Effect of high pressure treatment on rheological properties of xanthan/guar mixtures

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In this experiment, the effect of high pressure treatment on rheological behavior of xanthan/guar mixtures has been investigated and compared using steady and oscillatory shear measurements. This was done by passing 0.5 wt% gum solutions through a two-stage homogenizer at 200 bar in several cycles (0 - 5 cycles) to observe changing in rheological parameters. Originally, xanthan solution induced semi-solid behavior and guar solution induced high viscous non-Newtonian fluid behavior. Strong synergistic was found in X/G mixtures. High viscosity and K with high structural stability were obtained with high viscous particle gel properties. After pressurized, structure destruction exhibited with decreasing in viscosity and storage modulus, $G'$. Increased in cycles of homogenizations, samples showed more severe destruction. Also, xanthan showed higher tolerance to high pressure than guar. Among all samples, X/G mixtures at 15:85 gave the highest viscosity with high structural stability (low $n$ value). This may contributed to its strongest binding interaction of X/G mixtures.

Keywords: Xanthan, Guar, Homogenization, Rheological properties, Synergistic effect of mixed gum

1 INTRODUCTION
It has been reported the degradation in viscosity of xanthan gum when pressurized [1]. However, such studies have been limited in numbers. With high viscosity [2-3] promoted xanthan/guar blends to be interested in food application. Knowledge about the rheological properties as a function of high pressure on mixed gum solutions is main aim of this study.

2 MATERIALS AND METHODS
2.1 Materials
Xanthan gum type 402 (E 415), guar gum (E 412) were kindly donated from Loryma GmbH, Germany.

2.2 High pressure treatment
2 kg solutions were prepared by dispersing gum powders in distilled water at room temperature. All solutions (0.5 wt%) were continuously stirred with a propeller for 10 min at 600 rpm and stored overnight at 4 °C. High pressure treatment (HP) was applied to the stock solutions (25 °C) using a two-stage homogenizer at 200 bar for 1 to 5 cycles.

2.3 Rheological measurements
All tests were performed at 20 °C using a Physica UDS 200 rheometer (Germany) with a Z3 DIN rotational cylinder. Steady state flow curves were measured by increasing and decreasing shear rate (0.1 to 100 /s in 1 min). Data from downward curves were calculated by Ostwald-de Waele (Eq. 1),

$$\tau = K \cdot \dot{\gamma}^n$$

and Herschel-Bulkley equations (Eq. 2).

$$\tau = \tau_0 + K \cdot \dot{\gamma}^n$$

Where $\tau$ is shear stress (Pa), $\dot{\gamma}$ is shear rate (1/s), $K$ is consistency factor (Pas$^n$), $n$ is flow index and $\tau_0$ is yield stress (Pa). The storage ($G'$) and loss ($G''$) moduli and $\delta = G''/ G'$ were measured at strain rate of 0.001 in the frequency range from 0.01 to 50 Hz with $f = 1$ Hz.

3 RESULTS AND DISCUSSION
3.1 Rheological behavior of gum solutions
The strong synergistic interaction has been seen in mixed gum. At 15:85, the strongest interaction has been found with highest viscosity demonstrating that 15:85 should be the most compatibility for the binding interaction with guar (Tab. 1). At higher amount of xanthan (> 50 wt%), they showed lower $K$ and viscosity with yield stress, representing the particle gel-like system which clearly exhibited from xanthan. We hypothesized that at high amount of xanthan, only some parts of xanthan can bind with guar and most parts are self organization and might cause the lower binding capacity with guar.

Table 1: Rheological parameters and effective viscosity of 0.5 wt% gum solutions at 20 °C

<table>
<thead>
<tr>
<th>X:G</th>
<th>$\tau_0$ (Pa)</th>
<th>$K$ (Pas$^n$)</th>
<th>$n$</th>
<th>$r$</th>
<th>$\eta_{eff}$ (100/s)</th>
<th>Eq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:100</td>
<td>-</td>
<td>1.409</td>
<td>0.498</td>
<td>0.982</td>
<td>0.139</td>
<td>OW</td>
</tr>
<tr>
<td>15:85</td>
<td>-</td>
<td>3.626</td>
<td>0.335</td>
<td>0.998</td>
<td>0.170</td>
<td>OW</td>
</tr>
<tr>
<td>50:50</td>
<td>0.191</td>
<td>3.786</td>
<td>0.298</td>
<td>1.000</td>
<td>0.151</td>
<td>HB</td>
</tr>
<tr>
<td>85:15</td>
<td>0.706</td>
<td>3.268</td>
<td>0.267</td>
<td>1.000</td>
<td>0.119</td>
<td>HB</td>
</tr>
<tr>
<td>100:0</td>
<td>0.911</td>
<td>3.350</td>
<td>0.256</td>
<td>1.000</td>
<td>0.118</td>
<td>HB</td>
</tr>
</tbody>
</table>

OW refers to Ostwald-de Waele equation and HB refers to Herschel-Bulkley equation

At 0.5 wt%, xanthan induced semi-solid behavior whereas guar induced high viscous non-Newtonian...
fluid behavior (Fig. 1). Interestingly, X/G mixtures showed $G'$ and $G''$ variations similar to xanthan.

3.2 Effect of high pressure treatment

After pressurized at 200 bar, the structure destruction has been shown evidenced by the substantial decreasing in $\eta_{eff}$ and $K$ with increasing $n$ value (Fig. 2).

CONCLUSION

High pressure has an obvious effect on the degradation in viscosity of gum solutions. All pressurized samples showed the reduction of consistency factor and effective viscosity. Among all samples, guar showed the most degradation while xanthan showed a good tolerance to high pressure which gave highest structural stability (lowest $n$ value) after five cycles of two-stage homogenization. X/G mixtures also have better tolerance to high pressure treatment than guar gum alone. This may attributed to its strong binding Interaction of X/G with structural arrangement dominant by xanthan gum.

REFERENCES