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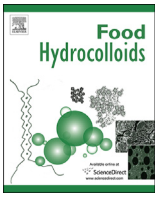

Review

Available water in konjac glucomannan–starch mixtures. Influence on the gelatinization, retrogradation and complexation properties of two starches

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ABSTRACT

The effects of konjac glucomannan (KGM) on the gelatinization, retrogradation and complexation properties of potato and broad bean starches were investigated by differential scanning calorimetry and X ray diffraction. It was established that the addition of 1% KGM in starch suspensions causes a slight decrease in the amount of available water in the system. However, this seems sufficient to disrupt the gelatinization and the retrogradation of potato and broad bean starches. In addition, the ability of amylose to interact with carvacrol is strongly affected by the presence of KGM. A rheology study showed on one hand that addition of KGM to starch decreased the gel character of the system, irrespective of the presence of carvacrol. However, carvacrol induced a strong increase of the storage modulus of starch gel for the same KGM content.

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1. Introduction

Starch is one of the most important and abundant food hydrocolloids. It is used not only as a main ingredient of staple foods but also as a thickener, gelling agent, stabilizer and fat replacer in processed food products. To avoid negative effects such as syneresis, which may occur during storage, other hydrocolloids are often added to starch to maintain overall product quality throughout the shelf-life. Synergistic interactions between starch and the added hydrocolloid may modify the texture, improve moisture retention and control water mobility. The viscosity is then generally increased and starch swelling, gelatinization and retrogradation may be modified (Alam, Siddiqui, Lutfi, & Hasnain, 2009; Khanna & Tester, 2006; Takahiro et al., 2005; Yoshimura, Takaya, & Nishinari, 1996).

Konjac glucomannan (KGM) is the main component of tuber of *Amorphophallus konjac*, KGM has been introduced into Europe (E425) and USA as a food additive due to its gelling and emulsifying properties. It is an essentially linear polysaccharide composed of blocks of β-1,4-linked mannose and glucosyl units with approximately 5–10% acetylation (Khanna & Tester, 2006; Yoshimura, Takaya, & Nishinari, 1997). KGM was reported to interact synergistically with carrageenan, xanthan, gellan gum, and with starches of various botanic origins: maize (Khanna & Tester, 2006; Yoshimura et al., 1996, 1997), wheat (Takahiro et al., 2005; Zhou, Wang, Zang, Du, & Zhou, 2008), potato (Khanna & Tester, 2006), tapioca (Muadklay & Charoenrein, 2008), and rice (Charoenrein, Tatirat, Rengsutthi, & Thongngam, 2010; Huang, Kennedy, Li, Xu, & Xie, 2007). All these authors found that the high water holding capacity of KGM prevented syneresis from occurring in starch gels and slowed down the retrogradation rate of starch during storage.

Starch is composed of two main components: amylose, a mainly linear polymer of about 500–6000 α-D glucosyl units and amylopectin, a highly branched polymer of α-D glucosyl present in numbers varying between 15 and 60 per chain. It is well established that amylose can form helical inclusion complexes with a variety of compounds such as iodine (Bluhm & Zugenmaier, 1981), dimethyl sulfoxide (Winter & Sarko, 1974), alcohols (Brisson, Chanzy, & Winter, 1991; Buléon, Delage, Brisson, & Chanzy, 1990; Rappenecker & Zugenmaier, 1981), and aroma compounds (Biais, Le Bail, Robert, Pontoire, & Buleon, 2006; Nuessli, Sigg, Conde-Petit, & Escher, 1997) in aqueous solution. The molecular organization of amylose complexes with various fatty acids has also been extensively studied (Biliaderis & Galloway, 1989; Biliaderis, Page, Slade, & Sirett, 1985; Godet, Bizot, & Buléon, 1995; Godet, Buléon, Tran, & Colonna, 1993). Two families of amylose complexes structures have been identified in the literature, namely V_6 and V_8, where 6 and 8 represent the number of D-glycosyl units per helix turn. For V_6 types, two trapping modes could be suggested: intra-helices inclusion V_{6I} (Vh) and intra-inter-helices inclusion V_{6II}, V_{6III}, where I, II and III represent the varying volume between helices in the crystalline stacking. For V_{6I} (Brisson et al., 1991), small molecules could be entrapped only in the cavity of the helix (Godet, Tran, Colonna, Buléon, & Pezolet, 1995) and for V_{6II} and V_{6III}, molecules could also be entrapped between helices. Another possibility is a larger cavity with eight D-glucose residues per turn, V_8, which allows the inclusion of bulky molecules (Le Bail, Rondeau, & Buléon, 2005; Winter, Chanzy, Putaux, & Helbert, 1998). Characteristic X-ray diffraction patterns (V_{6I}, V_{6II}, V_{6III}, V_8) are reported in the literature (Le Bail et al., 2005; Yamashita & Monobe, 1971).

The complexing molecule tested was carvacrol which can induce V6III amylose structure (Biais et al., 2006). Carvacrol $C_6H_3CH_3(OH)(C_3H_7)$, is a monoterpenoid phenol and it is found in a number of plants and herbs such as wild bergamot, thyme and pepperwort, but it is most abundant in oregano. Carvacrol inhibits the growth of several bacteria strains, like *Escherichia coli* and *Bacillus cereus*. Its low toxicity together with its pleasant taste and smell suggests its use as a food additive to prevent bacterial contamination. Furthermore it has mild antioxidant properties and this may become important in the search for natural replacements for synthetic antioxidant food additives.

The addition of a small amount of KGM to starch matrices might affect the interactions between ligands and starch. However, to our knowledge, publications on the effect of konjac glucomannan on starch complexation are scarce.

The objective of the present work was to characterize the ability of blends of starch and konjac glucomannan to reduce the amount of freezable water and to observe the influence of addition of this hydrocolloid on the gelatinization, retrogradation and complexation properties of potato and broad bean starches.

2. Materials and methods

2.1. Materials

Potato starch was purchased from Sigma–Aldrich (FRANCE), broad bean (*Vicia faba*) starch from Woodstone Food (USA), purified konjac glucomannan was kindly supplied by the University of New South Wales of Sydney (AUSTRALIA) and carvacrol was supplied by Aldrich (Saint-Louis, USA). The initial moisture content of starches and konjac glucomannan was determined by Thermo Gravimetric Analysis (TGA 2050 CE) (Table 1).

Table 1
Moisture content (on dry basis).

	Konjac glucomannan	Potato starch	Broad bean starch
Moisture content	12.4%	12.9%	7.9%

2.2. Treatment and storage of the samples

2.2.1. Rapid Visco Analyzer

Homogeneous suspensions containing starch and/or konjac glucomannan (Table 2) were prepared using a Rapid Visco Analyzer™ (model RVA 3, Newport Scientific, Australia) equipped with the Thermocline™ software.

Twenty eight grams of water were stirred (20 rpm) for 10 min by nitrogen bubbling to prevent oxidation, and were put in the aluminum flask. Starch was gently added and the mixture starch–water was stirred (200 rpm) to avoid sedimentation. Directly afterwards, konjac glucomannan was added very slowly and with a strong stirring (700 rpm). Then, the mixture was put in the RVA and heated at 90 °C at a constant rate of 10 °C/min, kept for 15 min and