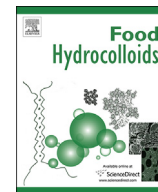


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# Food Hydrocolloids

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## A comparison of the sensory and rheological properties of molecular and particulate forms of xanthan gum<sup>☆</sup>

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### ABSTRACT

A particulate form of xanthan gum was prepared by extrusion cooking. The temperature dependence of the viscosity of this form shows similarities to starch with an increase in viscosity to a maximum with increasing temperature as a result of the swelling of the particles. The rheology and mixing behaviour with water of the particulate and conventional molecular forms of xanthan were compared with a modified starch. The particulate xanthan products mixed rapidly with water in a similar way to ungelatinised starch, whereas conventional molecular xanthan systems mixed poorly. Using an experienced sensory panel, model tomato products thickened with the three systems were compared at equal shear viscosities. The panel could not discriminate between the tomato flavour of the three products, but found that the xanthan products were perceived as being significantly thicker. These observations were consistent with previous work. Salt perception for both xanthan products was poorer than for the starch thickened systems. A hypothesis to explain why xanthan does not fit into the previously postulated link between mixing and perception is presented.

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### 1. Introduction

It is well recognised when the viscosity of a hydrocolloid thickened product is increased there is a decrease in flavour and taste perception. This generally occurs once the hydrocolloid concentration exceeds the  $c^*$  concentration (Baines and Morris, 1987; Cook, Hollowood, Linforth & Taylor, 2003; Hollowood, Linforth & Taylor, 2002; Koliandris, Lee, Ferry, Hill & Mitchell, 2008; Morris, 1993). At the  $c^*$  concentration, sometimes called the overlap concentration, the hydrodynamic volumes of the polysaccharide coils start to closely pack in the solution and the rheological properties of the solution changes from dilute to semi-dilute. A detailed definition and discussion of this concentration is given by Lapasin and Prilic (1999). However, analysis of nose space volatiles during consumption showed no decrease in intensity when the  $c^*$  concentration is exceeded (Hollowood et al., 2002) so it seems unlikely that this

decrease in taste and flavour is due to a reduction in the amount of volatiles reaching the sensing organs. Cook et al. (2003) showed that an increase in viscosity as measured by the Kokini oral shear stress or other viscosity related parameters could be directly related to taste perception. However, there is evidence that high viscosity products thickened with starches show good taste and flavour perception in contrast to products thickened with most hydrocolloids (Ferry et al., 2006; Hill, Mitchell & Sherman, 1995). Thus different perception magnitudes can be obtained at the same value of viscosity parameters such as the Kokini oral shear stress.

It was suggested by Baines and Morris (1987) that restricted mixing between the hydrocolloid solution and saliva could be the reason for the reduction in taste and flavour perception above  $c^*$ . To test this hypothesis Ferry and co-workers (Ferry et al., 2006) visualised mixing by including a small amount of red dye in the hydrocolloid solution and gently mixing the solution by hand with water. This showed clearly that at high viscosities starch thickened products generally mixed much more readily with water and presumably saliva than products thickened with hydrocolloids above the  $c^*$  concentration. For starch the efficiency of mixing was less good if the granule structure had been disrupted as would be the case when unmodified waxy maize starch was subjected to shear following gelatinisation or as a result of the action of amylase.

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Thus even though there will be a reduction in viscosity within the mouth as a result of amylase activity within the time scale of consumption (Ferry, Hort, Mitchell, Lagarrigue & Pamies, 2004) because the enzyme disrupts the granular structure of starch, subjects with a higher amylase activity perceive taste less well (Ferry et al., 2006). The differences in the ease of mixing of hydrocolloid solutions and suspensions of swollen starch granules can be understood from the ease of breakup of viscous liquid droplets. Droplets thickened by granular starch broke up more readily than droplets thickened by hydrocolloid solutions (Desse, Mitchell, Wolf & Budtova, 2011).

From the above arguments it follows that if the structure of a hydrocolloid solution could be converted from a molecular solution to a particulate suspension resembling starch, then taste and flavour perception at high viscosities should be improved. We have previously demonstrated that by extrusion processing xanthan gum can be converted to a particulate form (Serenio, Hill & Mitchell, 2007). In this previous paper it was suggested that the xanthan structure was reorganised during the extrusion process. A consequence of this reorganisation is the creation of polyelectrolyte particles maintained by xanthan dihelical junction. An investigation aimed at understanding why this occurs in the extrusion process but not during conventional heating is being undertaken and will be the subject of a separate submission.

