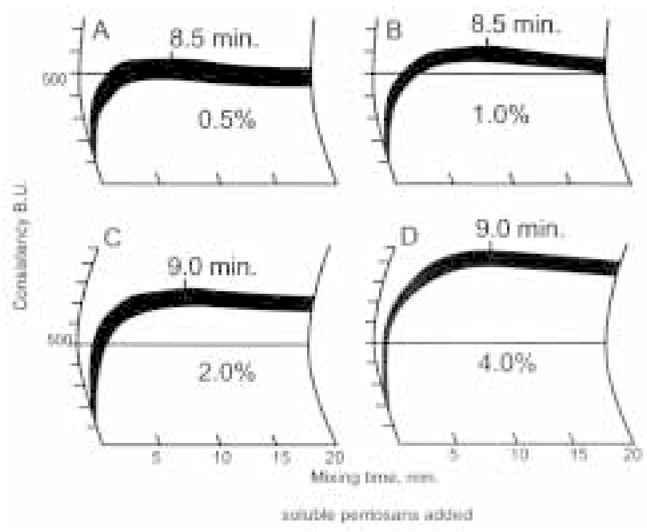

Figure 3: Farinograms A to D showing changes with the addition of 0.5 to 4.0% water-soluble pentosans (from CHRS flour). Control Farinogram for these doughs is identical with that shown in Fig. 2.

Conclusions:

Reports from many workers show that NSPs had a significant effect on flour and dough properties and play an important role during bread making. If 0.5-1.0% of NSP can have this kind of effect on Farinograms, then it is important to consider NSPs an additional value and quality indicator for New Zealand wheat cultivars. At present the contribution of NSPs to inter-cultivar differences between New Zealand wheat cultivars is unknown. However, the NSP content of various flour mill stocks and the effect of NSPs on flour functionality will be investigated as a part of the millstream project which was recently initiated.