

## GELATIN

### GELATIN AND GELATINATION:

Gelatins are defined as a class of water soluble proteinaceous substances which have no existence in nature, but are derived from the insoluble parent protein collagen, by any one of a number of procedures involving the destruction of the secondary and higher structures of the collagen and in most cases the primary structure as well (Veis, 1964). Gelatins have a typical amino acid compositions containing large amounts of proline, hydroxyproline, alanine and glycine, the latter constituting approximately one third of the molecule (Mitchell, 1976).

Gelatins have been the subject of much research, both into their structural relationship with collagen and into their behaviour within specific applications (Stevens, Wijaya, and Paterson, 1995; Johnston-Banks, 1990). Rheology investigations have been made into the following areas:

- (a) Relationship between the rigidity modulus (G) and other variables
- (b) Applicability of the theory of rubber elasticity
- (c) Viscoelasticity

### CHARACTERISATION OF GELATIN:

The ability to form a gel without doubt is one of the most important properties of gelatin, its strength and viscosity are the two most important measurements used to assess its grade and physical quality. Gel strength properties are related to:

1. The proportion of  $\alpha$ - and  $\beta$ - chain components
  2. Gel concentration
  3. Temperature
  4. Maturing time
  5. Additives
  6. pH
- } Gelatin structure is dependant upon concentration, where gels of low concentration have a more liquid-like character, whereas those with high concentrations behave more like solid materials. Concentration also influences intermolecular linkages within the gel network. Formation of cross-bonds is the slowest part of gelatination where under ideal conditions the strength of the gel increases with *time* as more cross-bonds are formed (GMIA, 1993)

In contrast the viscosity of gelatin solutions is related to the average molecular weight, in particular to the degree of oligomerisation of the  $\alpha$ - chains. The pH is also a critical factor involving an isoelectric point where minimum viscosity is obtained, above and below which gel viscosity increases.

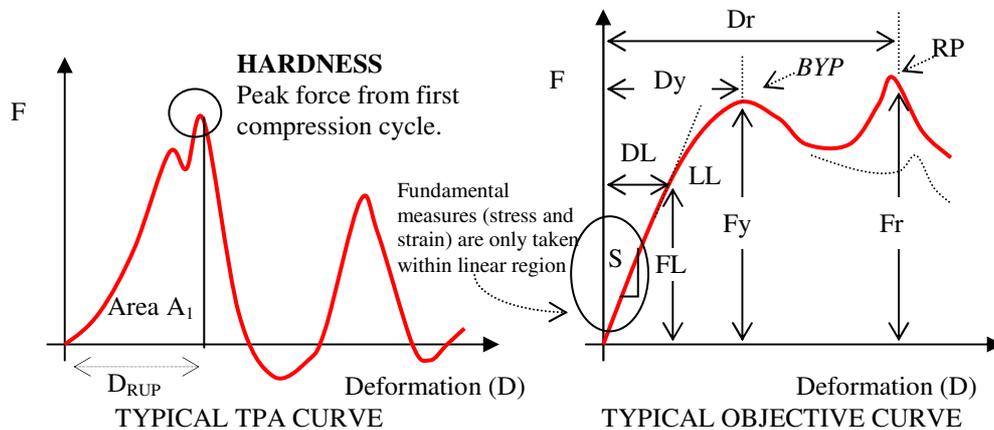
Gel testing can therefore be used as an objective method to quantify the effects of these factors within the production process and optimise the quality of finished products.

**GEL TESTING AND THE LFRA TEXTURE ANALYSER:**

In 1978 the LFRA Texture Analyser (TA) was introduced as a semi-automated method for the quality assessment of gel strength. The apparatus was developed in partnership with the world renowned Leatherhead Food Research Association as a more accurate and precise method for the assessment of gel strength, where it soon became an industrial standard replacing the original Stevens Boucher Electronic Jelly Tester.

The instrument is a precision penetrometer with a range of selectable plunger speeds and penetration distances. There are 3 modes of operation: “normal” for a single penetration test; “cycle” for repeated penetration tests, such as those employed within Texture Profile Analysis (TPA); and “hold” for load dissipation at a constant penetration distance, e.g. stress relaxation. The combination of these variables permits calculation of wide range of parameters relating to both empirical and fundamental evaluation of the selected samples.

**GENERALISED FORCE-DEFORMATION CURVES**



**Where:** S = Elastic Modulus calculated from slope; *BYP* = Bioyield point; RP = Rupture Point (*Gel Break*); LL = Linear Limit; FL and DL = Force and Deformation at Linear Limit; FY and DY = Force and Deformation at bioyield point; Fr and Dr = Force and deformation at rupture point.

