Rheology Solutions
for the Food Industries

Explanation and Evaluation of Mouthfeel

RHEO253

Company Profile

Rheology Solutions Pty Ltd is a specialist sales and service organisation dedicated to the science of materials characterisation and are the exclusive Australian distributor for the brand names HAAKE, NESLAB, PRISM and CAHN from Thermo Fisher Scientific, Optical Control Systems, Schleibinger Gerate and Marimex Industries Corporation range of equipment and instruments, and they also distribute the Shimadzu range of tensile testers and texture analysers.

Rheology Solutions recognises the importance of specialisation and dedication to a specific science and as such provides full technical support and service throughout Australia. The company goal is to integrate industry experience and materials characterisation techniques to provide practical solutions for customers.

Rheology Solutions has an established applications laboratory equipped with a comprehensive range of instruments to meet the requirements of material characterisation. Specialist contract testing services are also available and contracts can be tailored to suit discrete tests or protracted testing requirements involving a series of tests over a period of weeks or months.

A range of seminars and application specific workshops as well as product launches and demonstrations are provided throughout Australia. The seminars and workshops are designed to meet the needs of specific customer and industry applications. Rheology Solutions has its head office in Victoria and works with a team of specialist sales and factory trained service personnel throughout Australia. The combined experience of this team ensures that Rheology Solutions are able to provide their customers with access to the products to ensure that the right technical support and service is provided.

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Tim’s Top Tips: Rheology Solutions for the Food Industries

Explanation and Evaluation of Mouthfeel

Key Words: *Mouthfeel, rheology, rotational, extensional, universal tester, taste panel, solid, semi-solid, liquid, viscosity, viscometer, rheometer, viscoelastic, force and displacement measurements.*

About The Author

Tim has a background in engineering and specifically in rheology, with a B.Eng and Ph.D. in Chemical Engineering and has held postdoctoral research positions in engineering rheology. Tim's research has continued for the last seven years and recent interests and publications include the application of rheology and rheometry to mineral, food, polymer and surface coatings systems. His current position encompasses the managment of customer contract testing and also includes customer focussed education and training. Additionally he is available to provide technical input for existing or proposed materials characterisation systems for both laboratory and production.

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Introduction

Often the food industry must overcome problems related to (and often dominated by) the flow properties of their product, though the relationship between these properties and production related issues are not always immediately apparent. It is the purpose of this series of articles, “Rheology solutions for the food industries”, to help illuminate the issues faced by the industry, how they relate to the flow properties of the problem materials and how they can be successfully measured and controlled with a view to better processing.

Definitions

Mouthfeel is the textural part of the experience of the consumer when chewing and swallowing food. The foods can be liquid, semi-solid or solid and the elements of mouthfeel can be measured relative to the various physical properties of the food in deformation and flow.

Background and Discussion

Traditionally, taste panels have been used to evaluate mouthfeel but the results are often inconclusive unless large numbers of participants and a lot of time are available. Sophisticated and sensitive measurement techniques and equipment now allow much of this work to be done using scientific instruments. In the case of the relationship between mouthfeel and liquid (and semi-solid) flow properties, the important variables may include some, or all, of extensional viscosity the elastic and viscous moduli the complex viscosity, shear viscosity, thixotropy etc and can be measured on Controlled Stress (CS) rheometers or Controlled Rate (CR) viscometers. For solid and semi-solid materials, properties like adhesiveness, cohesiveness, brittleness, and hardness etc, measured according to Szczeniak on a texture analyser have been shown to be important for the prediction of mouthfeel.

Mouthfeel analysis using uniaxial compression or extension – solid and semi-solid materials

Rheology Solutions Instrument

Shimadzu EZ Test

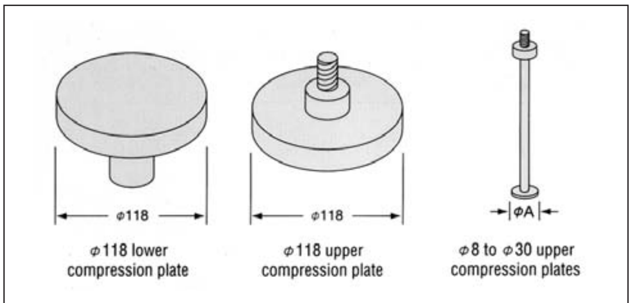
Texture analyser for measuring the flow and deformation of solid and semi-solid foods.

