Rheology

NORDIC CENTRE OF EXCELLENCE NETWORK IN FISHMEAL AND FISH OIL

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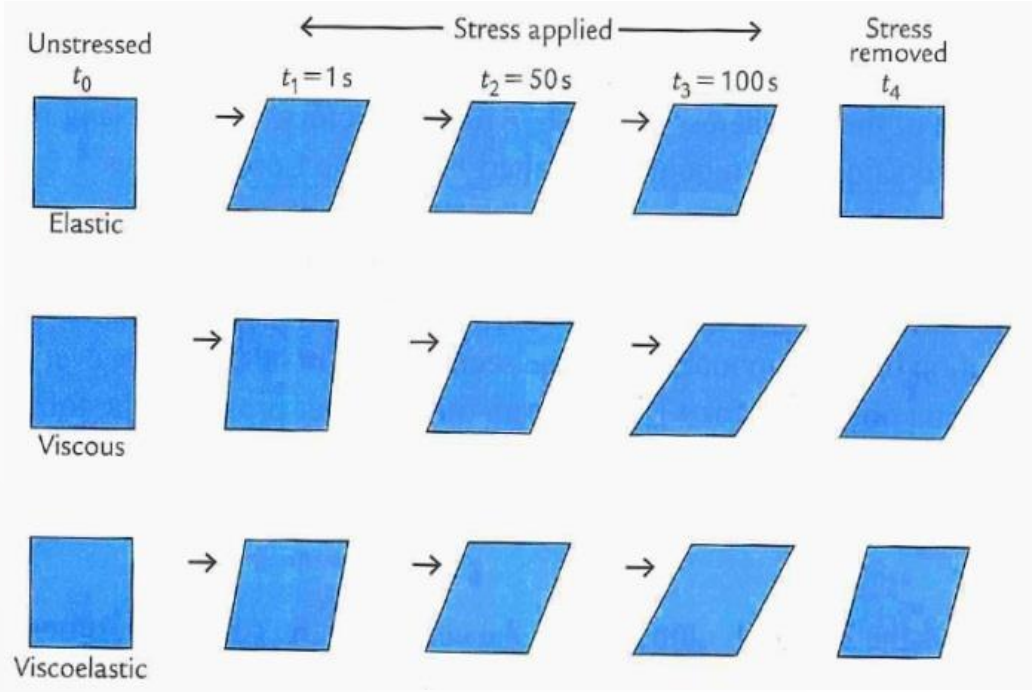
Rheology

- Study of deformation (solid like materials) and flow properties (fluid like materials) under the influence of external forces

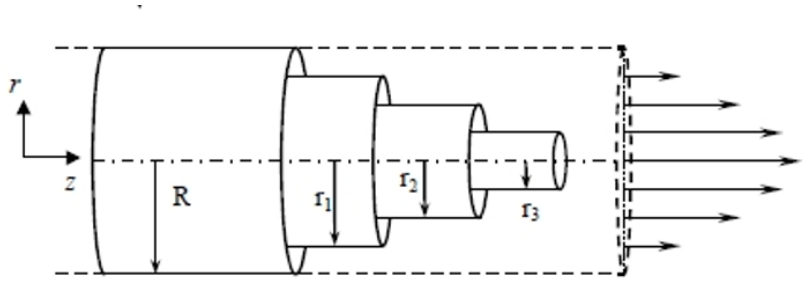
- Fishmeal and other feed polymers are both solids and liquids. They are called viscoelastic because they simultaneously exhibit some of the elastic properties of an ideal solid and some of the properties of and ideal liquid



Bourne (2002)

Viscosity

- Means the flow properties of liquids or resistance against flow.
- Higher resistance against flow or higher viscosity means higher friction between the fluid layers



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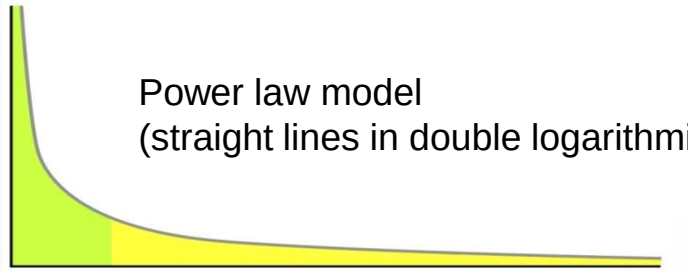
- Fishmeal and other feed polymers shows a pseudoplastic behavior. It means that the viscosity decreases with an increasing shear rate (shear tinning):



