ACTA UNIVERSITATIS AGRICULTURAE ET SILVICULTURAE MENDELIANAE BRUNENSIS

Volume LIX 35 Number 5, 2011

USAGE OF HYDROCOLLOIDS IN CEREAL TECHNOLOGY

Ľ. Mikuš, Ľ. Valík, L. Dodok

Received: March 9, 2011

Abstract

MIKUŠ, Ľ., VALÍK, Ľ., DODOK, L.: *Usage of hydrocolloids in cereal technology.* Acta univ. agric. et silvic. Mendel. Brun., 2011, LIX, No. 5, pp. 325–334

Hydrocolloids are high-molecular-weight polymer substances soluble in water which create viscous colloidal solutions. They are mainly used to influence functional properties of food (structure, texture, etc.), improving their properties during production (bigger dough volume, better dough manipulation – better adhesion), increasing stability, maintaining taste firmness in frozen products and prolonging durability of cereal products in food industry.
Hydrocolloids are characteristic for their thickening effect and are used for their emulsifying and steadiness properties. The aim of this review is to provide useful information about hydrocolloids including chemical structure, origin, common and recommended usage in food industry, proper application in the cereal technology and future scientific heading of these hydrocolloids.

hydrocolloids, colloidal solution, thickening, toughening

Food hydrocolloids are biopolymers with high molecular weight, containing a hydrophile string, often with colloidal properties (ability to firmly bind large amount of water, up to one hundred times of its weight), which are used as ingredients in food industry to adjust the microstructure, texture, taste and to prolong shelf-life. Their properties are affected by size of molecules, directions and association of molecules, concentration, size of particles, dispersion degree and others.

The name “hydrocolloid” includes many polysaccharides obtained from plants, seaweed, microorganisms, as well as modified biopolymers created by chemical or enzyme adaptation of starch and cellulose (Renard, 1996; Rollet, 1995).

Food industry observed an increased application of these biopolymers in the last years. Although they are used at concentrations less than 1% they have considerable effect on texture and sensorial properties in food products.

Hydrocolloids have neutral taste and aroma, which enables them free access to food insertion. Hydrocolloids are used as sugar, fat and gluten substitutes, stabilizers (emulsions, foams), crystallizing inhibitors, thickening agents, gelatinization substances and they also modify starch gelatinization (Chenlo, 2009; Rosell, 2001). Natural hydrocolloid gums are a good source of soluble dietary fibre (up to 85% of dry mass). Their energy value is minimal to none, therefore are hydrocolloids used as fat replacing ingredients. Soluble dietary fibre also reduces the concentration of cholesterol and improves gastrointestinal functions and glucose tolerance (Sozer, 2009).

Hydrocolloid usage in cereal technologies depends on their properties to densify liquids (viscosity increase), water holding capacity, hydration rate and effect of temperature on hydration (for most hydrocolloids viscosity drops with rising temperature) (Příhoda, 2003).

From health point of view, hydrocolloids are used in dough and bread systems to block fat absorption during the baking process so that they can develop fatty acids with shorter chains to create nutritionally richer food.

In the following survey, we aimed at description of the hydrocolloids which are related to cereal technology.

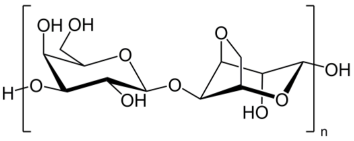
SEAWEED HYDROCOLLOIDS

Most important seaweed hydrocolloids are agars, carrageenans and alginates, which are produced in form of colourless powders (Philips, 2000).

AGAR (E406)

Agar was the first hydrocolloid used as an additive into food in Asian countries 300 years ago. Hydrocolloids are products extracted from seaweeds for their colloidal properties. Agar is a strong emulsifier hydrocolloid derivable from seaweed. It forms intracellular gel matrix in various kinds of agarophyte red algae - (family *Rhodophyceae*), where it has a similar function as cellulose in higher plants. Agars main structure consists of repeated (1,3)-β-D-galactopyrazole and (1,4)-3,6-anhydro-α-D-galactopyrazole units, with small changes and with a low content of sulfate esters. Main neutral polysaccharide is agarose (Fig. 1), which basic structural unit is disaccharide agarobiose. Seaweed (source of agar) is mainly from the family *Gelidaceae*, *Gracilariaceae* and *Pterocladiaceae*, which grows on the coast of Portugal, South Africa, India, Japan, Mexico, Chile and New Zealand. Agar is mostly gained by hot water extraction in neutral, acidic or alkali environment. In alkali environment a partial sulfate hydrolysis occurs and agars with modified properties are created. Extracts are freeze dried to obtain gels, which are dried after (Hoefler, 2004; Kohajdová, 2009).

Agars are soluble in hot water at 85 °C and higher. After cooling they form gel, which is used at concentrations of 0.5 to 2.0%. This gel is melting at higher temperature than at which was created at 95 °C. Resistance to deformation is improved when they are combined with different hydrocolloids, for example with carob. Agar is used to form glaze in confectionary products and to prolong shelf-life of cereal products. In Japan it is also used as an independent substance which produces various kinds of flavoured gels or edible coatings (Zamora, 2005; Velíšek, 1999; Norziah, 2006).



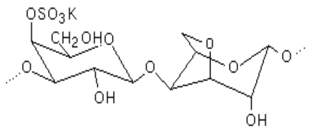
1: *Aragose chemical structure fraction (Wikipedia, 2010)*

CARRAGEENAN (E407)

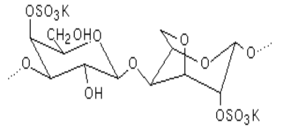
Main species *Rhodophyceae* (red sea-grass and seaweed) in commercial fabrication of carrageenans includes species from the genera *Euchema (E. cottonii* and *E. spinosum)*, *Chondrus* and *Gigantina*. Seaweed species *Euchema* is a bushy plant 50 cm high, which grows on cliffs and in lagoons near Philippines and Indonesia, seaweed *Chondrus crispus* form dark small bushes 0.1 m high near north Big Pond and seaweed species *Gigantina* grows in cold waters of South America (Chile) which grows up to 5 m high (Rosell, 2001; Příhoda, 2003; Philips, 2000).