In the current paper we compare the properties of particulate and molecular (conventional) xanthan and a modified starch in terms of rheology, mixing behaviour and sensory perception. The main objective of the work was to test the hypothesis that the particulate form of xanthan would show better taste and flavour perception than the conventional form at comparable viscosities.

## 2. Materials

Xanthan gum (Keltrol-T) was a gift from CP Kelco and a modified waxy maize starch (ColFlo 67) came from National Starch. Tomato juice with a declared salt content of 1.7 mg NaCl/100 ml was purchased from a local supermarket. Deionised water was used for the rheological and viscosity measurements on the aqueous systems, but tap water was used for the soups tested by the panellists.

## 3. Methods

### 3.1. Preparation of extruded xanthan

The xanthan powders were processed using a Prism TSE 24 MC (Thermo Fisher, UK) twin screw extruder. The powder and water feed rates were 2 kg/h and 1.4 l/h and the screw speed was 300 rpm.

The heater temperatures and screw profiles are shown in Fig. 1.

A ribbon die with a slit dimension of 30 × 1 mm was used. Pressure and temperature behind the die was determined.

Residence time was measured by including a small amount of red dye in the water feed and measuring the time for the change in colour of the product exiting the die to be observed. After exiting the die the product was dried at a temperature of 70 °C in a conventional oven. The dried material was milled using a Perten laboratory mill 3600 (Perten, UK) and sieved to give samples in the particle size range of 250–425 microns.

### 3.2. Rheological characterisation of xanthans, starch and soups

#### 3.2.1. Rapid viscosity analysis

Information about the change in viscosity with temperature was obtained using a Rapid Viscosity Analyser (Newport Scientific, Australia) operating under conditions frequently used to monitor starch pasting. The appropriate weight of starch or xanthan powder was added to 30 g of a 0.2% solution of NaCl in water maintained initially at a temperature of 25 °C. After holding at this temperature for 2 min the sample was heated at 14 °C/min to 95 °C, held at this temperature for 5 min and cooled to 25 °C. The sample was continuously stirred at 160 rpm.

#### 3.2.2. Intrinsic viscosity

To determine if the extrusion process had degraded the xanthan the zero shear intrinsic viscosity was measured in 0.2% NaCl at 20 °C. An Anton Paar MCR 301 rheometer equipped with concentric cylinder geometry was used. Solutions of extruded xanthan were taken from the RVA canister after the sample had gone through the full temperature profile described above. Measurements were also made on solutions of the original non-processed material. The samples were diluted with 0.2% NaCl to give xanthan concentrations in the range 0.005–0.03% w/w. The intrinsic viscosity was obtained from a combined Huggins and Kramer extrapolation of the zero shear rate viscosity.

#### 3.2.3. Steady shear and complex viscosity

The steady shear and complex viscosity of the xanthan and starch suspensions or solutions was measured in the rheometer at 20 °C. In this case the rheometer was equipped with sand blasted parallel plate geometry with a diameter of 50 mm and a gap size of 1 mm. Complex viscosity measurements were made in the linear viscoelastic region. This same protocol was also used to measure the rheological properties of the model soups used for sensory testing.

### 3.3. Preparation of model soups for sensory evaluation

The particulate form of xanthan produced by extrusion is believed to be maintained by rearrangement of the dihelical linkages that maintain the native structure. On heating the particulate form above the order disorder transition temperature these linkages are

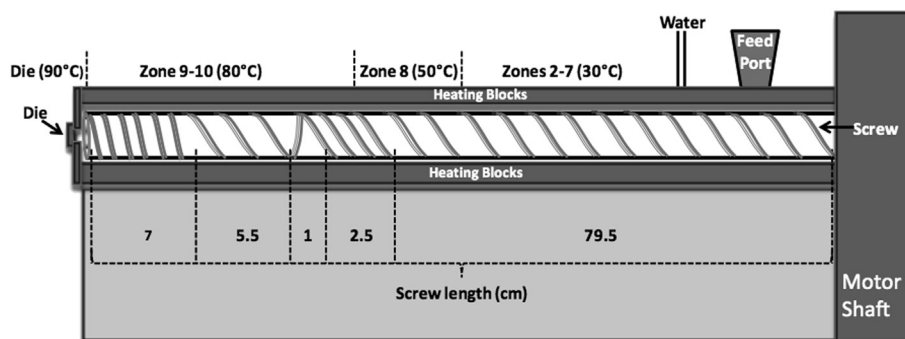


Fig. 1. Screw configuration and barrel temperature profiles of the extruder.

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