**INTRODUCTION**

- The importance of fruits, vegetables, and whole grains as part of a healthy diet is well documented, in part because of their abundance of naturally occurring dietary fibers. Demonstrated benefits of dietary fibers relevant to the management of overweight and obesity include reduced appetite and energy intake, prolonged absorption of nutrients, and reduced body weight.
- Ingestion of functional fibers and high-viscosity polysaccharides has been employed as a strategy to improve glycemic control, suppress appetite, and facilitate weight loss in patients with increased cardiometabolic risk.
- Prospective studies suggest that consumption of fibers with higher viscoselastic properties were 2-4 fold more effective at reducing appetite and energy intake than fibers with lower viscoselastic properties.
- Superabsorbent hydrogels are three-dimensional cross-linked polymer networks capable of absorbing much larger quantities of water compared to linear structures of functional fibers, thus resulting in more rigid, elastic gel particles. Hydrogel technologies have been employed for a variety of therapeutic uses such as tissue engineering and enhanced drug delivery.

**METHODS**

- Processed functional fibers (psyllium, guar gum, and glucomannan) and Gelesis200 were pre-hydrated in simulated gastric fluid (SGF). 0.18 (V/V) media in a 1:80 (w/V) ratio, and vegetables (mixed salad greens, cucumbers) were subjected to mechanical digestion in SGF, SIF, and SCF.
- Remnants of digested samples were poured onto an AERS rotational rheometer (TA Instruments) equipped with parallel plates (60 mm/hatchle configuration) for determination of elastic modulus (G') in triplicate.

**RESULTS**

- **Gelesis200 vs. Processed Functional Fibers (Figure 4A and Figure 5)**
  - Throughout 180 min digestion in SGF, the G' of Gelesis200 (range: 1,301 ± 145 to 2,082 ± 35 Pa) was maintained orders of magnitude higher than glucomannan (range: 27 ± 2 to 69 ± 3 Pa), which had the highest elastic modulus of any functional fiber tested.
  - The G' pattern was maintained during 120 min digestion in SIF (range: 994 ± 139 to 1,220 ± 169 Pa for Gelesis200 versus 42 ± 2 to 50 ± 4 Pa for glucomannan).
  - The G' of glucomannan and guar gum were maintained during a final 30 min digestion in SCF, Gelesis200 lost its elastic modulus (G' < 10).

- **Gelesis200 vs. Vegetables (Figure 4B and Figure 5)**
  - Throughout digestion in SGF and SIF, the G' pattern of Gelesis200 (range: 994 ± 139 to 2,082 ± 35 Pa) was remarkably consistent with that of masticated mixed salad greens (range: 105 ± 11 to 2,074 ± 101 Pa) and cucumber (range: 72 ± 11 to 4,915 ± 200 Pa), and all three lost their elastic modulus in SCF.

- **Gelesis200 vs. Gelesis100 (Figure 4C and Figure 5)**
  - During digestion in SGF and SIF, the G' pattern of Gelesis200 was maintained consistently higher than Gelesis100 (range: 257 ± 3 to 950 ± 10 Pa), and both lost their elastic modulus in SCF, which is consistent with degradation by extracellular enzymes.

**DISCUSSION**

- Although it has been long established that weight loss of 5 to 10% can lower the risk of weight-related comorbidities, realization of this benefit from dieting is frequently derailed by biologic feedback mechanisms that stimulate appetite, reduce dietary compliance, and ultimately lead to a rebound of energy intake and weight gain. Consequently, this has prompted efforts to understand the extent eating behavior and metabolism are influenced by the rheological properties of food and/or food additives, in addition to their intrinsic caloric value and macronutrient composition.
- Several properties of natural fibers, including viscosity and elasticity, appear to confer benefits of appetite control and weight loss. However, less than 3% of individuals in the United States consume recommended amounts. Thus, efforts to compare dietary intake include supplementation with processed functional fibers which have linear structures that have lower viscoselastic properties.

- In this in vitro model of GI digestion, Gelesis200 and Gelesis100 demonstrated viscoselastic profiles that were orders of magnitude superior to that of common processed functional fiber supplements (psyllium, guar gum and glucomannan), and were remarkably similar to the profiles of the masticated vegetables tested. This latter observation is consistent with the components and structure of the hydrogels (Figure 3), which when hydrated in the GI system, results in individual gel particles that are fluid-containing 3D cellulosic matrices, akin to plant cells.

- Increasing the elasticity of ingested meals has been shown to increase feelings of fullness in humans. Similarly, acute dosing of Gelesis200 in humans increased subjective feelings of fullness and satiety in subjects who were overweight and had obesity, and chronic dosing of Gelesis200 elicited weight loss and improved glycemic control. The data observed in this study provides in vitro mechanistic evidence for these phenomena in humans, and suggests that Gelesis200 may induce feelings of satiety and fullness by mimicking the physical properties of ingested vegetables.

**CONCLUSIONS**

- In this in vitro model of GI digestion, Gelesis200 and Gelesis100 demonstrated viscoselastic profiles that were similar to masticated vegetables, and were orders of magnitude superior to that of common processed functional fiber supplements. The viscoselastic and viscoselastic properties of the two hydrogels suggest a potential for different therapeutic applications.

References:

6. Christian Demitri, Yishai Zohar, Hassan M. Heshmati, Lorien E. Urban, William G. Aschenbach, and Alessandro Sannino. (ECO Abstract #937) Superabsorbent Hydrogels in vitro digestion in simulated gastric, small intestine, and colonic fluid (SIF, SCF) and all three lost their elastic modulus in SCF.
7. These data provide evidence that Gelesis200 and Gelesis100 mimic the physical properties of ingested vegetables, which may in turn confer satiety-inducing, weight-loss, and glycemic-control benefits to patients with obesity or diabetes.

**Table 1: Composition of simulated gastrointestinal fluids**

<table>
<thead>
<tr>
<th>Simulated Fluid</th>
<th>Composition per 1,000 mL</th>
<th>Approximate pH</th>
<th>Digestion Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gastric (SGF)</td>
<td>0.25 g NaCl, 0.4 g pepsin</td>
<td>-2.1</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>0.5 g NaCl, 0.8 g pepsin</td>
<td>-1.8</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>2.0 g NaCl, 3.2 g pepsin</td>
<td>-1.2</td>
<td>60</td>
</tr>
<tr>
<td>Small Intestine (SIF)</td>
<td>6.8 g KH2PO4, 10.0 g pancreatic (trypsin, amylase, ribonuclease, protease)</td>
<td>-8.8</td>
<td>120</td>
</tr>
<tr>
<td>Colonic (SCF)</td>
<td>6.8 g KH2PO4, 10.0 g pectinase</td>
<td>-8.8</td>
<td>30</td>
</tr>
</tbody>
</table>

**Figure 1:** Comparison of superabsorbent hydrogels and linear processed functional fibers.

**Figure 2:** Gelesis200 is composed of modified cellulose (carboxymethylcellulose) and citric acid, both found in common foods.

**Figure 3:** Differential hydration kinetics and capacity between Gelesis100 and Gelesis200, determined by simulated gastrointestinal fluid uptake ratios. SIF = simulated gastric fluid, SF = simulated intestinal fluid, SCF = simulated colonic fluid.

**Figure 4:** Comparison of elastic modulus between Gelesis200 and processed functional fibers (panel A), vegetables (panel B), and Gelesis100 (panel C). Data presented as log-transformed transformation of G' values in parcels.

**Figure 5:** Visual comparison of processed functional fibers, vegetables, Gelesis200 and Gelesis100 following hydration and mastication.