E. cottonii contains kappa carrageenan and *E. spinosum* contains iota carrageenan. They are mostly extracted with hot water in alkali environment as sodium salts (by acidifying acid carrageenans are created) and a final product is acquired by drying or by coagulation with solvents. Carrageenan is a linear polysaccharide with high molecular weight, containing repeated galactose and 3,6-anhydro-galactose units (sulfated and non-sulfated), joined with α-(1,3) and β-(1,4) glycoside bonds. Based on the amounts of sulfate groups, carrageenans can be divided into 8 groups, from which only three are used in the food industry such as lambda-, iota- and kappa- carrageenans (Fig. 2, 3, 4) (Hoefler, 2004; Velíšek, 1999).

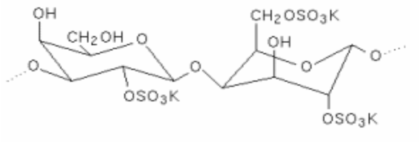
Kappa-carrageenan forms a strong gel with potassium ions, whereas iota-carrageenan forms almost none. All carrageenans are soluble in hot water, but only kappa- and iota-carrageenans are soluble also in cold water. Iota-carrageenan is used in concentration of 0.2% and its effectivity depends on the amount of salt and on starch retrogradation in cereal product (Funami, 2008). Carrageenans are stable within pH range 5 to 10, in acidic environment hydrolysis occurs and viscosity is dropping. They are used as cream and freeze filling stabilizers (emulsifier, thickening and gelatinization agent) (Soukoulis, 2008; Langendorff, 2000). Kappa-carrageenan as a secondary hydrocolloid with a primary hydrocolloid (xanthan gum) improved reological properties and increased stability of a frozen product (ice cream) during storage due to its



2: *Kappa-carrageenan chemical structure (Carrageenan structure, 2010)*



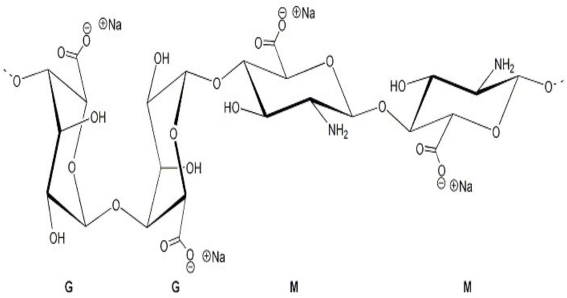
3: *Iota-carrageenan chemical structure (Carrageenan structure, 2010)*



4: *Lambda-carrageenan chemical structure (Carrageenan structure, 2010)* interaction with casein, hence is mainly used in milk products at concentrations of 0.01 to 0.1% (Guarda, 2004; Yanes, 2002; Gomez, 2007). Similar synergetic effect is known also for kappa-carrageenan and carob (Yamazaki, 2008). In the mixture with lecithin it softens bread crumb, improves volume and structure of bread (Barcenas, 2009; Kohajdová, 2008).

ALGINATES (Sodium alginate E401)

Alginates are alginate acids, which come from so called "brown seaweeds" *Phaeophyceae* species, growing near north Big Pond, Norway, France and Britain's coast. Industry sources of alginate acids are seaweed from species *Macrocystis pyrifera, Laminaria hyperborea* and genera *Ascophyllum* and *Sarrgasum*. Seaweed dry matter comprises 40% alginate acid. It is gained as sodium salt (alginate) from seaweed by extraction with NaOH and Na_2CO_3 solutions. It coagulates like calcium salt $CaCl_2$ or reacts with HCl, which creates alginate acid. Final product is neutralized. Alginates are linear β-D-mannuron acid and α-L-guluron acid polymers joined with glycoside (1,4) bonds (Příhoda, 2003; Velíšek, 1999). Alginates form thermostable gels in the presence of calcium ions. The amount of guluron acid influences their various gel properties. All alginates are colourless, or light yellow, without smell or aroma. They are used as thickening and emulsifying agents to improve structure of bakery products, dressings, sauces and ice creams at concentration of 0.1 to 0.5% (Guarda, 2004; Yanes, 2002; Gomez, 2007). Mixture of small amount of calcium alginate and sodium alginate (Fig. 5) significantly increases solution viscosity. This mixture is used in fruit jelly and pudding making (sodium alginate reacts with calcium present in milk). Thermo-reversible gels are formed due to the reaction of high esterified pectins with proton amino acids residues in proteins to create coagulates. This method is used for protein removal, for example in beer. These gels also have cryoprotective properties and improve structure and taste stability in frozen products (Ptáčková, 2008; Sim, 2010; Huang, 2001).

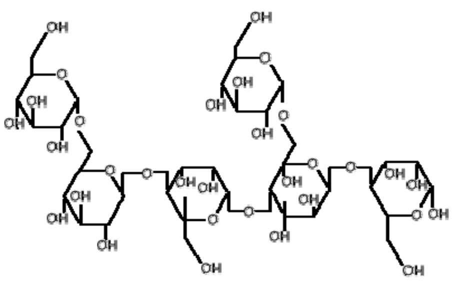


5: *Sodium alginate E 401 (Wikipedia, 2010)*

HYDROCOLLOIDS FROM BULBS, SEEDS AND SOME VEGETATIVE PLANT PARTS

GUAR GUM (E412)

