Rheological properties of plant-based protein composite gels

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Background

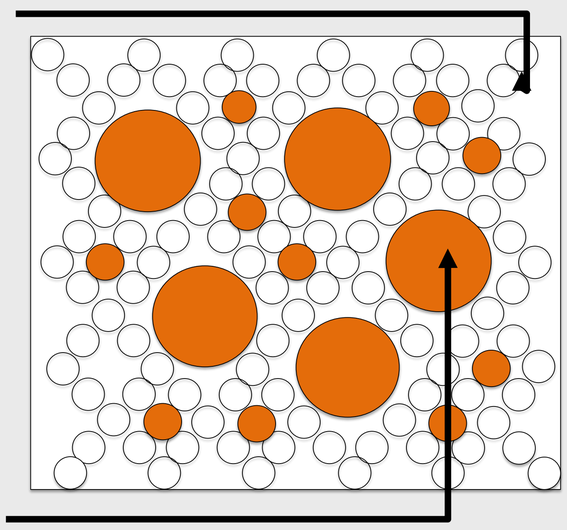
Increasing trends on plant-based diets, including protein intake, require diversification of plant protein sources. Wide range of alternative protein sources has been explored, which also covered agricultural side-stream such as cereal bran. However, the nature of cereal protein properties, i.e. low solubility, restrict full utilisation in various foods, Therefore, this work aims to study the applicability of low purity oat bran protein (OBP) concentrate as filler particles of soy protein isolate (SPI) gel system.

Experimental

Protein gels were prepared from a fixed concentration (13% wt) of SPI dispersed in 20 mM $CaCl_2$ solutions, added with different concentrations of OBP (2, 4, 6, and 8% of total weight). In situ gelation was conducted by temperature ramp from 20 to 95 oC in a stress-controlled rheometer (Physica MCR 301, Anton Paar, Austria) with a serrated parallel-plate geometry and 1 mm gap. Oscillatory strain sweeps were performed to obtain viscoelasticity data.

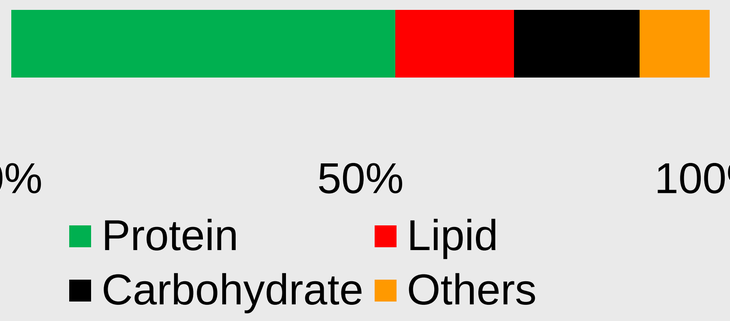
Composite gel

Soy protein isolate (SPI) as the gel matrix



Low purity oat bran protein (OBP) concentrate as the filler particles

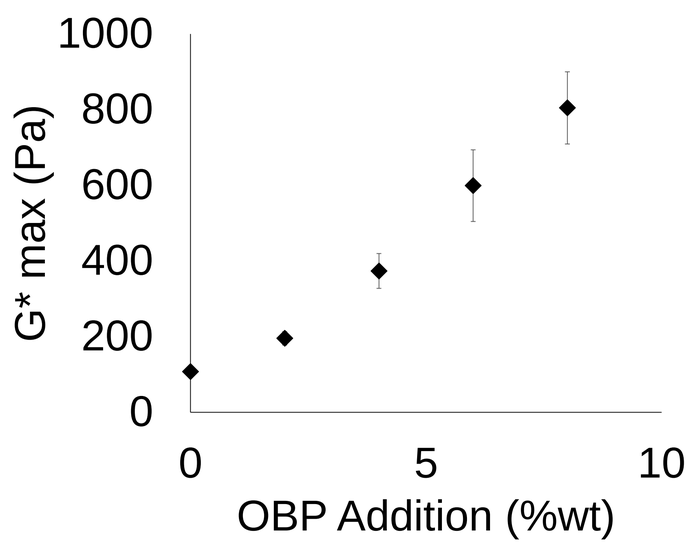
Composition of OBP



Gel Rigidity

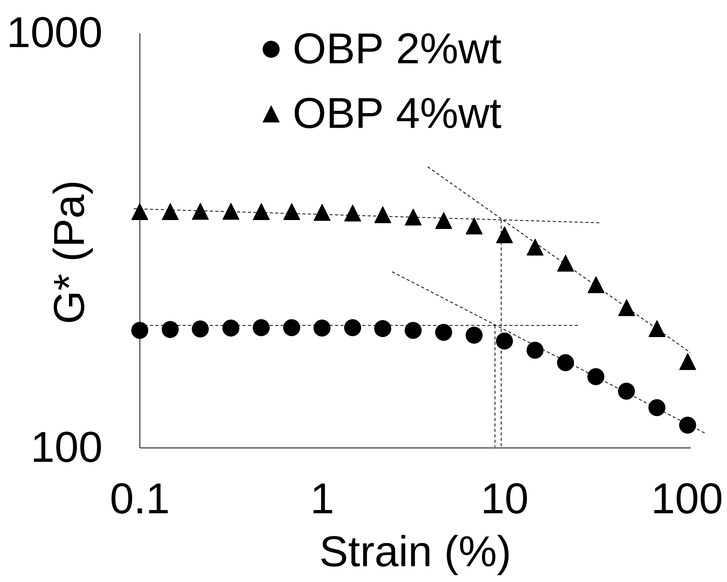
Rigidity of composite gel, expressed as complex modulus (G*), increased with increasing OBP concentration.