Power law model
(straight lines in double logarithmic scaling)

http://en.wikipedia.org

Analytical methods

- Rotational rheometry - viscometer

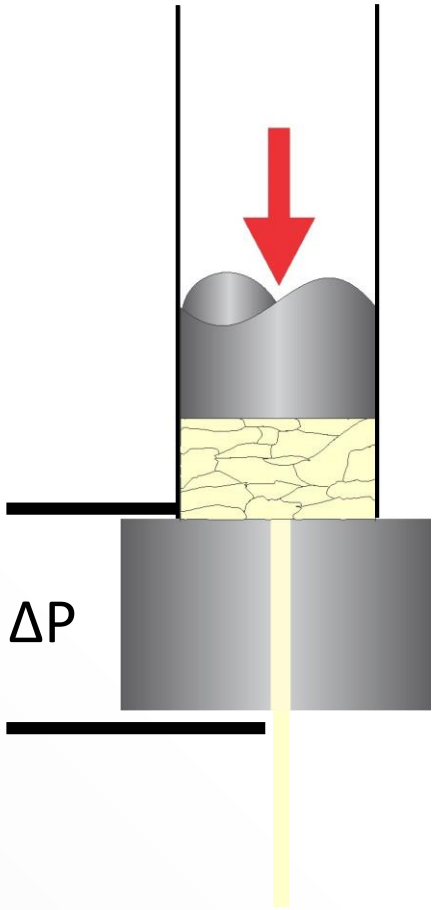
- Capillary rheometry

- Viscosity by swelling – Rapid Visco Analyzer (RVA) pasting

Capillary rheometry

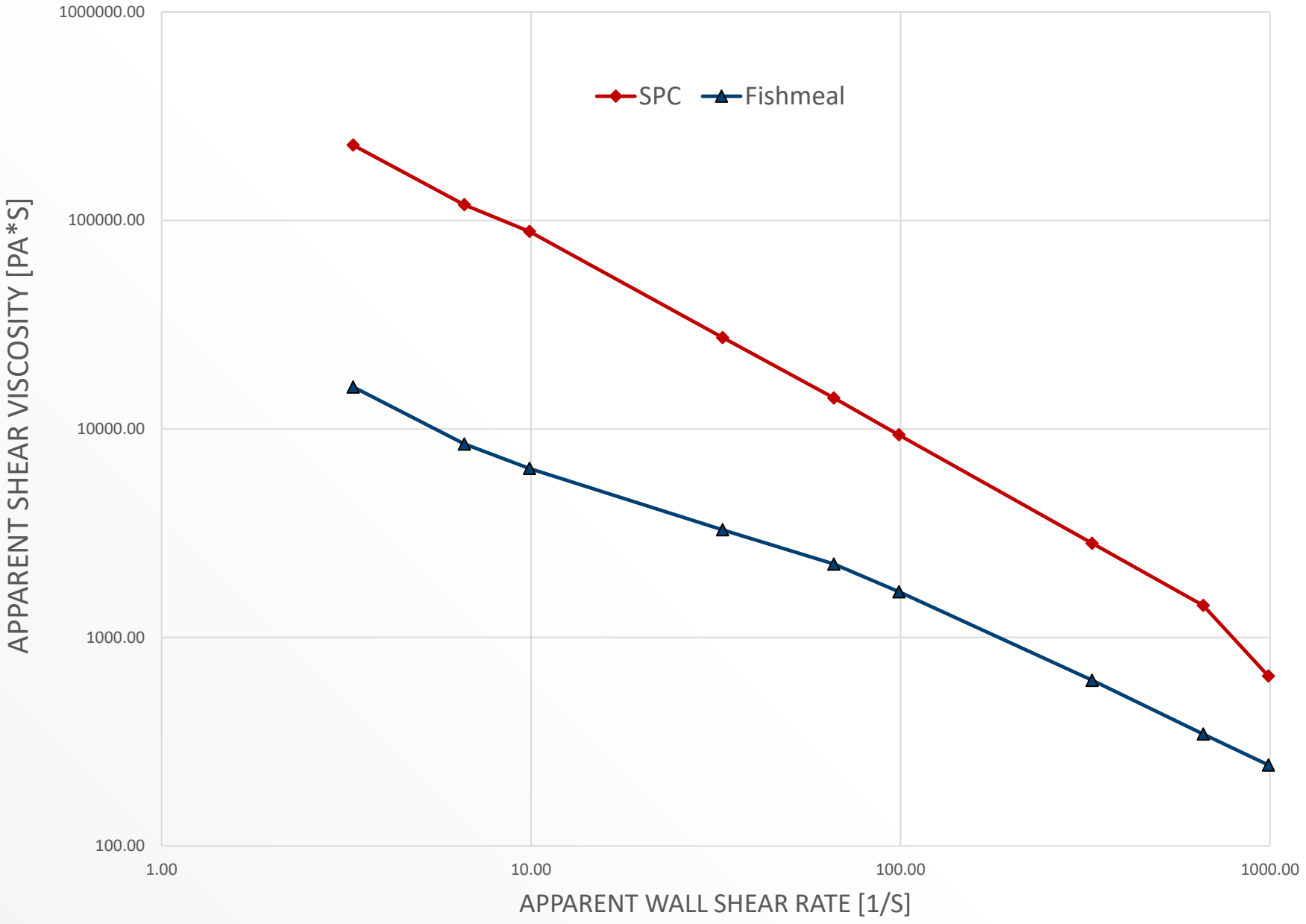
- A capillary rheometer consists of a piston and a capillary die where the barrel wall temperature is controlled