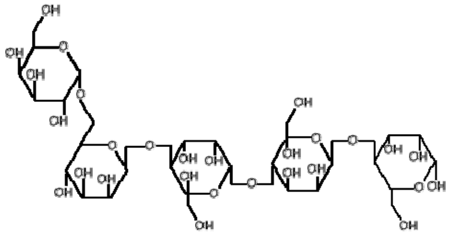
Guar gum (Fig. 6) is gained from guar legume seed endosperm *Cyamopsis tetragonolobus*, Leguminosae, after sprout and surface layer removal. This plant grows mostly in India and Pakistan as a food commodity, but since 1950 it grows also in Texas and Arkansas as a commercial commodity. Guar gum is a soluble non-ionic polysaccharide (Achayuthakan, 2008). This polysaccharide consists of (1,4) bonded β-D-manopyranozyl units with one α-D-galaktopyranozyl unit and with a (1,6) bond on every second main unit. Wide guar branching is responsible for its easier hydratation properties and also for its higher water activity and stability in solutions with pH 4 to 10. Guar gum is frequently used with xanthan gum for their synergetic effect, which improves dispersion viscosity (Chaisawang, 2005). Guar gum has a wide range of usage and is mainly consumed plant seed gum. Commonly is used at concentrations of 0.1 to 0.5% (Chenlo, 2009; Gomez, 2007; Huang, 2001). Partially it is used as water-soluble food fibre, which has physiological activity (lowering pH of food in intestines, lowering cholesterol concentrations, fatty acids and glucose in human body) (Grupta, 2009). Addition of guar gum in dough during kneading gives the dough higher elasticity. Guar gum lowers the crust hardness, enhances specific volume, improves texture and slows aging of bread and bakery products (Ribotta, 2004). It is used as ice cream stabilizer, wheat substitute in gluten-free bakery products for celiac diet and to increase volume and to slow aging of bakery products. It is also added into some dessert mixtures to allow blending and milling of dry matter, which is not possible in normal dough (Velíšek, 1999; Kohajdová, 2008).



6: *Basic guar gum structure (Food ingredients, 2010)*

CAROB GUM (E410)

Carob gum (Locust bean gum) or St. John's bread (Fig. 7) – flour from endosperm seeds of *Ceratonia siliques* L. is a galactomannan composed from (1,4)-β-D-manopyranosyl unit joined with (1,6)-α-D-galaktopyranosyl unit repeating itself every fourth time. Carob gum grows near the Mediterranean Sea and is sensitive to low temperatures. Carob trees grow up to 9 m high and their pods start to grow after 7 to 15 years. Carob gum soaks and is insoluble in cold water. Carob properties are only little dependable from pH, salts and temperature due to its non-ionic structure (Philips, 2000; Hoefler, 2004; Velíšek, 1999). Galactose position on the linear manose structure affects solubility mechanism and controls reological properties of carob gum, it is called "M/G ratio". Thus higher ratio manose (M) to galactose (G) increases viscosity (Dakia, 2008). Carob gum by itself does not form gels, but increases elasticity and gel firmness of agar and carrageenan (Goncalves, 2005). Gel is formed only in the presence of xantham gum, which also alone doesn't create gels. Ratio of xanthan and carob gum is 0.25:0.75 (Ramirez, 2002). Carob gum is used to increase volume and to slow aging of bakery products, to stabilize and thicken fruit fillings, frozen products and semi-products. It is not favourable to create clean dispersions due to its non-soluble endosperm seed content. It is used at concentrations of 0.1 to 0.5% (Huang, 2001, Acrocas, 2009; Makri, 2006). Carob gum is relatively costly and therefore it is frequently falsified with cheaper guar gum (Arda, 2009; Kohajdová, 2009). Synergic effect of xanthan gum, agar and carrageenan is also well known (Dakia, 2007).



7: *Basic carob gum structure (Food ingredients, 2010)*

PLANT AND EXUDATES HYDROCOLLOIDS

ARABIC GUM (E414)

Arabic gum or gum *Acacia* is an exudate from *Accacia senegal* tree. It is a heteropolysaccharide with 2% protein content, obtained from batch or branch of *Accacia* trees (Li, 2010). Arabic gum was used to embalm mummies and also to paint some hieroglyphs. These trees grow north from equator in Africa to Sahara and from Senegal to Somalia. Sap dries on branches. Dried sap is harvested and sorted by its size and colour. Gums from Accacia senegal and Accacia seyal are complex polysaccharides and both contain small portion of nitrogen material, which can't be removed by purification. Their chemical properties differ with climate, year season, tree age, etc. Arabic gum is a substituted acidic arabinogalactan. Basic structural unit is except D-galactose (44%) and L-arabinose (27%) also α-L-rhamnopyranose (13 %), in smaller amount β-D-glucuronic acid and 4-O-methyl-β-D-glukuronic acid (16%) (Philips, 2000; Hoefler, 2004; Velíšek, 1999). It is soluble in water and it has good emulsifying properties. Arabic gum has unique ability to be soluble in water at concentration up to 50% (w/w). Viscosity is strongly affected by pH values (maximal values are within pH 4.5 to 8.0) and in the presence of electrolytes viscosity is dropping. At commonly used concentrations they do not create gels. Arabic gum mainly stabilizes oil in water type emulsions due to proteins bonded to polysaccharides and is used at concentrations of 0.1 to 1% (Huang, 2001; Makri, 2006; Funami, 2008). Arabic gum is added into wheat dough to slow aging of bakery products, to improve volume of bakery products, to milder consistence in ice creams and in confectionery to stop sugar crystallization (Dickinson, 2003; Yadav, 2007; Ali, 2009; Islam, 1997).

