



Figure 4  
The necessity of the Food Allergy and Intolerance Databank  
based on the different stakeholder groups' opinion

### RHEOLOGICAL PROPERTIES OF A GLUCOMANNAN OBTAINED FROM A PSYCHROPHYLIC YEAST STRAIN *SPOROBOLOMYCES* *SALMONICOLOR AL<sub>1</sub>*

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#### ABSTRACT

Rheological properties of glucomannan were studied, such as its intrinsic viscosity ( $6.90 \pm 0.22$ ) dl.g<sup>-1</sup>. The rheological profile of aqueous solutions of glucomannan was described by the power law  $\tau = K\gamma^n$  as the value  $0.33 \leq n \leq 0.60$  was not affected in a statistically noticeable manner by variations of concentration  $0.25 \leq C \leq 2.0\%$  or temperature  $25 \leq T \leq 82^\circ\text{C}$ , which confirmed the pseudoplastic behaviour of glucomannan solutions as non-Newton liquids. It was shown that the structuring of the concentrated aqueous solutions of

glucomannan was due to the formation of hydrogen linkages between the relevant macromolecules.

## INTRODUCTION

Konjac glucomannan is a neutral polysaccharide isolated from the tuber of *Amorphophallus konjac* c.Koch. It consists of  $\beta$ -1,4- linked D- D-glucosyl and D-mannosyl units at a ratio 1:1.6, with about 1 in 19 units being acetylated (Zhang et al. 2004). Konjac glucomannan is mainly used in food industry as a gelling agent, thickener, film former, stabilizer, emulsifier and soluble fiber source in bakery products, confectionary, dairy products, noodles, pasta, health foods, functional foods, frozen foods and ice cream, canned, minced meat and fish, salad dressing and sauces, pet foods, edible films and capsules ( Nishinari et al. 1992; Ratcliffe et al. 2005). Polysaccharides containing D-mannose and D-glucose in similar proportions were isolated from plants and produced from yeasts (BeMiller et al. 1993; Adami and Cavazzoni, 1990; Chiura et al. 1982; Vorotynskaya et al. 1992; Pavlova et al. 2004). Yeast glucomannan is not marketed as a dietary supplement.

The aim of this paper is to present the study of rheological properties of aqueous solutions of glucomannan produced by the psychrophilic strain *Sp. salmonicolor* AL<sub>1</sub>.

## MATERIALS AND METHODS

Yeast strain *Sporobolomices salmonicolor* AL<sub>1</sub> was isolated from soil lichen taken from the region of the Bulgarian base on Livingston Island, Antarctica and selected as a suitable producer of exoglucomannan (Pavlova et al. 2004). It was registered in the National Bank for Industrial Microorganisms and Cell Cultures, Bulgaria, under № 08290. Exopolysaccharide production, isolation of crude exopolysaccharide and its chemical analysis was published in a previous article of ours (Pavlova et al. 2004).

Intrinsic viscosity  $[\eta]$  of glucomannan solutions was determined by measurements with capillary viscosimeter VPG 2 type Ubelode at temperature 25<sup>0</sup>C. Experimental data processing was done by a computer program written in FORTRAN 77 on the grounds of an algorithm for finding a linear equation in accordance with Huggins equation (Morawetz 1967). The rheological profile of the aqueous glucomannan solutions was measured by means of a Rheotest – 2 Rheoviscometer, Germany, using measuring cylinder of the device N. The concentrated solutions of glucomannan under study were within the 0.50 – 2.50% range. The measurements were conducted at different temperatures in the

25 ÷ 82<sup>0</sup> C. range. The Oswald-de Waale power law model (Holdsworth 1993) was used to describe the flow behaviour of glucomannan solutions

$$\tau = K \cdot \gamma^n \quad (1)$$

where  $\tau$  is the shear stress (Pa), and  $\gamma$  is the shear rate (s<sup>-1</sup>) K is the consistency index (Pa.s<sup>n</sup>), n is the flow behaviour index (dimensionless)

The numerical values of the shear rate  $\gamma$  and the shear stress  $\tau$  were processed using REOTEST computer program written in FORTRAN 77. During test data processing, the methods of the least squares were applied to find equations of simple and plural linear regression (Draper 1981). Numerical procedures implementation was performed by computer subroutines compiled by (Johnson 1980).