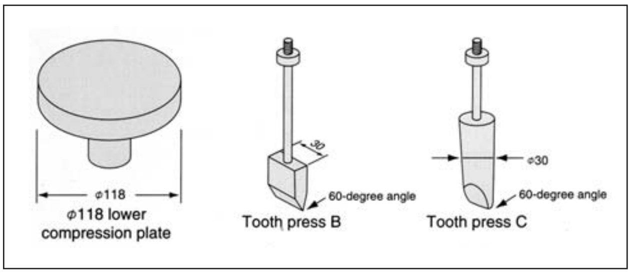
The efficiency and suitability of instrumentation for mouthfeel testing for solid and semi-solid materials using uniaxial compression or extension is related to the geometry of the probe and to the textural characteristic which one is trying to emulate. In general, uniaxial testing machines are used for this purpose and the tests involve displacement of the foodstuff either by forcing the probe downwards, compressing or cleaving the material and measuring the force required to do so, or by moving the probe upwards, allowing the material to relax, or stretching the material.

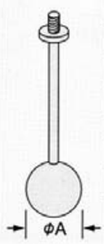
Potential problems with these measurements include:

- *Which is the correct sensor?*

There is a large variety of different sensors. The list of sensor geometries includes flat plates, conical probes, 2- and 3-point bending jigs, tooth presses and many other custom built sensors for individual applications. This diversity is not itself a problem, and may in fact help to solve problems, but care must be taken that the most appropriate one is chosen for the job. Often the changing resistance of a product to compressive (eg while measuring the changes in hardness or crispiness over time or in different storage atmospheres) or extensional forces (eg for measuring the suitability of different packaging sealants for different storage conditions) is an indication of the continuing suitability of the material for consumption.







-XX	φA
-01	φ3
-02	φ5
-03	φ7
-04	φ8
-05	φ10
-06	φ15
-07	φ20
-08	φ25

Cohesion test jig
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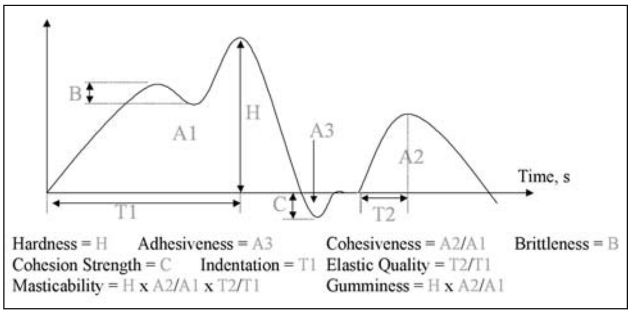
- *Repeatability:*

A relatively large number of tests (often up to 10 or 20) are often necessary in order that a statistically relevant measurement is made. This is particularly true of semi-solid materials eg spreadable cheeses. The number of tests is often high relative to those required on a rheometer, for example, but the time and expense is usually lower than that associated with taste panels. This repeatability issue is not in general related to the measurement or the instrument, more often to inconsistent sample preparation or to the heterogeneous nature of many food products. In the cases where the repeatability is related to the measurement, then a change in conditions, such as increasing or decreasing the speed of the cross-head, or reviewing the suitability of a particular load cell or sensor may be necessary. Often, the same load cell can not be used to measure all of the products a company manufactures (eg for a dairy company, yoghurt, spreadable cheese and hard (eg cheddar) cheese may all require different load cells so that the best data can be gathered.

- *Which is the best test method?*



Textural characteristics as defined by Szczeniak for textural analyses

Szczeniak, at General Foods in the USA, standardised many of these measurements and defined many of the textural properties measured today, for example hardness, cohesiveness, brittleness elastic quality and so on. The relevance of these textural characteristics to mouthfeel is that, these measurable quantities have been shown in many research papers to relate directly to the experience of the consumer when chewing and swallowing food.