TRAGACANTH GUM (E413)

Tragacanth gum is exudate gained from *Astragalus* bush, from which *A. gummifier*, *A. microcephalus* and *A. kurdicus* are the most known one. They are small plants growing in dry deserts and highlands of southwest Asia from Pakistan to Greece mainly in Iran and Turkey (Chenlo, 2009; Philips, 2000; Hoefler, 2004). Tragacanth gum contains besides small starch amount (1 to 3.6%) also two polysaccharide groups. First group composes of arabinogalactans (60 to 70% mass), which main chain is created from D-galactopyranosyl units with β-(1,4) bonds, in sideways chains D-galactopyranosyl units are coupled with β-(1,6) bonds and terminal arabinose units are connected to β-D-galactose with (1,2), (1,3) and (1,5) bonds. Second group comprises pectin type acidic polysaccharides created from α-D-galacturonic acid with (1,4) bonds (Velíšek, 1999). Tragacanth gum is resistant to hydrolysis, to mechanical straining and is lightly influenced by pH. In water it forms highly viscosious paste or gel dispersions already at low concentrations. It can hold bonded water in frozen food and it is used in concentration of 0.1% as thickening, emulsifying and stabilizing agent into various glazings and fillings into frozen and blank stock products (Glicksman, 1982).

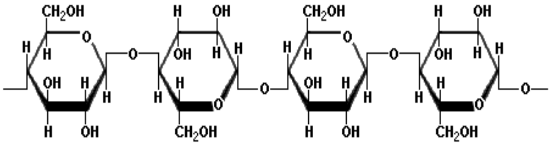
GUM KARAYA (E416)

Gum karaya, known as gum *Sterculia*, is a dry extract from *Sterculia urens* Roxburgh and other *Sterculia* brands, or from *Cochlospermum gossypium* A.P De Condolle and *Cochlospermum* Kunth. Gum karaya is gained from bushy *Sterculia urens* trees, which grows on Indian subcontinent and *S. setigera*, which grows in Sudan and in other northafrican countries. These trees grow up to 10 m high on dry rocky mountains in middle and north India. Gum karaya is a complex of partially acetylated polysaccharides with high molecular weight. It is glycano-rhamno-galacto-uritan, which main polysaccharide chain is composed of L-rhamnopyranose and D-galacturonic acid, which are joined by glycosidic α-(1,4) and α-(1,2) bonds. Ending units are rhamnose, galactose and glucuronic acids, some units are partially acetylated (Philips, 2000; Hoefler, 2004; Velíšek, 1999). Gum karaya is poorly soluble, at low concentrations (< 0.02%) forms solutions and at higher concentrations (up to 5%) viscosious colloidal dispersions. Commercially sold gum karaya contains 60% of neutral saccharide residue (galactose and rhamnose), 40% acidic residues (galacturonic and glucuronic acid) and 8% of acetyl groups (Vinod, 2010). It is used as emulsifier, to improve water holding capacity, as foam stabilizer, to increase dough stability and to prolong shelf-life of bakery products (Barcenas, 2009).

CELLULOSE AND ITS CHEMICALLY MODIFIED DERIVATE HYDROCOLLOIDS

CELLULOSE (E460)

Cellulose (Fig. 8) is a main component of most plants and is widely used in food and other industries. To modified cellulose derivates belongs methyl cellulose (E 461), hydroxy propyl cellulose (E 463), hydroxy propyl methyl cellulose (E 464), methyl ethyl cellulose (E 465) and karboxy methyl cellulose (E 466). Structurally it is a polymer chain composed of repeated anhydro glucosyl units joined with β-(1,4) glycoside bonds. Each anhydro glucosyl unit contains three hydroxyl groups, which can be substituted (*10, 11*). Karboxy methyl cellulose (CMC) 0.1 to 0.2% (Chenlo, 2009; Gomez, 2007) and hydroxyl propyl methyl cellulose (HPMC) 0.1% (Guarda, 2004) are added to improve wheat and whole grain. Hydrocolloids increase bread volume, softens bakery texture, prolong freshness of bakery products and lower physical damage caused by ice particles during storage at very low temperature. Most common hydrocolloid for this purpose is HPMC (Barcenas, 2004; Ashwini, 2009). Cellulose derivates are used as non-caloric thickening agents in creams, bakery and confectionary fillings with low caloric intake (Xue, 2009).



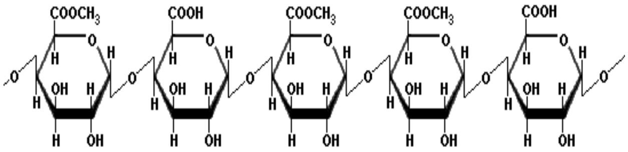
8: *Basic cellulose structure (Zamora, 2005)*

PECTINS (E440)

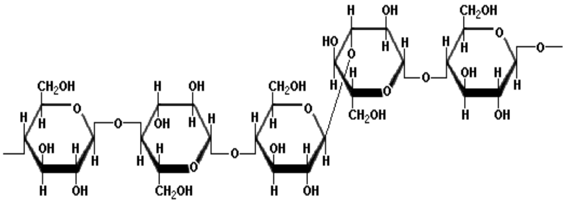
Pectins (Fig. 9) used as food additives are heteropolysaccharides of only plant origin, which contain at least 65% of D-galacturonic acid units joint with α-(1,4) bonds and are partially esterified by methanol. They are mostly present in fruit and vegetable (about 1%) and are commercially created mainly from citrus peels (20 to 40% of pectin) or from apple peel (10 to 20% of pectin). Pectin is isolated by acidic extraction (pH 1.5 to 3) at temperature levels from 60 to 100 °C and than dried or thickened. Pectins are divided according to their esterification degree – DE (% of galacturonic acid metylation in methyl-ester form) to high-esterified pectins (HM) with DE above 70% and to low-esterified pectins (LM) with DE under 50%, which can be amidified (LMA) or non-amidified (NLMA). Pectins are soluble in water and insoluble in most organic dissolvents. Solubility in water drops with growing molecular weight and esterification degree of carboxy groups. Highesterified pectins are soluble in warm environment. Dispersions have low viscosity, therefore pectin is not used as a thickening agent (Philips, 2000; Hoefler, 2004; Velíšek, 1999). Pectin molecules have in neutral environment negative charge, therefore they react with positively charged polymers (proteins). In acidic environment pectin stabilizes casein. Pectin like Arabic gum produces stable emulsions at low concentrations. Emulsifying effects of pectin are caused by protein residues in its structure (Leroux, 2003). Lambda-carrageenan with pectin improves bread firmness and pectin increases the bread volume (Ribotta, 2005). Pectin is used at concentrations 0.5–1.5% to form gel products, also is used in confectionary fillings and in confectionary industry to stabilize foam during lashing (Dickinson, 2003; Tykvartová, 2008). Together with 0.2% calcium chloride pectin increased mechanical gel properties (increased level of stress – 15% and hardness – 22%) (Barrera, 2002). Pectins proteinaceous moiety functions increase the accessibility and surface activity of emulsion droplets (Funami, 2007; Lutz, 2009; Funami, 2010).