## RESULTS AND DISCUSSIONS

The parameters established during the batch fermentation of the strain indicated that a temperature of 22 °C, aeration at 0.75 v/v/m and agitation at 500 rpm proved to be the most suitable conditions for polysaccharide synthesis. During the biosynthetic process, the apparent viscosity of the culture broth increased to the maximum value of 15.37 mPa.s, and the polysaccharide yield was 5.63 g/l on a culture medium containing 4.00% of sucrose and 0.25% of ammonium sulfate, at a temperature of 22°C for 120 hours.

The following results were obtained from the experiments carried out with capillary viscometer VPG 2 type Ubelode at temperature 25<sup>0</sup>C from Huggins equation

$$[\eta] = (6,90 \pm 0,22) dl \cdot g^{-1} \quad K_H'' = 0,58 \pm 0,14$$

The rheological profile of glucomannan water solutions was determined at a shear rate  $\gamma$  at 1,5 ÷ 1312 s<sup>-1</sup>. The n values obtained during our studies from equation (1) for all solutions of glucomannan fell within the 0,33 ≤ n ≤ 0,60 range, which showed that glucomannan behaved as pseudoplastic non-Newtonian liquids.

The quest for dependence of  $n = f(C\%)$  and  $n = f(T)$  did not yield satisfactory results. For all regression dependences the correlation coefficient was R < 0.63. This was to show that n was not affected in a statistically noticeable manner by the variation of concentration and temperature.

The magnitude of the consistency index K grew with increase of concentration of solutions. Both exponential (Eq.2) and power type (Eq.3) relations were

found to be suitable for the description of the relationship between the concentration and the consistency index.

$$K = 1,064 \cdot \exp(0,9876C) \quad (2)$$

the correlation coefficient  $R=0.932$

$$K = 3,781 \cdot C^{0,883} \quad (3)$$

the correlation coefficient  $R=0.976$

The joint effect of the concentration  $C$  and temperature  $T$  on the  $K$  values was studied by means of a multiplicative model of multiple regression of the kind (4):

$$K = \alpha \cdot C^\beta \cdot \exp\left(\frac{\Delta E_a}{RT}\right) \quad (4)$$

where  $\alpha$  and  $\beta$  are constants,  $R$  – gas constant  $\text{kJ/mol.K}$ ,  $\Delta E_a$  – activation energy ( $\text{kJ/mol}$ )

Processing the experimental data was implemented using the MLRG software based on the least squares method for finding multiple regression within the range  $0,25 \leq C \leq 2\%$  and changes in  $T$  within the  $25 \leq T \leq 82^\circ \text{C}$  range. The values obtained for the constants in equation (4) at a multiple correlation coefficient  $R_n=0.969$  were:

$$\alpha = 4,75410^{-5}$$

$$\beta = 0,7579$$

$$\Delta E_a = 28,55 \pm 1,24 \frac{\text{kJ}}{\text{mol}}$$

According to (Cottrelli 1954) the energy of the hydrogen bond is  $\Delta E_a \approx 23,4 \frac{\text{kJ}}{\text{mol}}$

The value we obtained for the activation energy showed that, the hydrogen bonds established between the separate macromolecule chains had a dominant importance in the formation of structures in the aqueous solutions of glucomannan. Their ruptures when the velocity gradient  $\gamma$  was changed and the following recovery determined the pseudoplastic nature of glucomannan. The

value we obtained for the activation energy  $\Delta E_a = 28,55 \frac{kJ}{mol}$  was very close to

the value of the activation energy  $\Delta E_a = 27,63 \frac{kJ}{mol}$

Obtained by Maekaji (Nishinari et al. 1992) on konjac mannan obtained from the tuber of the *Amorphophallus konjac* plant c. Koch.

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