- *The tests are, in general, relative:*

The complexity of the flow field during the displacement, and the heterogeneity of the test material means that the dissipation of the forces through the materials is difficult to fully predict. As a result, it is often not possible to collect absolute data. On the other hand, relative data is usually sufficient for many applications.

- *Control of the compression/extension of the sample:*

Many samples fracture under quite low loads, and it is often necessary to refine the test technique to ensure that fracture is avoided, if that is desired. It may be important to avoid fracture of the material on the first compression of a multiple compression test on the same material (as in the Szczeniak diagram shown earlier), whereas for a tooth press simulation, clearly sample fracture is desirable.

- *Poor mimicking of mastication:*

Clearly, mastication takes place in several directions and with varying force as we sense different textures in the food in our mouth. Standardising test techniques, (by always using the same force and/or strain (displacement) parameters for each test and choosing a test which best represents the element(s) of mouthfeel which are important to your consumer) at least permit the same properties to be measured, though the difficulties with mimicking the complexity of the mouth have not been overcome.

- *Stiff materials can be difficult to measure:*

Solid materials can cause problems during measurements because of their high rigidity. Though this is not often the case with food materials since the mouth would be damaged if too-stiff materials were chewed, instrumentation itself can help avoid this potentially painful outcome. For highly rigid materials, the measuring equipment itself should be highly rigid, so that the instrument or sensor do not deform before the sample does. Judicious choice of instrument and the load cell (measuring range, accuracy etc), suited to stiff materials is necessary at the instrument specification stage.

Mouthfeel analysis using rotational viscometers and rheometers and extensional rheometers – liquids

Rheology Solutions Instrument
HAAKE ViscoTester VT550

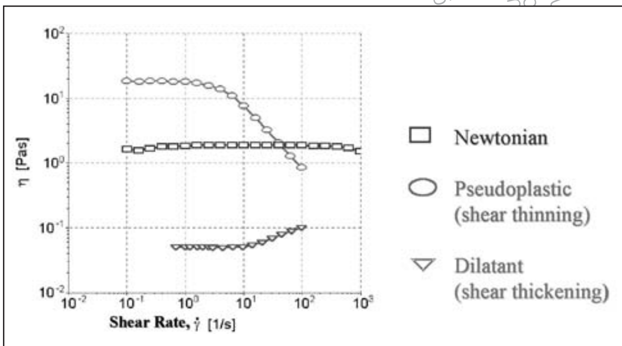
CR rheometer for measuring the flow properties of liquid foods.

Liquid and semi-solid testing using rotational viscometers and rheometers, and extensional rheometers.

Small sample volumes are required for most rheometers and viscometers, unless they are in-line. In the case of a laboratory viscometer or rheometer, the material is placed in a gap between a holding cup or a flat plate and a cylindrical, conical or flat plate sensor. The sensor moves (rotates or oscillates), resulting in a measured force and displacement of the sensor and sample. The force and displacement are used to measure the flow properties of the material. These flow properties – yield stress, shear viscosity, extensional viscosity and viscoelastic properties – can be related to some of the textural properties of liquid or semisolid foods.

Potential issues surrounding these types of tests may include:

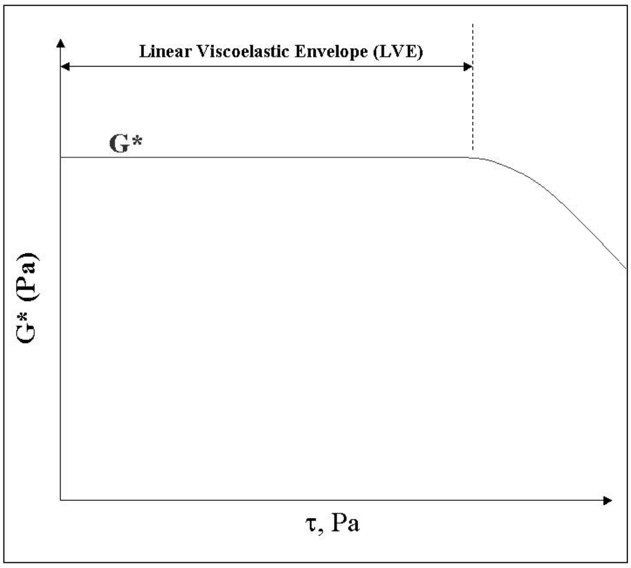
- *Shear properties difficult to comprehend:*



Knowledge of a single point viscosity for shear thickening or shear thinning foods can not fully define their behaviour

Shear viscosity is simply the resistance of the material to flow. Except for a few materials, shear viscosity is a function of shear rate, and should be measured at a variety of shear rates so that a clear picture of the behaviour of the material is obtained for mouthfeel analyses – chewing and swallowing occur at many different shear rates due to the diverse movements of the jaws and tongue.