β-GLUCAN

β-glucans (Fig. 10) are high plants cell walls constituents, they are present in cereal seeds in bigger amount (barley, oat, rye, wheat, etc.), in mushrooms (*Pleurotus ostreatus, Ganoderma lucidum, Lentinula edodes, Grifola frondosa*), in bakery yeast cell walls (*Saccharomyces cerevisiae*), in seaweed and in bacteria (Beta-glucan, 2010). Content of the β-glucan depends more on cultivar type then on



9: *Basic pectin structure (Zamora, 2005)* environmental or agronomical factors. Content of glucans in wheat and rye is 0.2 to 2%, in brown rice 1 to 2%, in oat 5 to 10% and in barley 14 to 16%. Both barley and oat β-glucans are stable within pH range from 2 to 10, resp. 2 to 11 (at room temperature) (Burkus, 2000). Highest concentration of β-glucan is in endosperm. β-glucan is a polysaccharide composed of glukopyranosyl units joined with (1,4)-β and (1,3)-β units. Solubility of β-glucan depends on its structure, which depends on its origin (it drops in series oat>barley>wheat) and it drops with higher number of (1,4) bonds in its molecule. Protein bonded β-glucans are insoluble, solubility increases with higher temperature and after partiall hydrolysis a gel is formed (molecules don't form gel). Many hydrocolloid products containing β-glucan from oat and barley, e.g. Oatrim, Nu-TrimX and Barleytrim were developed during 15 years. These products beside their health aspects could partially substitute fat or flour in food, which reduces their calorie content. Research indicates, that a small β-glucan addition in bakery products can lead to increased bread glycemic index with increased starch digestibility (Brennan, 2007). Oat β-glucan hydrocolloids are made by fractionation of oat bran after boiling in hot steam. These products include Nutrim-OB with 10 g β-glucan/100 g and C-Trim20 with 20 g β-glucan/100 g. Suyong Lee et al. partially replaced flour with these products and concluded that Nutrim-OB can partially replace flour up to 20% and C-Trim20 up to 10% without negative effect on taste and structure of bakery product (Lee, 2009). Recommended daily portion of β-glucan is 3 g per day or 0.75 g per meal (Sahan, 2008). β-glucan is used in bakery products at concentrations 0.2 to 1.4% to increase consistency, resistance to deformation, fluidity and elasticity of dough. β-glucan affects dough reology in two ways: breaking the gluten matrix and increasing the whole dough viscosity. This effect depends on its molecular weight and on used flour quality (Skendi, 2009; Skendi, 2010). Addition of β-glucan rich hydrocolloids in food as a fat or flour replacement is a good way to improve health trough dietary fibre increase and decrease of calorie intake (Brennan, 2007; Wood, 2007; Lazaridou, 2007).

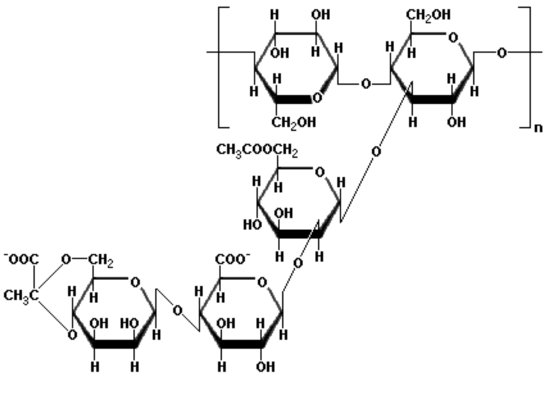


10: *Basic β-glucan structure (Zamora, 2005)*

HYDROCOLLOIDS FROM MICROORGANISMS

XANTHAN GUM (E415)

Xanthan gum (Fig. 11) is an anion extracellular polysaccharide produced by bacterium *Xanthomonas campestris* (Achayuthakan, 2008). Xanthan gum is soluble in cold water, has high molecular weight (M = 2.5 × 10^6 g/mol), high and stable viscosity independent from pH. With increased temperature it drops at first but grows after (conformation molecule changes). This polysaccharide is also resistant to enzymatic degradation. Xanthan gum by itself does not form gels. It has synergic effect at low concentration with guar gum, carob gum and konjak gum (Arocas, 2009). Result of this effect is improved viscosity at low concentration of guar and carob gum. At higher concentrations of xanthan gum are carob and konjak gums responsible for formation of soft, elastic and thermally reversible gels. Xanthan gum structure is linear with main β-D-glucose chain with saccharidal bond on every C-3 glucose, which contains glucuronic acid residue binded to manose unit. Xanthan gum, alginate and carob gum affect moisture content, texture and retrogradation enthalpy of bread crust. It is commonly used with emulsifier to develop non-gluten bread, bread rich on proteins, bakery fillings, sirup glazings, desserts and milk products, cakes, to stabilize emulsions (mostly oil/water) and to improve stability of frozen dough at concentration of 0.1 to 0.25% (Guarda, 2004; Gomez, 2007; Arocas, 2009, Makri, 2006). Xanthan gum also prolongs shelf-life of bakery product due to gluten-starch inhibition and lower moisture loss of crumb (Barrera, 2002; Simsek, 2009; Matuda, 2008; Shittu, 2009).