- By setting the piston speed and measuring the pressure drop across the capillary die, viscous behavior can be calculated



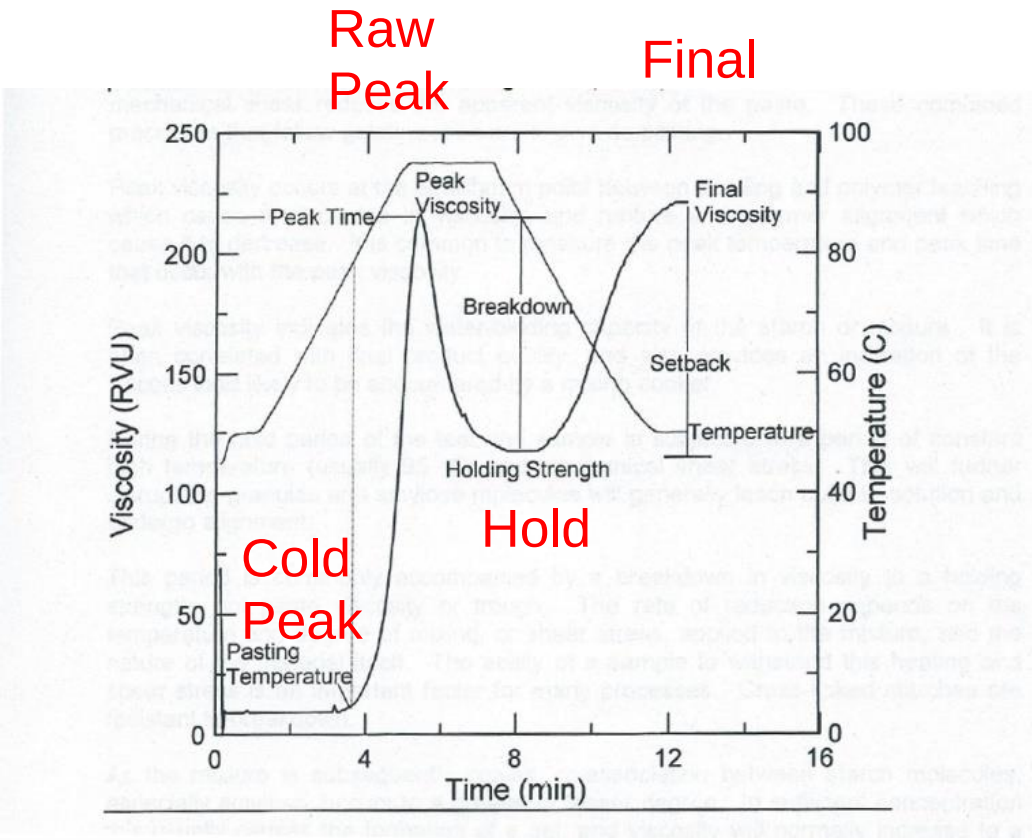
https://www.goettfert.com/fileadmin/assets/Downloads/EN/PDF/Produkte/Kapillarrheometer/Brochure_RHEOGRAPH_eng_01.pdf

