Potravinarstvo, vol. 6, 2012, no. 1, p. 42-44
doi:10.5219/173
Received: 11. December 2011. Accepted: 7. January 2012.
Available online 15. February 2012 at www.potravinarstvo.com

ISSN 1337-0960 online

MOLECULAR PROPERTIES OF SELECTED POLYSACCHARIDES DETERMINED BY SEC CHROMATOGRAPHY AND THEIR IMPACT ON WATER ABSORPTION OF WHEAT FLOUR

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ABSTRACT

Chemical composition and solubility in water of selected polysaccharides as β-glucan, arabinoxylan and inulin preparation were determined. All these preparation were of good purity, they consist of at least 71% of polysaccharide of intrest. Solubility in water was the highest in the case of inulin and the lowest in the case of β-glucan. Molecular properties of examined preparations were determined by SEC chromatography. β-glucan and arabinoxylan were of much higher molecular mass than inulin. Molecular mass of examined polysacharides was corelated with increase of water absorption of the flour caused by 2% addition of each polysaccharide.

Keywords: inulin, beta-glucan, arabinoxylan, SEC analysis

INTRODUCTION

Size exclusion chromatography (SEC) is presently the most popular method in theanalysis and characterization of both synthetic and biopolymers. SEC became a conventionalmethod for determination of molecular mass distributions of numerous polymeric materialssuch as polysaccharides. The knowledge of molecular mass and its distribution for polymericmaterials is necessary to estimate their processability and basic utility properties **(Trathnigg, 2000)**.

B-glucan, arabinoxylan and inulin are popular non starch polysaccharides. β-glucan and arabinoxylan are the most important fraction of dietary fiber whereas inulin is the reserve polysaccharide of several plants.

Cereal β-glucan (BG) is a polysaccharide, which consists of linear chains of β-D-glucopyranosyl units linked via (1→3) and (1→4) linkages. β-glucan is acknowledged as a functional and bioactive food ingredient **(Lazaridou, Biliaderis and Izydorczyk, 2007)**. Thefunctional properties are related to its solution behavior. β-glucan has the ability to formviscous solutions and increase water absorption of the dough. β-glucan molecules have theability to self-associate and form aggregates, which may contribute to increased viscosity **(Cuiand Wang, 2009; Wood, 2004)**.

Arabinoxylan (AX) is a major component of the cell walls of wheat and rye, consisting of a linear backbone of (1→4)-linked β-D-xylopyranose units. The xylose units can be either unsubstituted or mono- or di-substituted with L-arabinofuranose **(Cleemput et al., 1993; Izydorczyk and Biliaderis, 1995)**. Other substituents, including glucuronic acids, D-galactose and/or hydroxycinnamic acids (mainly ferulic acid) may also be present **(Izydorczyk and Biliaderis, 1995)**.

In general, arabinoxylans are classified as water extractable AX (WE-AX) or water unextractable AX (WU-AX) **(Courtin & Delcour, 2002)**. Arabinoxylans influence dough reology in similar way to β-glucan increasing water absorption of the flour.

Inulin consists primarily of β (2–1) fructosyl fructose units with commonly a reducingend formed in an individual glucopyranose unit **(Stevens, Meriggi, & Booten, 2001)**. This structural singularity raises its interesting properties like beneficial nutritional attributes, which in turn excites the chemical modification of inulin in recent years **(Beylot, 2005)**.

Inulin has a significant effect on the rheological properties of dough in depending on the added amount **(Tokár et al., 2011)**. From the technological point of view addition of preparation of these polysaccharidesto the dough may influence its properties such as water absorption. Moreover there is relationship between molecular properties of these polysaccharides and ability to bind water.

The aim of this research work was to determine molecular properties of inulin, BG and AX preparation and their influence on water absorption of wheat flour.

MATERIAL AND METHODOLOGY

Three kinds of preparations of beta-glucan, inulin and arabinoxylan were examined using SEC chromatography. Innovative β-glucan preparations (BG-1 and BG-2) were obtained from polish producer the Futurum company. Preparation of beta glucan (BG-Ch) was also obtained from Chinese producer. Inulin was obtained from Dera Food Technology company. Innovative rye arabinoxylan preparation was isolated by laboratory method **(Buksa et al., 2010)**.