11: *Basic xanthan gum structure (Zamora, 2005)*

SUMMARY

In spite of wide scale of hydrocolloid usage in bakery and confectionary products there are only few empiric studies and very little information about interactions between hydrocolloids and bakery ingredients. Certainly the relationship between hydrocolloids and starch, gluten and surrounding water molecules is responsible for quality of bakery products. Deeper analysis of hydrocolloid interactions inside the bread should bring useful informations for their optimal usage. Hydrocolloids are able to modify gluten and starch properties, mainly by influencing gluten hydratation and interfering during gelatization and retrogradation of starch. Nowadays scientists try to combine good thickening properties with effective nutraceutical and nutritional (fibre) benefits in a hydrocolloid to gain more positive hydrocolloid effects and to incorporate them in a final bakery product. Past innovative developments include: agglomeration to suppress dusting, cellulose free **xanthan gum** for compatibility with cellulosics, cholesterol reduction and cancer risk avoidance (e.g. **CMC/HPMC**, **pectin**, **carrageenan**), dispersibility to accelerate hydratation at low shear, identification of nutritional benefits (fibre) and production of a clarified and faster dissolving version of hydrocolloids. Price is also an essential factor, therefore new hydrocolloids are invented and known hydrocolloids are improved to fulfill market demands for a healthy, cheap and effective bakery additive (Sozer, 2009; The world of food ingredients, 2010).

Acknowledgements

The work was supported by The Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic for the Structural Funds of EU, OP R&D of ERDF in the frame of the Project "Evaluation of natural substances and their selection for prevention and treatment of lifestyle diseases" (ITMS 26240220040) and by the agency APVV in the frame of project Nr. 0310-06 and VMSP-II-0024-09.

REFERENCES

ACHAYUTHAKAN, P., SUPHANTHARIKA, M., 2008: Pasting and rheological properties of waxy corn starch as affected by guar gum and xanthan gum. *Carbohydrate Polymers*, 71: 9–17.

ALI, B. H., ZIADA, A., BLUNDEN, G., 2009: Biological effects of gum arabic: A review of some recent research. *Food and Chemical Toxicology*, 47: 1–8.

ARDA, E., KARA, S., PEKCAN, O., 2009: Synergistic effect of the locust bean gum on the thermal phase transitions of k-carrageenan gels. *Food Hydrocolloids*, 23: 451–459.

AROCAS, A., SANZ, T., FISZMAN, S. M., 2009: Improving effect of xanthan and locust bean gums on the freeze-thaw stability of white sauces made with different native starches. *Food Hydrocolloids*, 23: 2478–2484.

AROCAS, A., SANZ, T., FISZMAN, S. Z., 2009: Improving effect of xanthan and locust bean gums on the freeze-thaw stability of white sauces made with different native starches. *Food Hydrocolloids*, 23: 2478–2484.

ASHWINI, A., JYOTSNA, R., INDRANI, D., 2009: Effect of hydrocolloids and emulsifiers on the reological, microstructural and quality characteristics of eggless cake. *Food Hydrocolloids*, 23: 700–707.

BARCENAS, M. E., BENEDITO, C., ROSELL, C. M., 2004: Use of hydrocolloids as bread improvers in interrupted baking process with frozen storage. *Food Hydrocolloids*, 18: 769–774.

BARCENAS, M. E., O-KELLER, J. D., ROSELL, C. M., 2009: Influence of different hydrocolloids on major wheat dough components (gluten and starch). *Journal of Food Engineering*, 94: 241–247.

BARRERA, A. M., RAMIREZ, J. A., GONZALEZ-CABRIALES, J. J., VAZQUEZ, M., 2002: Effect of pectins on the gelling properties of surimi from silver carp. *Food Hydrocolloids*, 16: 441–447.

Beta-glucan: *http://en.wikipedia.org/wiki/Beta-glucan*

BRENNAN, CH. S., CLEARY, L. J., 2007: Utilisation Glucagel® in the β-glucan enrichment of breads: A physicochemical and nutritional evaluation. *Food Research International*, 40: 291–296.

BURKUS, Z., TEMELLI, F., 2000: Stabilization of emulsions and foams using barley β-glucan. *Food Research International*, 33: 27–33.

Carrageenan structure:
http://www.cybercolloids.net/library/carrageenan/introduction-carrageenan-structure.

DAKIA, P. A., BLECKNER, CH., ROBERT, CH., WATHELET, B., PAQUOT, M., 2008: Composition and physicochcemical properties of locust bean gum extracted from whole seeds by acid or water dehulling pre-treatment. *Food Hydrocolloids*, 22: 807–818.

DAKIA, P. A., WATHELET, B., PAQUOT, M., 2007: Isolation and chemical evaluation of carob (Ceratonia siliqua L.) seed germ. *Food Chemistry*, 102: 1368–1374.

DICKINSON, E., 2003. Hydrocolloids at interfaces and the influence on the properties of dispersed systems. Food Hydrocolloids, 17: 25–39.

Food ingredients: *http://sci-toys.com/ingredients/*

FUNAMI, T., NAKAUMA, M., ISHIHARA, S., TANAKA, R., INOUE, T., PHILLIPS, G. O., 2010: Structural modifications of sugar beet pectin and the relationship of structure to functionality. *Food Hydrocolloids*, 1–9, in press.

FUNAMI, T., NAKAUMA, M., NODA, S., ISHIHARA, S., ASAI, I., INOUCHI,, NISHINARI, N. K., 2008: Effects of some anionic polysaccharides on the gelatinization and retrogradation behaviours of wheat starch: Soybean-soluble polysaccharide and gum arabic. *Food Hydrocolloids*, 22: 1528–1540.

FUNAMI, T., NODA, S., HIROE, M., ASAI, I., IKEDA, S., NISGINARI, K., 2008: Functions of iota-carrageenan on the gelatinization and retrogradation behaviors of corn starch in the presence or absence of various salts. *Food Hydrocolloids*, 22: 1273–1282.