- *Viscoelastic properties not repeatable:*



In the LVE, properties are independent of the amplitude or force applied during oscillatory measurements

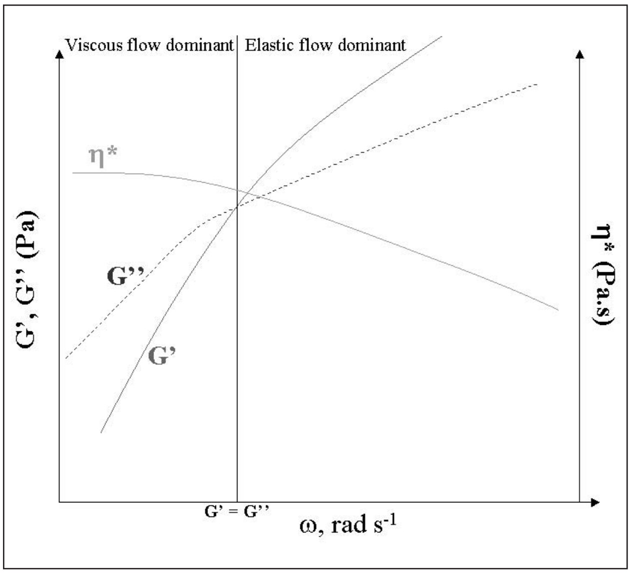
Viscoelastic properties are generally measured by means of a frequency sweep (i.e. oscillating the sensor at different rates in the sample) in the Linear Viscoelastic Envelope (LVE). If the measurements are not carried out in the LVE they will not be repeatable, and most likely will not be comparable between materials.

- *Viscoelastic properties difficult to understand:*

Rheology Solutions Instrument
HAAKE MARS

CS rheometer for measuring the flow properties of liquid foods.

In general the properties measured are the viscous and elastic moduli and the complex viscosity. The complex viscosity is a measure of the resistance of the material to flow and the viscosity at a variety of frequencies of oscillation (analogous to shear rate) should be known to fully define the material. Higher viscosity materials will require higher forces to initiate and continue flow. At low frequencies, for polymeric systems (starch, guar, xanthan, carageenan gums etc), the viscoelastic moduli show the contribution of high Molecular Weight (MW) species, the crossover point of the moduli shows the point at which the moduli are equal and is often used as a quality control point for materials. Changes in the magnitude of the moduli at the crossover point imply changes in molecular weight distribution, and changes in the frequency at which the crossover point occurs implies a change in the mean MW of the system. Some practical and theoretical training can often help nervous operators overcome the perceived complexity of viscoelastic measurements and assessing the data.



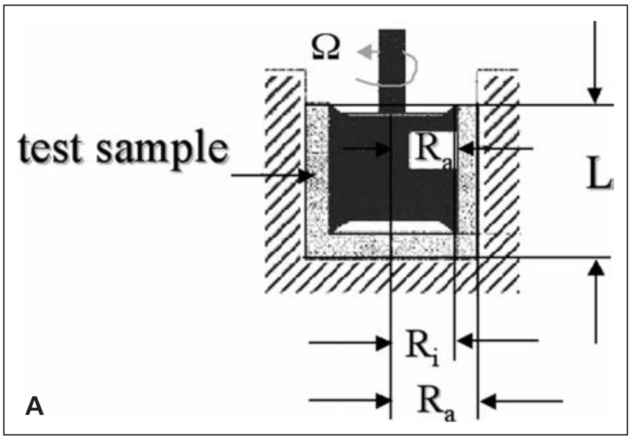
Viscoelastic flow properties tell us about the undisturbed (in the LVE) structure of the material

