ABSTRACT

The aim of the dissertation was to investigate the non – starch polysaccharides effect, used in the form of extracts of mucilaginous substances from flax, chia and *Plantago psyllium* seeds, shaping selected parameters of the quality of bread.

The materials used in the study were rice flour, maize starch, maize amylose, *Saccharomyces cerevisiae* freeze – dried yeast, lactic acid bacteria starter cultures LV2, flax *Linum usitatissimum* L, chia *Salvia hispanica* L., and *Plantago psyllium* seeds.

The work presents an analysis of the chemical composition of ground flax, chia and *Plantago psyllium* seeds. Mucilaginous substances (non-starch polysaccharides) were extracted from whole seeds of the plants listed using laboratory methods and characterisation of the freeze-dried extracts was performed, with determination of the chemical composition, including the content of protein, fibre, sugar residues and uronic acids released from the hydrocolloid molecules after acid hydrolysis, phenolic compounds, myo-inositol phosphates, and analysis of the molecular weight distributions of the hydrocolloids contained in the extracts.

The study was a research using gluten – free model breads, consisting only of key components. The composition of gluten – free model mix (model flour) with optimal baking properties, composed of rice flour, corn starch and sucrose in proportions 78,4 : 19,6 : 2 respectively, was determined, and the analysis of the composed model flour was carried out by determining its chemical composition, as wellamylographic characteristics.

In order to determine the seed extracts effects on the properties of gluten – free dough and bread, the dough was prepared using the direct method (single – phase) and with the soughdough, without and with 1% of extracts from which the breads were subsequently baked. The water absorption of the model mixtures and the dough yield were determined. In bread obtained on the day of baking, determinations of baking loss, bread volume and myo-inositol phosphate content were made, while moisture content, crumb hardness and content of carboxylic acids, sugars and alcohols were determined after 1 and 3 days of storage. Breads with 10% of ground seeds were also baked for comparison. In addition, to test the effect of the extracts in relation to the amylose content of the flour, breads with a 10% increase in amylose were also baked and tested.

In order to determine the effect of 1% addition of extracts on bread ageing, the dynamics of crumb digestion and the content and molecular weight of resistant starch contained in the crumb of breads obtained on the day of baking and after 1 and 3 days of bread storage were studied. In addition, amylograph viscosity measurements were carried out on amylograph aqueous suspensions of lysophilised crumb of breads baked by the direct method, on sourdough and crumb of breads baked by the direct method with 10% increased amylose, obtained on the day of baking and after 1 and 3 days of storage.

The mucilage substances extracted from all three types of seeds (flax, chia and *Plantago psyllium* seeds) with the efficiency in the range of 8,5 – 10,6% constituted in more than 75% fiber containing non-starch polysaccharides.

The highest content of polysaccharides was found in *Plantago psyllium* seed extract (PP-ex), while the lowest in chia seed extract (SH-ex). Heteropolysaccharides composed of uronic acid molecules and sugar residues such as xylose, arabinose, glucose, galactose and mannose were found in all extracts. Additionally, rhamnose was found in flax seed extracts (LU-ex) and PP-ex, fucose in LU-ex, and mannose in SH-ex and PP-ex. In addition, in polysaccharide extracts, the presence of phenolic acids: ferulic acid, p-coumaric acid and, in SH-ex, additionally caffeic acid, occurring also as substituents in the molecules. A significant part of the extracted mucilages substances were arabinoxylans, of which the largest number were found in *Plantago psyllium* seed extract and the least were found in flax seed extract.

The polysaccharides extracted from *Plantago psyllium* and chia seeds consisted almost exclusively of a high-molecular fraction, whereas the polysaccharides from flax seeds consisted of a high-molecular and a low-molecular fraction. Among the three preparations, the *Plantago psyllium* polysaccharides were characterised by the highest molecular weight.