Complex modulus of composite gel

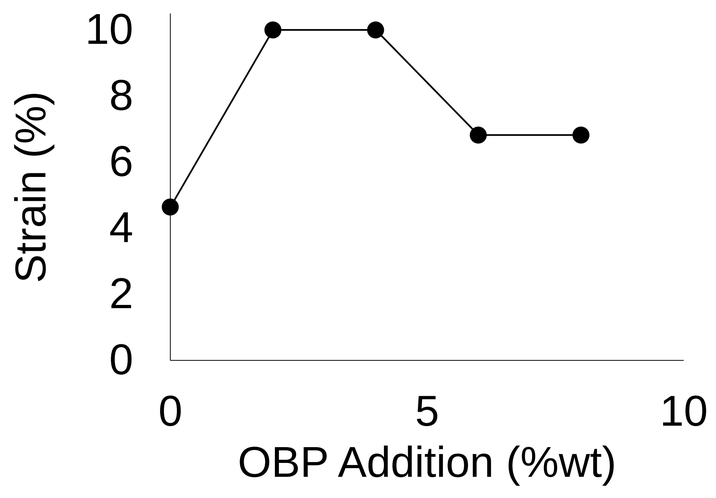


Fracture Properties

Complex modulus vs strain



Fracture onset strain



Concentration of OBP particles incorporated to SPI gels affected the fracture properties of composite gels.

Polymer Blending Rules

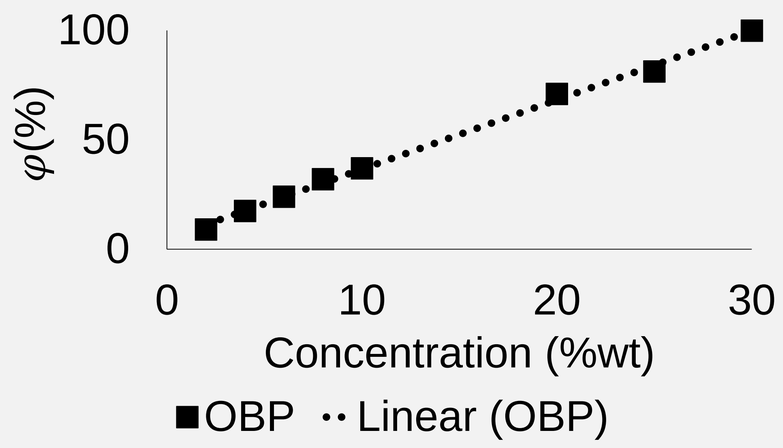
In composite gel, local concentration of constituent phase are affected by its volume fraction (φ) and overall concentration, i.e. matrix $[M]_o$ or filler $[F]_o$.

$$\varphi_M + \varphi_F = \mathbf{1} \quad \text{(eq.1)}$$

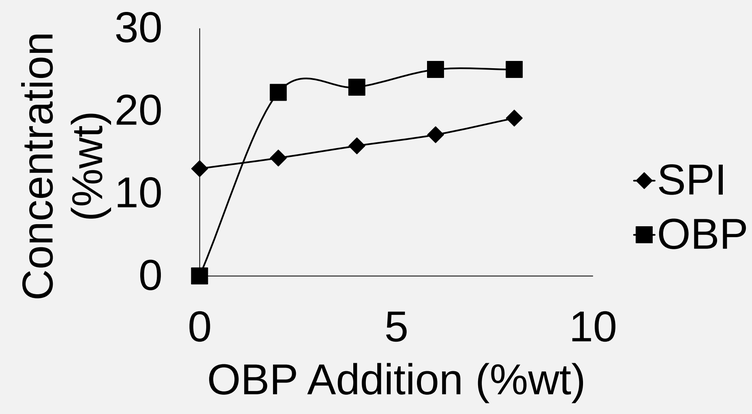
$$[M]_{Local} = [M]_o/\varphi_M \quad \text{(eq. 2)}$$

$$[F]_{Local} = [F]_o/\varphi_F \quad \text{(eq. 3)}$$

OBP volume fraction (φ) measured by centrifugation method



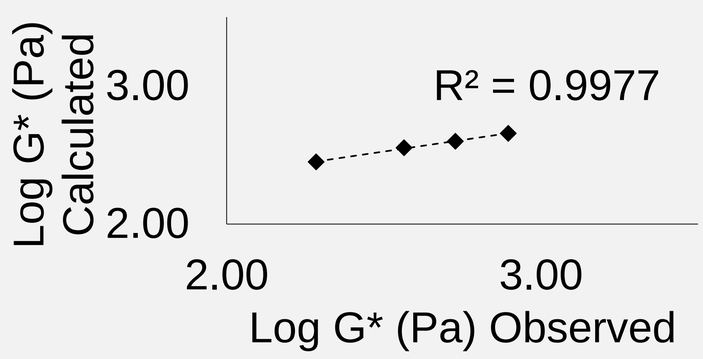
Local concentration of constituent



Moduli (G) of particle-filled gel (Composite) often can be explained as combination effects of moduli and volume fraction (φ) of both matrix (M) and fillers (F), using polymer blending rules.

$$G_{Composite} = G_M\varphi_M + G_F\varphi_F \quad \text{(eq.4)}$$

Fitting to the model



Conclusions

Addition of OBP as particle fillers in SPI gel system, increased gel rigidity and fracture onset strain up to certain concentration. Elastic moduli of composite gel can be explained using polymer blending rules exhibited by high R^2 values of fitted model.

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