Viscous behavior of plasticized fishmeal

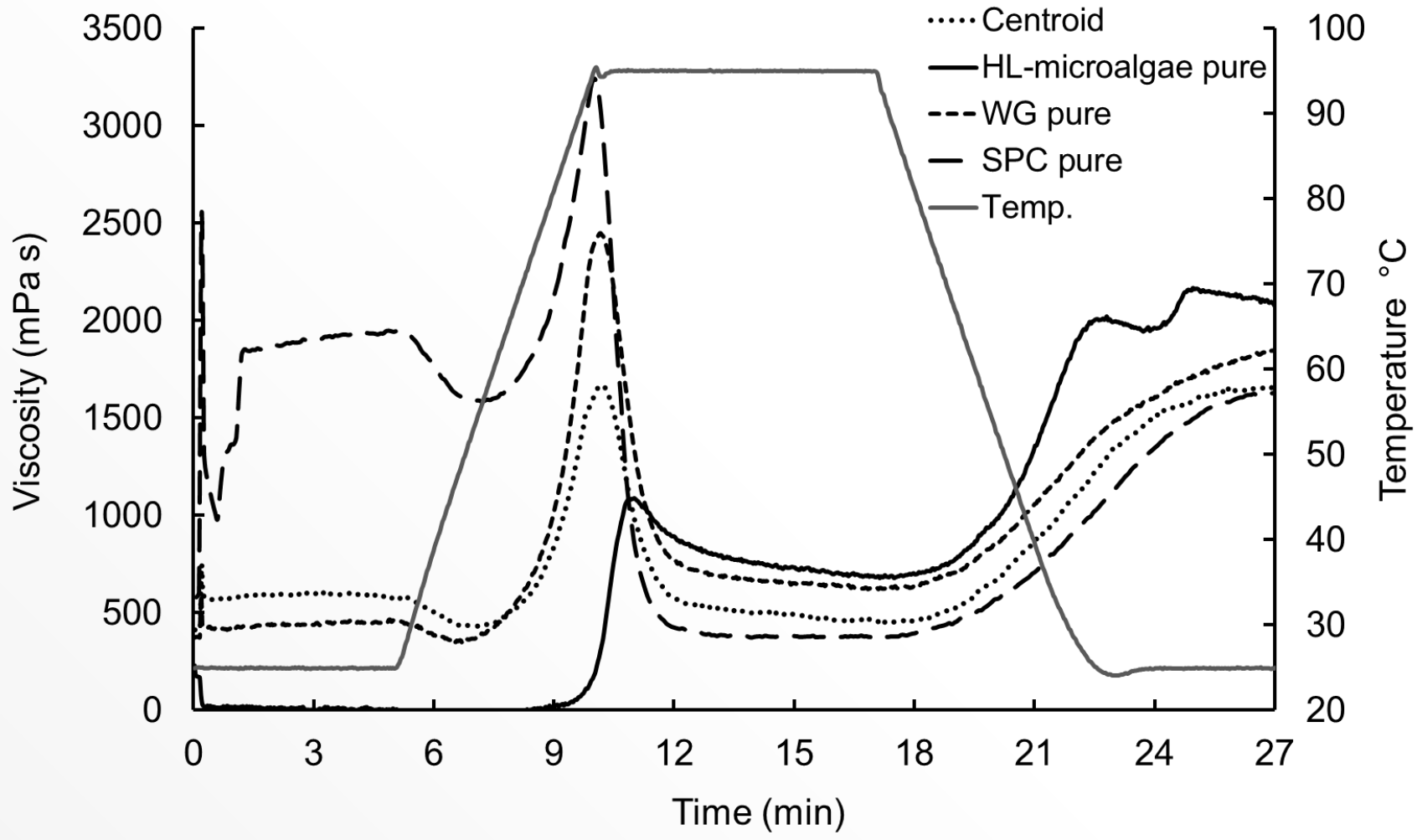


Samuelsen & Oterhals, Nofima ©, unpublished data

Viscosity by swelling – RVA pasting



RVA viscosity for feeds containing different ingredients



Samuelsen et al. 2018. Anim. Feed Sci. Technol. 236:14-28

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Glass transition and flow-starting temperatures

Glass transition

- a temperature where the biopolymer transits from a brittle glassy to a soft rubbery state

- glass transition temperature (T_g)

Flow-starting

- a state where the biopolymer can be considered as a highly viscous melt or fluid (start to flow).