The amount of water addition required to obtain the same optimum dough consistency of the model gluten – free dough, prepared both by the single – phase method and with the sourdough starter from the base mix (model flour) without and with 1% extracts (used in place of part of the flour), was proportional to the molecular weight of the added hydrocolloids and increased for individual samples in the series: control < LU-ex < SH-ex < PP-ex.

As a positive consequence of the above differences in the amount of water added to the dough, higher dough yields, higher bread volumes per 100 g of flour and higher

crumb moisture of the samples with extracts were obtained compared to the corresponding samples without extracts.

The addition of the LU-ex extract resulted in a crumb with a strong structure expressed by the highest volume of bread baked from the same amount of dough using both baking technologies, compared to the corresponding samples without the extracts. In addition, the crumb of bread with LU-ex and PP-ex extracts was characterized by low hardness.

In breads baked by the single – phase method and with sourdough starter, a 1% addition of extracts resulted in a significant reduction in moisture loss and an increase in hardness compared to the control sample (bread without extracts). In assuring crumb moisture retention during storage, PP-ex extract proved to be the most effective in bread obtained by the direct method, and SH-ex in bread obtained with sourdough. As far as the reduction of crumb hardening during storage is concerned, a 1% share of *Plantago psyllium* seed plant extracts (PP-ex), characterized by a high arabinoxylans content, proved to be the most effective.

The addition of the mucilage substance extracts from the seeds had little effect on the myo-inositol phosphate content, whereas the addition of ground seeds (especially chia) resulted in an increase in the myo-inositol phosphate content of flour and bread. During fermentation and baking there was a defossorylation of phytates with a high degree of phosphorylation, much more effective with sourdough baking.

The highest content of aroma – forming compounds was found in the bread crumb baked using the sourdough method with LU-ex extract rich in short-chain arabinoxylans, while in breads with SH-ex and PP-ex the content of organic acids and sugars was similar to or lower than the control sample. During storage, the carboxylic acid and sugar contents were concentrated due to crumb drying, while ethanol was partially evaporated.

A 10% higher proportion of amylose (AM) in the model mix had a positive effect on bread volume for samples without the addition of extracts, but the volumes of breads with extracts were smaller compared to the corresponding breads baked from the standard base mix. Breads baked from the model flour with an increased AM proportion were characterized by a correspondingly higher crumb hardness compared to the corresponding breads baked from the standard base mix. During storage, the crumb of breads baked with increased AM hardened significantly more intensively compared to the corresponding variants of breads baked with the standard model mix.

A 1% addition of each extract increased the crumb content of rapidly digested starch (RDS), slowly digested starch (SDS) and decreased the content of very slowly digested starch (DS), with PP-ex being the most effective and LU-ex the least effective. The type of dough technology did not significantly affect the RDS content, while the use of sourdough baking increased the SDS and resistant starch (RS) content in the crumb of the breads. Increasing the proportion of AM in the dough resulted in a significant decrease in RDS and SDS content with a more than 2-fold increase in RS content in the bread crumb. During storage, all crumb samples showed a reduction in RDS content and an increase in SDS and RS content.

Irrespective of the baking method used, as well as the increased proportion of AM in the model gluten – free flour, the molecular weight of RS (resistant starch) isolated from the crumb of breads with extracts was lower, compared to samples representing the respective control. In the bread crumbs using sourdough, the molecular weight of RS was higher than in the bread crumbs obtained using the single – phase method. The RS molecular weight in the crumb of all bread variants decreases progressively during storage.

The amylographic analysis of the model bread crumb showed that the use of extracts (in particular PP-ex), resulted in incomplete starch sticking during baking. The addition of all extracts resulted in an increase in initial viscosity, maximum viscosity and a decrease in the starch sticking temperature in the breads crumb. The increase in starch stickiness temperature and the decrease in viscosity, correlated with crumb hardness, observed in crumb samples from breads obtained on successive storage days resulted from strong interactions between starch chains and dough components.