FUNAMI, T., ZHANG, G., HIROE, M., NODA, S., NAKAUMA, M., ASAI, I., COWMAN, M. K., AL-ASSAF, S., PHILLIPS, G. O., 2007: Effects of the moiety on the emulsifying properties of sugar beet pectin. *Food Hydrocolloids*, 21: 1319–1329.

GLICKSMAN, M., 1982: Food Hydrocolloids. New York: CRC press, 1, 219 pp.

GOMEZ, M., RONDA, F., CABALLERO, A. C., BLANCO, A., ROSELL, C. M., 2007: Functionality of different hydrocolloids on the quality and shelf. life of yellow layer cakes. *Food Hydrocolloids*, 21: 167–173.

GONCALVES, S., ROMANO, A., 2005: Locust bean gum (LBG) as a gelling agent for plant tissue culture media. *Scientia Horticulturae*, 106: 129–134.

GUARDA, A., ROSELL, C. M., BENEDITO, C., GALOTTO, M. J., 2004: Different hydrocolloids as bread improvers and antistaling agents. *Food Hydrocolloids*, 18: 241–247.

GUPTA, S., SHAH, B., SANYAL, B., VARIYAR, P. S., SHARMA, A., 2009: Role of initial apparent viscosity and moisture content on post irradiation rheological properties of guar gum. *Food Hydrocolloids*, 23: 1785–1791.

HOEFLER, A. C., 2004: *Hydrocolloids*. USA, Minnesota: Eagan press, 111 pp.

HUANG, X., KAKUDA, Y., CUI, W., 2001: Hydrocolloids in emulsions: particle size distribution and interfacial activity. *Food Hydrocolloids*, 15: 533–542.

CHAISAWANG, M., SUPHANTHARIKA M., 2005: Effect of guar gum and xanthan gum additions on physical and rheological properties of cationic tapioca starch. *Carbohydrate Polymers*, 61: 288–295.

CHENLO, F., MOREIRA, R., PEREIRA, G., SILVA, C., 2009: Rheological modeling of binary and ternary systems of tragacanth, guar gum and methylcellulose in dilute range of concentration at different temperatures. *LWT- Food Science and Technology*, 42: 519–524.

ISLAM, A. M., PHILLIPS, G. O., SLJIVO, A., SNOWDEN, M. J., WILLIAMS, P. A., 1997: A review of recent developments on the regulatory, structural and functional aspects of gum Arabic. *Food Hydrocolloids*, 11: 493–505.

KOHAJDOVÁ, Z. & KAROVIČOVÁ, J., 2008: Influence of hydrocolloids on quality of baked goods. Acta Scientiarum Polonorum, 7: 43–49.

KOHAJDOVÁ, Z. & KAROVIČOVÁ, J., 2009: Application of hydrocolloids as baking improvers. *Chemical Papers*, 63: 26–38.

KOHAJDOVÁ, Z., KAROVIČOVÁ J., SCHMIDT, Š., 2009: Significance of emulsifiers and hydrocolloids in bakery industry. Acta Chimica Slovaca, 2: 46–64.

KOHAJDOVÁ, Z., KAROVIČOVÁ, J., GAJDOŠOVÁ, Ž., 2008: Význam hydrokoloidov v pekárstve. *Potravinárstvo, 2: 9–19.*

LANGENDORFF, V., CUVELIER, G., MICHON, C., LAUNAY, B., PARKER, A., DE KRUIF, C. G., 2000: Effects of carrageenan type on the behavior of carrageenan/milk mixtures. *Food Hydrocolloids*, 14: 273–280.

LAZARIDOU, A., BILIADERIS, C. G., 2007: Molecular aspects of cereal β-glucan functionality: Physical properties, technological applications and physiological effects. *Journal of Cereal Science*, 46: 101–118.

LEE, S., INGLETT, G. E., PALMQUIST, D., WARNER, K., 2009: Flavor and texture attributes of foods containg β-glucan-rich hydrocolloids from oats. *LWT- Food Science and Technology*, 42: 350–357.

LEROUX, J., LANGENDORFF, V., SCHICK, G., VAISHNAV, V., MAZOYER, J., 2003: Emulsion stabilizing properties of pectin. *Food Hydrocolloids*, 17: 455–462.

LI, Y., FANG, Y., ZHANG, H., NISHINARI, K., AL-ASSAF, S., PHILLIPS, G.O., 2010: Rheological properties of gum arabic solutions: from Newtonianism to Thixotropy. *Food Hydrocolloids*, in press.

LUTZ, R., ASERIN, A., WICKER, L., GARTI, N., 2009: Structure and physical properties of pectins with block-wise distribution of carboxylic acid groups. *Food Hydrocolloids*, 23: 786–794.

MAKRI, E. A., DOXASTAKIS, G. I., 2006: Study of emulsions stabilized with *Phaseolus vulgaris* or *Phaseolus coccineus* with the addition of Arabic gum, locust bean gum and xanthan gum. *Food Hydrocolloids*, 20: 114–1152.

MATUDA, T. G., CHEVALLIER, S., FILHO, P. A., LEBAIL, A., TADINI, C. C., 2008: Impact of guar and xanthan gums on proofing and calorimetric parameters of frozen bread dough. *Journal of Cereal Science*, 48: 741–746.

NORZIAH, M. H., FOO, S. L., KARIM, A. ABD., 2006: Rheological studies on mixtures of agar (*Gracilaria changii*) and κ-carrageenan. *Food Hydrocolloids*, 20: 204–217.

PHILLIPS, G.O., WILLIAMS, P.A., 2000: *Handbook of Hydrocolloids*. England: Woodhead publishing limited, 453 pp.

PŘÍHODA, J., HUMPOLÍKOVÁ, P., NOVOTNÁ, D., 2003: *Základy pekárenské technologie*. Praha: Pekař a cukrář s.r.o., 363 pp.