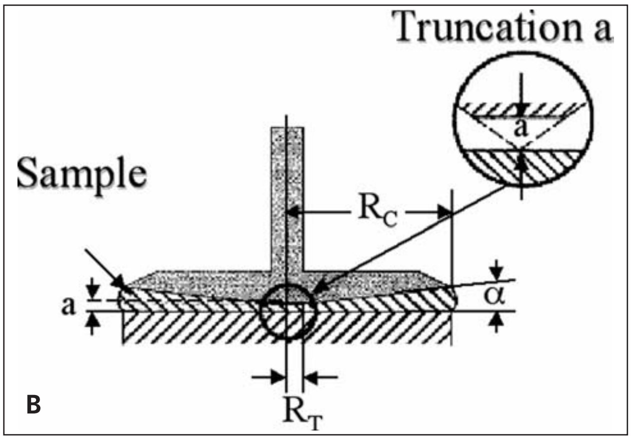
- *Relative vs absolute data:*

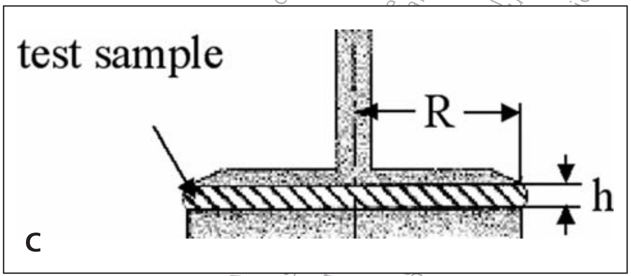
Rheology Solutions Instrument
HAAKE ViscoTester VT7L Plus

Relative viscometer for QA/QC measurements (large gap between sensor and holding cup)

Some of the early model instruments, for example those meeting the 'Brookfield' standard, ISO 2555, for testing provide the user with relative data for most materials, because the gap between the holding cup and the rotating sensor is large. In contrast, most modern viscometers can provide absolute data because the measuring gap is small and the sensor geometry is fully defined.







Fully defined (viscometric) measuring geometries (a) concentric cylinder, (b) cone & plate, (c) parallel plate for rheometry and viscometry

For any given material at the same temperature, a measurement made using a cone/plate sensor geometry gives an absolute measurement, and the same answer as one made with a concentric cylinder apparatus.

- *Poor mimicking of mastication:*

As in the case of uniaxial testers, the types of movement in the human mouth are much more complicated than that generated by a rotational instrument. However it has been shown that, by using standard tests such as frequency sweeps, shear sweeps with preshear, yield stress tests etc, the rheological quantities measured using these instruments can be related to the experience of the consumer during mastication.

- *Structural disruption on loading:*

Many foods, in particular semisolids, but also liquids are made up of delicate biological scaffolds. These can be disrupted by shear stresses, for example by stirring, or by closing the measuring geometry of a viscometer or rheometer. This problem can often be overcome by allowing the material to rest afterwards, so that the structure rebuilds. In cases where the structure does not recover, then the degradation can at least be made repeatable by using computer controlled geometry closure, rather than the manual equivalent. Another often used solution is to preshear the material to a state of equilibrium, so that the structure has always been destroyed to the same level before the commencement of each test. This technique has the obvious disadvantage that the material is no longer identical to that first experienced by the consumer, but can be used along with suitable quality benchmarking to determine the mouthfeel of a material.

Mouthfeel analysis using a taste panel – all edible foodstuffs

Taste panels are the ultimate approval mechanism for foods, no machine can perfectly imitate the complexities of simultaneously chewing, smelling and tasting.

Texture analysis using a taste panel is achieved using a group of people representative of the general population of interest to the product manufacturers. These panellists may be trained, in which case, fewer of them are generally required since terminology and scoring for the potentially confusing nomenclature of texture analysis is simplified when the participants fully understand it. If the panellists are not trained, the numbers required are usually greater, and the time required to collect the relevant data is also greater. This technique, however has the advantage that it is being carried out by humans, and therefore the complexities of tasting, chewing and swallowing are all accounted for. Both solid and liquid foods can be tested.