Sugar composition of selected polysaccharides was determined by HPLC/RI analysis. Samples were hydrolyzed using 2M H_2SO_4 (100°C, 2h), neutralized, filtered through 0,45 μm filter and applied on HPLC column system. Glucose, xylose, arabinose and fructose solutions were used as a standard.

Free sugars after dissolving in water for 24h at 50°C were determined using anthronemethod **(Morris, 1948)**.

Molecular mass distribution profiles were performed by SEC analysis. SEC system consist of 2 columns filled with Sephacryl gels (Pharmacia) with dimension of S-200, 37 x 1,6 cm and S-500, 46 x 1,6, peristaltic pump (Pharmacia) and fraction collector. 0,32% Na_2CO_3 solution was used as eluent and flow rate was 0,429 cm^3/min. Calibration curve was measured using pullulans with known molecular mass P-10, 50, 200, 400, 800 (Shodex Standard, Macherey-Nagel) and glucose. Preparation were dissolved 24h in 0,32% Na_2CO_3 at 50 ºC, centrifuged 5 min at 12000 x g and applied on column system. In collected after analysis fractions total carbohydrate was determined by anthrone method **(Moris, 1948)**. Glucose was used for calibration of polysaccharides concentration. Weight average molecular mass M_w, number average molar mass M_n and polydispersity index (PDI) were calculated from mass distribution.

RESULTS AND DISCUSSION

Basic chemical composition of examined preparation was presented in table 1. All preparation were of good quality. β-glucan preparation consisted of 72 to 83% of glucose which is component of beta glucan. Arabinoxylan preparation was composed of arabinose and xylose content determined as 71% and small amount of glucose. Inulin preparation was composed of 92% of fructose and 9,6% od glucose, which both are components of inulin. The solubility in water (50°C) of isolated polysacharides present in preparation was almost 100% in the case of arabinoxylan and inulin and slightly worse in the case of β-glucan preparation.

Water absorption of wheat flour type 650 with addition of 2% of each preparation (added before mixing, in the place of 2% of the flour) compared to flour without any additives showed that using of β-glucan and arabinoxylan preparation resulted in strong increase of water absorption determined by farinograph. Otherwise inulin addition resulted in no change of water absorption of the flour.

Determination of molecular mass distribution profiles by SEC analysis (fig. 1) and calculation of molecular properties (tab. 2) of examined polysaccharides showed that inulin was of smaler average molecular mass than arabinoxylan and β-glucan. Extensive molecules of β-glucan and arabinoxylan were responsible for higher water absorption of examined flour with addition of these compounds. Otherwise much smaller molecules of inulin did not influenced water absorption.

Tab. 1 Basic chemical composition of preparation

	Total sugar content [%]				Water soluble sugar content [%]	Increase of water absorption [%]**
	glu	xyl	ara	fru		
BG-1	83±1,2	-	-	-	70,0	8,9
BG-2	72±1,7	-	-	-	67,2	-
BG-Ch	76±1,5	-	-	-	61,9	-
Arabinoxylan	3,8±0,5	53,3±0,6	38,1±0,4	-	73	6,9
Inulin	9,6±0,3	-	-	92±3,5	100*	0

* - declared by producer

** - estimated by farinograph on flour type 650, with 58,5% WA as the difference between water absorption of the flour without and with 2% addition of each preparation

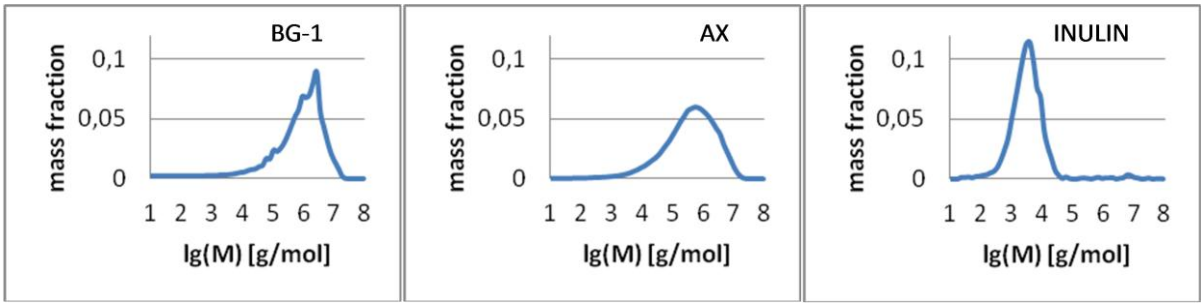

Fig. 1 Molecular mass distribution profiles of β-glucan (BG-1), arabinoxylan (AX) and inulin determined by SEC analysis