PTÁČKOVÁ, A., 2008: *Hydrokoloidy a jejich použití v potravinárství*. Zlín: Bachelor Thesis, Fakulta technologická, Univerzita Tomáše Bati, 48 pp.

RAMIREZ, J. A., BARRERA, M., MORALES, O. G., VAZQUEZ, M., 2002: Effect of xanthan and locust bean gums on the gelling properties of myofibrillar protein. *Food Hydrocolloids*, 16: 11–16.

RENARD, A. C., 1996: Ultra-fresh yoghurt or dessert. *Reveu Laitiere Francaise*, 555: 12–14.

RIBOTTA, P. D., AUSAR, S. F., BELTRAMO, D.M., LEÓN, A. E., 2005: Interactions of hydrocolloids and sonicated-gluten proteins. *Food Hydrocolloids*, 19: 93–99.

RIBOTTA, P. D., PÉREZ, G. T., LEÓN, A.E., ANÓN, M. C., 2004: Effect of emulsifier and guar gum on micro structural, rheological and baking performance of frozen bread dough. *Food Hydrocolloids*, 18: 305–313.

ROLLET, B., 1995: Stabilizers for dairy desserts: Some interesting interactions. *Revue-Laitiere-Francaise*, 555: 22–23.

ROSELL, C. M., ROJAS, J. A., BENEDITO, C., 2001: Influence of hydrocolloids on dough rheology and bread quality. *Food Hydrocolloids*, 15: 75–81.

SAHAN, N., YASAR, K., HAYALOGLU, A. A., 2008: Physical, chemical and flavor quality of non-fat yogurt as affected by a β-glucan hydrocolloidal composite during storage. *Food Hydrocolloids*, 22: 1291–1297.

SHITTU, T. A., AMINU, R. A., ABULUDE, E. O., 2009: Functional effects of xanthan gum on composite cassava-wheat dough and bread. *Food Hyfrocolloids*, 23: 2254–2260.

SIM, S. Y., AZIAH, A. A. N., CHENG, L. H., 2010: Characteristic of wheat dough and Chinese steamed bread upon addition of sodium alginates or konjac glucomannan. *Food Hydrocolloids*, accepted manuscript.

SIMSEK, S., 2009: Application of xanthan gum for reducing syruping in refrigerated doughs. *Food Hydrocolloids*, 23: 2354–2358.

SKENDI, A., BILIADERIS, C. G., PAPAGEORGIOU, M., IZYDORCZYK, M. S., 2010: Effects od two barley β-glucan isolates on wheat flour dough and bread properties. *Food Hydrocolloids*, 119: 1159–1167.

SKENDI, A., PAPAGEORGIOU, M., BILIADERIS, C. G., 2009: Effect of barley β-glucan molecular size and level on wheat dough rheological properties. *Journal of Food Engineering*, 91: 594–601.

SOUKOULIS, CH., CHANDRINOS, I., TZIA, C., 2008: Study of the functionality of selected hydrocolloids and their blends with κ-carrageenan on storage quality of vanilla ice cream. *LWT- Food Science and Technology*, 41: 1816–1827.

SOZER, N., 2009: Rheological properties of rice pasta dough supplemented with proteins and gums. *Food Hydrocolloids*, 23, 849–855.

The world of food ingredients:
http://www.foodingredientsfirst.com/home/Articledocument.rails?path=pdf&document=44%20hydrocolloids.pdf.

TYKVARTOVÁ, D., MRÁZEK, J., POSPÍŠIL, M., HRÁBE, J., 2008: Výber vhodných hydrokoloidu pro stabilizaci jakosti termizovaných smetanových sýru. *Potravinárska Revue*, 2: 74–77.

VELÍŠEK, J., 1999: *Chemie potravin 1*. Tábor: Ossis, 328 pp.

VINOD, V. T. P., SASHIDBAR, R. B., SARMA, V. U. M., RAJU, S. S., 2010: Comparative amino acid and fatty acid compositions of edible gums kondagogu (*Cochlospermum gossypium*) and karaya (*Sterculia urens*). *Food chemistry*, 123: 57–62.

Wikipedia: *http://commons.wikimedia.org/wiki/*

WOOD, P. J., 2007: Cereal β-glucans in diet and health. *Journal of Cereal Science*, 46: 230–238.

XUE, J., NGADI, M., 2009: Effects of methylcellulose, xanthan gum and carboxymethylcellulose on thermal properties of batter systems formulated with different flour combinations. *Food hydrocolloids*, 23: 286–295.

YADAV, M. P., IGARTUBURU, J. M., YAN, Y., NOTHNAGEL, E. A., 2007: Chemical investigation of the structural basis of the emulsifying activity of gum arabic. *Food Hydrocolloids*, 21: 297–308.

YAMAZAKI, E., KURITA, O., MATSUMURA, Y., 2008. Hydrocolloid from leaves of Corchorus olitorius and its synergistic effect on κ-carrageenan gel strength. *Food Hydrocolloids*, 22: 819–825.

YANES, M., DURAN, L., COSTELL, E., 2002: Effect of hydrocolloid type and concentration on flow behavior and sensory properties of milk beverages model systems. *Food Hydrocolloids*, 16: 605–611.

ZAMORA, A., 2005: Carbohydrates: *http://www.scientificpsychic.com/fitness/carbohydrates2.html.*

Address

Ing. Ľubomír Mikuš, doc. Ing. Ľubomír Valík, PhD., doc. Ing. Ladislav Dodok, CSc., Oddelenie výživy a hodnotenia potravín, Ústav biochémie, výživy a ochrany zdravia, Fakulta chemickej a potravinárskej technológie, Slovenská technická univerzita v Bratislave, Radlinského 9, 812 37 Bratislava, Slovenská republika, e-mail: lubomir.mikus@stuba.sk