- flow-starting temperature (T_f)

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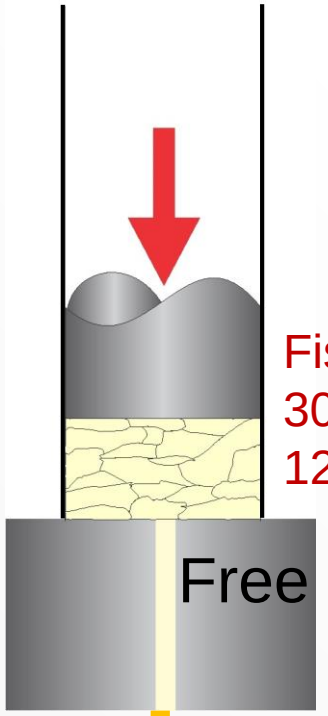


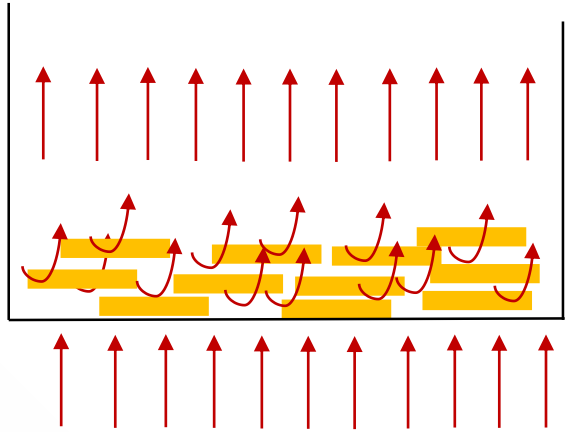
Fishmeal powder
30% moisture
120 °C

Free flowing melt

> T_f

Hot, humid fishmeal extrudate string

rubbery



Hot air drying

< T_g

Dried and cooled fishmeal extrudate pieces

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Analytical methods

Glass transition

- Differential Scanning Calorimetry (DSC)
- Close-chamber capillary rheometry (PTA)
- Dynamic Mechanical Analysis (DMA)

Glass transition and flow-starting temperatures

- Close-chamber capillary rheometry (PTA)

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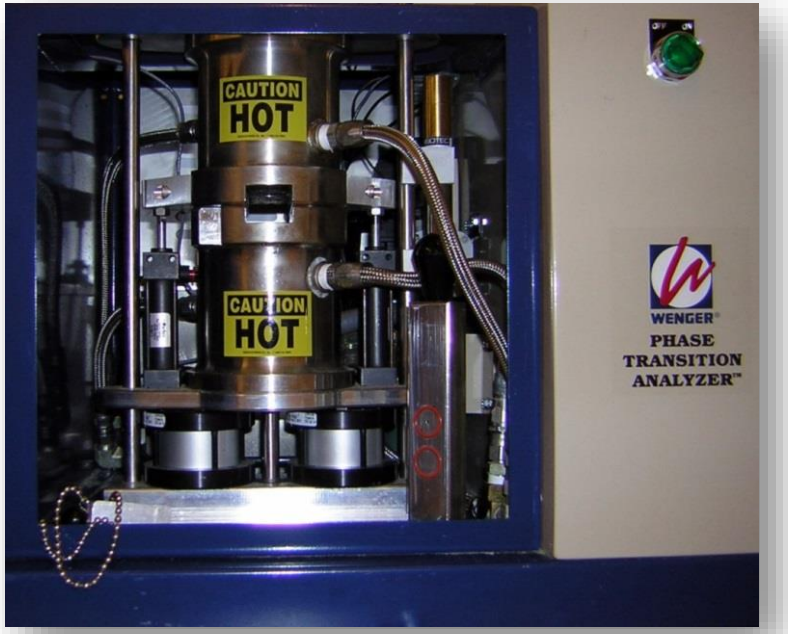
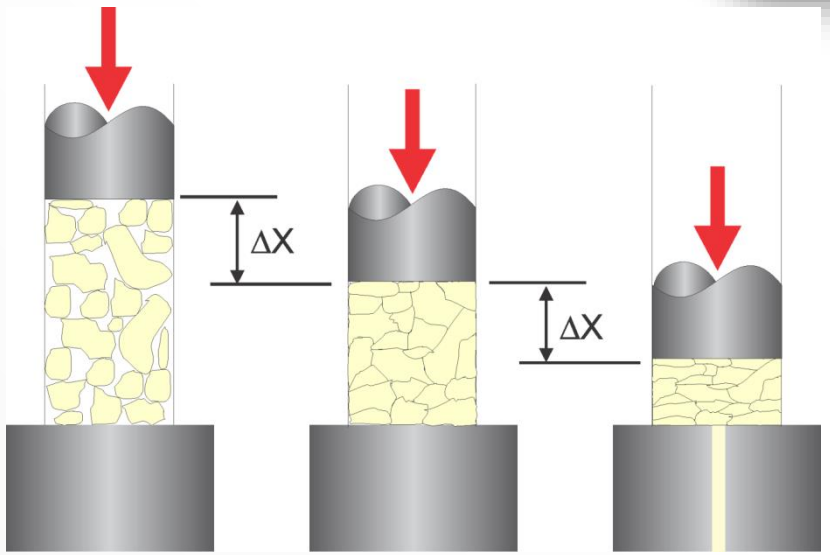
Closed-chamber capillary rheometry