Potential problems may include:

- *Panellist condition:*
  The events, culinary or otherwise, of the preceding few days, hours or minutes may have an unknown influence on the panellist's impression of the food which they are testing. This can make it difficult for the panellists to agree on their impressions.

- *Time and expense:*
  Large numbers of people and large amounts of time are necessary for these types of tests. Large numbers can often be reduced by training the panel before the testing begins.

- *Reproducibility:*
  Individuals can be highly subjective, and reproducibility may be an issue. Different demographic groups may also react differently to the same material. Different taste panels can be convened to cater for different target markets. Using standard terms, (like those defined by Szczeniak) which have been well defined and explained to the panellists is a good technique for at least reducing the possibility of these errors.

- *The measurements are not absolute:*
  Therefore it is difficult to compare results from different foodstuffs or from different panels. The use of standard terms and definitions can allow some comparisons with the mouthfeel of previously researched materials.

- *The influence of taste, odour etc:*
  Taste and odour can have an effect on the perception of texture, and it may be difficult for panellists to separate these effects. The best solution is to train the panel well, and if possible to use instrumental techniques to check panel data.

Summary

Table 1 summarises the possibilities for measuring mouthfeel using the techniques discussed. Each of the techniques is ranked between 0 and 5 for each of the potential issues and solutions, where:

5=Excellent	4=Good	3=Adequate
2=Possible	1=Difficult	0=Not Possible

Determining the most suitable type of instrument is not simply a matter of adding up the ranking for each. Rather, identify which measurement technique, variable etc is most relevant and appropriate for your application/product. Often, more than one technique is required to ensure consistency, reproducibility and accuracy is achieved.

More and more food companies are now including texture analysis and rheology to support, supplement and further direct their R&D and recipe modifications.

Table 1: Assessment of strengths/weaknesses for each technique

Technique:	Uniaxial Force Measurements	CR Viscometers	CS Rheometers	Extensional Rheometer	Taste Panel
Measures					
Solids	5	0	1	0	5
Semi-solids	3	4	2	2	5
Liquids	2	5	5	5	5
Sensors					
Large variety	5	5	5	3	1
Direct taste/odour detection*	1	1	1	1	5
Rigid samples easily measured	5	0	2	0	5
Structural disruption on loading avoidable	4	3	3	3	5
Test Method					
Absolute*	1	5	5	4	0
Relative*	5	5	5	5	5
Quickly varied	5	5	5	5	1
Widely varied	5	5	5	4	1
Objective measurements	5	5	5	5	1
Subjective assessments*	0	0	0	0	5
Tests inedible materials	5	5	5	5	0
Rapid test completion	4	4	4	4	2
Primary Variable Parameter					
Load/Force	5	0	5	1	1
Displacement	5	5	5	5	1
Number of Participants					
High*	0	0	0	0	5
Low*	0	0	0	0	2
Single operator	5	5	5	5	0
Results					
Intuitively comprehended	4	3	2	3	4

* *Depending on the test, these parameters may be viewed alternatively as either a strength or as a weakness*

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Other Notes Available in the Tim's Top Tips - Rheology Solutions for the Food Industries Series are:

- Explanation and Evaluation of Shelf life (Rheo254)
- Explanation and Evaluation of Processability (Rheo255)
- Explanation and Evaluation of Cohesiveness (Rheo256)

Other Information Available for the Food Industries include:

- Rheology Solutions for Food Industries Information Kit
- Applications Laboratory and Contract Testing Capabilities Statement for Food Industries
- Technical Literature for Food Industries

Focused on providing our customers with materials characterisation solutions through knowledge, experience and support.