Tab. 2 Molecular properties of examined preparations

	BG-1	BG-2	BG-Ch	AX	INULIN
M_n [g/mol]	8 506	9 652	7 848	16 949	1 724
M_w [g/mol]	1 754 092	958 351	308 610	1 208 462	85 459
PDI	206	99	39	71	50

CONCLUSION

All examined preparations were of good purity. Innovative β-glucan preparation was better puryfied than commercialy available preparation obtained from Chinese producer. Solubility of examined polysaccharides preparation in warm water were also good. Results of SEC analysis showed that molecular mass of polysaccharides is one of the most important factors responsible for water binding properties of the polysaccharides. Addition of retatively small molecules of inulin in comparison to big molecules of β-glucan and arabinoxylan did not influenced water absorption of the flour.

REFERENCES

BEYLOT, M. 2005. Effects of inulin -type fructans on lipid metabolism in man and in animal models. In *British Journal of Nutrition*, vol. 93, 2005, Suppl. 1, p. 163-168.

BUKSA, K., NOWOTNA, A., PRAZNIK, W., GAMBUŚ, H., ZIOBRO, R., KRAWONTKA, J. 2010. The role of pentosans and starch in baking of wholemeal rye bread. In *Food Research International*, vol. 43. 2010, no. 8 p. 2045-

CLEEMPUT, G., ROELS, S. P., VANOORT, M., GROBET, P. J. and DELCOUR, J. A. 1993. Heterogeneity in the structure of water-soluble arabinoxylans in European wheat flours of variable bread-making quality. In *Cereal Chemistry*, vol. 70, 1993, no. 3, p. 324-329.

COURTIN, C. M., DELCOUR, J. A. 2002. Arabinoxylans and endoxylanases in wheat flour bread-making. In *Journal of Cereal Science*, vol. 35, 2002, no. 3, p. 225-243.

CUI, S. W., WANG, Q. 2009. Cell wall polysaccharides in cereals: chemical structures and functional properties. In *Structural Chemistry*, vol. 20, 2009, no. 2, p. 291-297.

MORRIS D. L. 1948. Quartitative Determination of Carbohydrates With Dreywood's Anthrone Reagent. In *Science*, vol. 5, 1948, p. 107-108.

IZYDORCZYK, M. S., BILIADERIS, C. G. 1995. Cereal arabinoxylans: Advances in structure and physicochemical properties. In *Carbohydrate Polymers*, vol. 28, 1995, no. 1, p. 33-48.

LAZARIDOU, A., BILIADERIS, C. G., IZYDORCZYK, M. S. 2007. Cereal β-glucans: structures, physical properties, and physiological functions. In *Functional Food Carbohydrates*, 2nd ed., CRC Press : Boca Raton, FL, 2007, 570 p. ISBN 0-8493-1822-X.

STEVENS, C. V., MEREGGI, A., BOOTEN, K. 2001. Chemical modification of inulin, a valuable renewable resource, and its industrial applications. In *Biomacromolecules*, vol. 2, 2001, no. 1, 2001, p. 1-16. ISSN 1525-7797.

TOKÁR, M., BOJŇANSKÁ, T., IVANIŠOVÁ, E., DRÁB, Š. 2011. Effect of inulin addition on technological and baking quality of wheat bread. In *Potravinarstvo*, vol. 5, 2011, special issue, p. 326-331.

TRATHNIGG, B. 2000. Size - exclusion chromatography of polymers. In *Encyclopedia of analytical chemistry*, Wiley : Chichester, 2000, p. 8008-8034.

WOOD, P. J. 2004. Relationships between solution properties of cereal β-glucans and physiological effects - a review. In *Trends in Food Science & Technology*, vol. 15, 2004, no. 6, p. 313-320.

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