- Phase Transition Analyzer,
  a closed-chamber capillary rheometer

- Measures glass transition (T_g) and flow-starting (T_f) temperatures at elevated temperatures and a constant and high pressure



Wenger Manufacturing, Sabetha, KS, USA



with permission from Wenger

Strahm et al. 2000. Cereal Foods World 45:300-302.

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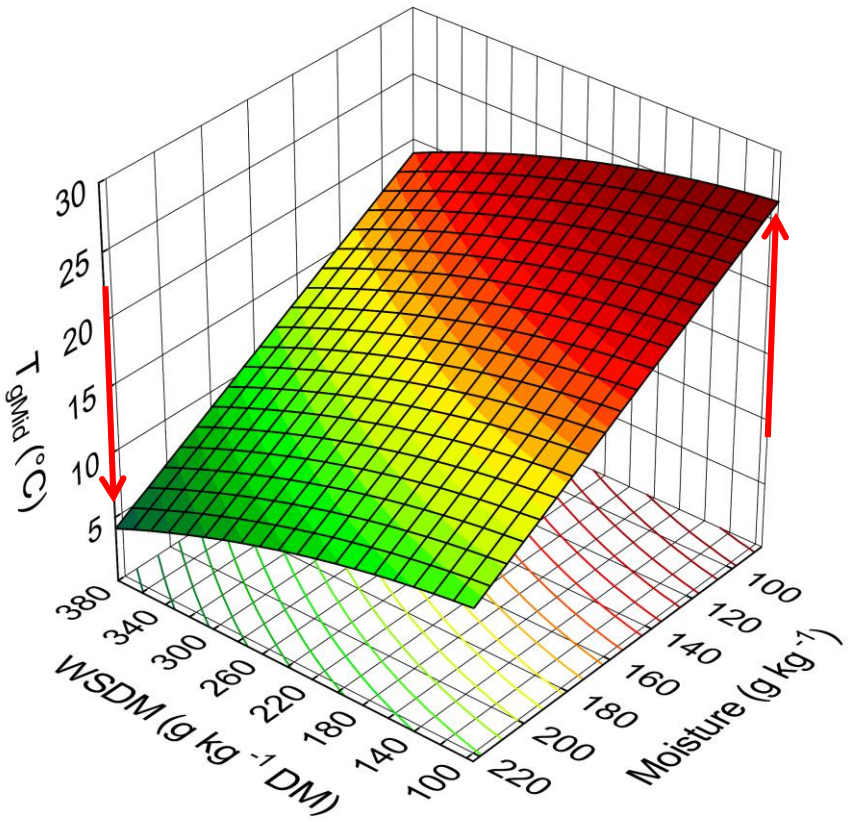
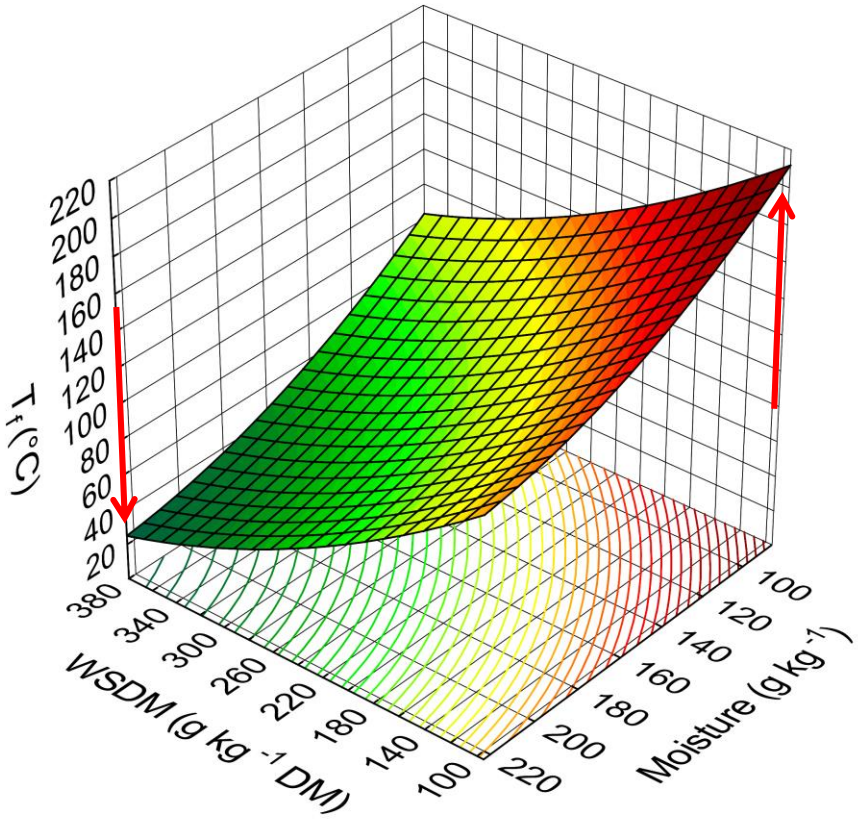
T_g and T_f as a function of moisture and water-soluble protein in fishmeal