Food Dictionary

Industry Term: **Adhesiveness**
Definition: The force require to remove food which has bonded to the hands during handling or to the roof of the mouth during eating.
Governing Properties: This is a solid rheological (mechanical) property, measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Brittleness**
Definition: The breakdown force of food in the mouth.
Governing Properties: This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Cohesiveness**
Definition: The extent of deformation and destruction of a product when a load is applied to it.
Governing Properties: This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Complex Viscosity**
Definition: The viscosity measured by dynamic rheometry, related to both the viscous and elastic portions of flow for a viscoelastic fluid.
Governing Properties: This is a property governed by the viscoelastic properties of the material - elastic and viscous moduli (G' and G"). It is measured on a CS rheometer using a frequency sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Controlled Stress (CS) Ramp**
Definition: A technique for testing materials. The shear stress is gradually increased, rather changed in a stepwise fashion.
Governing Properties: The capabilities of the rheometer will define its ability to conduct a CS ramp.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Crispiness**
Definition: The crispiness (or brittleness) of a product is the difference between the force required to fracture and the point at which the load begins to increase again due to compression of the material.
Governing Properties: This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Crossover Point**
Definition: The point at which the viscous modulus is quantitatively equal in to the elastic modulus.
Governing Properties: This is a property governed by the viscoelastic properties of the material - elastic and viscous moduli (G′ and G″). It is measured on a CS rheometer using a frequency sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Deformation**
Definition: The movement of an element of a material, usually as a result of some applied force
Governing Properties: The rate of deformation (shear rate) due to an applied force is dependent on the resistance of the material – it's viscosity in the case of a liquid, or rigidity in the case of a solid.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKERheoStress, HAAKE MARS, Marimex ViscoScope, Shimadzu EZ Test.

Industry Term: **Elastic and Viscous Moduli**
Definition: Many liquids have a solid-like (elastic) component and a liquid-like (viscous) component. The elastic and viscous moduli, G′ and G″ respectively, are measures of the contribution of these two to the deformation of the liquid.
Governing Properties: These are properties governed by the viscoelastic properties of the material - elastic and viscous moduli (G′ and G″). They are measured on a CS rheometer.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Elastic Quality**
Definition: The comparison between indentation and displacement when a load is added twice in succession to a food product.
Governing Properties: This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Extensional Viscosity**
Definition: The extensional viscosity of a liquid is the resistance to flow of the liquid as it is being stretched. This is a different property to (and independent of) either the shear viscosity or the complex viscosity.
Governing Properties: The extensional viscosity depends on the temperature, the rate of deformation of the liquid. It can be measured on an extensional viscometer.
Rheology Solutions Instrument: HAAKE CaBER

Industry Term: **Flow**
Definition: Measure of the ability of a sample to be moved (by gravity or other force).
Governing Properties: The rate of flow of a liquid is governed by its properties in shear, including the yield point at low shear, measured with a CR viscometer, and by the viscoelastic properties of the liquid, as measured on a frequency sweep by a CS rheometer. CR measurements can often be made in-line.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS, Marimex ViscoScope.

Industry Term: **Frequency Sweep**
Definition: This technique is an analysis of the dependency of the rate dependent viscoelastic properties; it is usually carried out in the LVE of the test material.
Governing Properties: N/A
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Hardness**
Definition: This describes a product which displays substantial resistance to deformation or breaking. It is the perceived force required to break the sample into several pieces during the first bite by the molars.
Governing Properties: This is a solid rheological (mechanical) property which is measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: Shimadzu EZ Test.

Industry Term: **Linear Viscoelastic Envelope (LVE)**
Definition: The LVE is the region in which the internal structure of a material remains unchanged as the imposed stress or deformation is gradually increased.
Governing Properties: Measured on a CS rheometer using a stress sweep or a strain sweep.
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Mouthfeel**
Definition: A combined experience from the sensations of the skin in the mouth during and/or after ingestion.
Governing Properties: Liquid properties – Extensional Viscosity, G', G", h*, Shear Viscosity, Thixotropy etc. Also related to solid mechanical properties like adhesiveness, cohesiveness, brittleness, hardness etc, measured according to Szczeniak on a texture analyser.
Rheology Solutions Instrument: HAAKE CaBER 1, HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS, Shimadzu EZ Test.

Industry Term: **Rheometer**
Definition: An instrument designed for the measurement of viscous and viscoelastic flow properties at specified temperature and atmospheric conditions, by measuring the force required to move one layer over another without turbulence.
Governing Properties: Rheometers often have air bearings, making them highly sensitive to small variations in load or displacement and can operate in rotation or oscillation for Controlled Rate or Controlled Stress modes. Some rheometers have mechanical bearings, but in general they do not have the required sensitivity to make good use of CS mode in these cases and can not run oscillatory measurements well (or at all).
Rheology Solutions Instrument: HAAKE RheoStress, HAAKE MARS.