Oterhals & Samuelsen, 2015. Food Res. Int. 69:313-321.
Samuelsen & Oterhals, 2016. Acuacult. Nutr. 22: 120-133.

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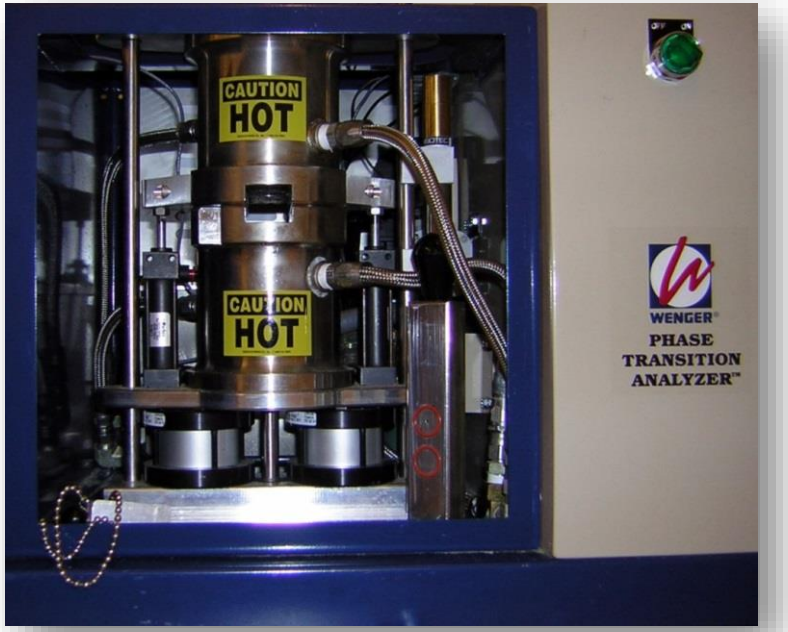
Research challenges

The differences in rheological properties impact the feed extrusion process and physical feed quality

- Can rheological measurements be alternative tools better describing fishmeal technical properties?

- Is it possible to establish a set of analysis enabling to predict and control the fishmeal behavior in the feed extrusion process?

Thank you for your attention!



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