Industry Term: **Shear Rate**
Definition: This is the rate of change of deformation through an element of a fluid due to an imposed deformation or stress.
Governing Properties: The shear rate is dependent on the geometry of the deformed element, and on the force or displacement imposed on it. Shear rate can be measured on a CS rheometer, or can be imposed by a CR viscometer.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term: **Shear Stress**
Definition: This is the force per unit area imposed on an element of fluid.
Governing Properties: The shear stress is dependent on the geometry of the fluid element and can be measured by a CR viscometer and may be imposed by a CS rheometer.
Rheology Solutions Instrument: HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Shear Viscosity**
Definition:	The shear viscosity is the resistance of a fluid to flow when a shear stress is exerted upon it.
Governing Properties:	Shear viscosity depends on temperature and usually shear rate or shear stress. It can be measured on a viscometer or a rheometer, using viscometric measuring geometries.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress.

Industry Term:	**Thixotropy**
Definition:	Thixotropic fluids show shear thinning behaviour combined with a time dependency. The viscosity of a thixotropic fluid drops when subjected to a constant shear rate for a period of time. The viscosity of thixotropic fluids often recovers substantially over a period of time after the shearing forces have been removed.
Governing Properties:	Thixotropy depends on the rate of structural recovery in the material. It can be measured using a flow curve on a CR or CS instrument, or by measuring the recovery of the moduli after shearing on a CS rheometer.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Viscoelastic Properties**
Definition:	These are properties of the material at rest. See 'Complex Viscosity', 'Elastic and Viscous Moduli', 'Crossover Point'.
Governing Properties:	Governed by the structural properties of the material at rest, measured on a CS rheometer.
Rheology Solutions Instrument:	HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Viscoelastic Moduli**
Definition:	The collective name for the elastic and viscous moduli, G' and G".
Governing Properties:	Usually measured using a CS rheometer.
Rheology Solutions Instrument:	HAAKE RheoStress, HAAKE MARS.

Industry Term:	**Viscometer**
Definition:	An instrument for measuring the viscosity of a liquid at specified temperature and atmospheric conditions, by measuring the force required to move one layer over another without turbulence; also referred to as viscometer.
Governing Properties:	Viscometers usually have mechanical bearings in their motor and generally operate in rotational mode only.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco

Industry Term:	**Yield Stress**
Definition:	The minimum shear stress required to initiate flow in a fluid.
Governing Properties:	Governed by the structural properties of the material at rest, measured by extrapolation using a flow curve, or using the vane technique, both on a CR or CS instrument. It can also be measured using a CS rheometer by a stress ramp.
Rheology Solutions Instrument:	HAAKE ViscoTester 550, HAAKE RotoVisco, HAAKE RheoStress, HAAKE MARS.

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Information Request Form

Tim's Top Tips – Rheology Solutions for the Food Industries
Explanation and Evaluation of Mouthfeel

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Contact Details:

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Company .... Department ....

Address ....

Suburb .... State .... Postcode ....

Telephone .... Fax ....

Email ....

Please send me more information on the following products:

- ☐ Shimadzu EZ Test – Texture Analyser
- ☐ HAAKE VT550 – Controlled Rate Viscometer
- ☐ HAAKE RotoVisco 1 - Controlled Rate Viscometer
- ☐ HAAKE ViscoTester VT6 Plus / VT7 Plus – QA Viscometer
- ☐ Contract Testing
- ☐ Technical Literature *(Please specify)*

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- ☐ HAAKE RheoStress RS600 – Controlled Stress Rheometer
- ☐ HAAKE CaBER 1 – Extensional Rheometer
- ☐ HAAKE MARS - Modular R&D Controlled Stress Rheometer
- ☐ Rheology Solutions for Food Industries Kit
- ☐ Training & Seminars
- ☐ Other *(Please specify)*

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Comments: ....

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Return your completed form to Rheology Solutions Pty Ltd by fax to 03 5367 6477 or post to Rheology Solutions Pty Ltd. PO Box 754. Bacchus Marsh. Vic. 3340.

Focused on providing our **customers** with materials characterisation **solutions** through knowledge, experience and support.

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