*Note:* Deformation is the distance a probe travels into product e.g. original sample height - distance probe travels into product (**from surface contact**).

(Adapted from Brennan, 1980, Bourne, 1978)

The two illustrations highlight potential measures, which may be generated through employment of the LFRA TA in conjunction with the computer interface package. The standard Bloom Value may be read directly from *view data with graphs window* through positioning of cursors at 4mm penetration distance. The software also allows the overlay of up to 3 test results where results from new and historical tests can be reviewed and compared. In-house tolerance limits may also be pre-set giving unique red, amber and green process control indications for QC Operators where instantaneous on-line quality assessment is required. In conclusion although the LFRA TA was originally designed as replacement to the Boucher instrument for simple Bloom measurement, its versatility and continuous improvement have lead to it being adopted for the general textural assessment of many food products and ingredients.

## RHEOLOGICAL GEL TESTING METHODS:

Rheological test methods are divided into three classes:

1. **FUNDAMENTAL:** Measures well defined parameters such as elastic modulus or viscosity.
2. **EMPIRICAL:** Measures parameters which can not be expressed in fundamental rheological quantities and thus results obtained are dependent upon sample geometry etc.
3. **IMITATIVE:** Measure various properties under test conditions similar to which the material is subjected in practice.

All gels exhibit viscoelastic properties and thus a complete rheological description requires the measurement of parameters over several decades of time (Mitchell, 1976). However for quality control purposes generally only a single quantity is determined utilising a well established empirical procedure such as the "Bloom test" (British Standard BS 757:1975; AOAC 1986).

### BLOOM TEST (BS 757: 1975; AOAC 1986):

Development of the Bloom test was largely the result of large multinational producers insisting the industry follow a single standard method of gelatin assessment in order to obtain industrial uniformity. The test has proved extremely successful to date due to its simplicity in both sample preparation and result interpretation. Bloom units are immediately recognised and understood as the uniform standard throughout the world.

The Bloom test involves mixing a 6.667% solution of medium Bloom gelatin at 60°C, setting into Bloom jars and conditioning at 10°C in a chill bath. The Bloom jars are then positioned beneath either the LFRA TA or QTS 25 where a standard ½" diameter cylindrical probe is penetrated into the set gel to a depth of 4mm at a constant speed. Differences between the BS 757 method and the newly adopted AOAC method are directly related to probe type. The BS 757 protocol utilises a ½" probe with 0.4mm radiused or chamfered edge which helps prevent breaking of the gel around the probe perimeter. The AOAC probe has no such radius and values attained are on average slightly higher than those generated with the original BS probe.

The Bloom test may be utilised and adapted to quantify the gel strength of a wide range of gels:

- (a) Agar (including employment of Kobe conditions)
- (b) Starch Gels
- (c) Mixed polysaccharide gels
- (d) Pectin
- (e) Carrageenan
- (f) Alginate etc.

By measuring the force:deformation relationship and force required to rupture the gel, enough information can be obtained to classify gels into categories such as brittle, firm, weak, elastic etc. (Mitchell, 1976).

**REASONS FOR MEASURING GEL STRENGTH:**

There is currently a trend within the food industry towards improving quality control and therefore many simple tests have been developed in order to measure physical/textural attributes of food materials. Among these tests the quantification of “*gel strength*” is of great importance. Quantification is frequently accomplished through penetrating gels formed in containers whilst utilising force-deformation instruments such as the LFRA Texture Analyser and the QTS 25. Simple instrumentation and methodology make penetration type tests highly compatible within the Quality Control environment. Whilst improvements in data handling (including the launch of the LFRA TA computer interface and newly developed *QTS 25 TexturePro™* software) have helped realise the full potential of these instruments, where considerable information relating to gel structure can be obtained.

Measurements of gel strength can be carried out by sensory panels or by instrumental rheological techniques. Rheological measurements of gels are made for a number of reasons:

1. The gelling behaviour of natural polymers varies with the raw material and the method of extraction, it is therefore essential for both purchasers and manufacturers of all gelling agents to have reliable tests for evaluating “*gel strength*”.
2. Rheological measurements are used to complement information relating to the structure of products containing gels as a means of at-line monitoring, an integral part of good process control
3. Instrumental measures can be used in place of sensorial methods of evaluating the textural characteristics of gels, providing objective measures to subjective characteristics.

Rheological measurements can replace or complement sensory methods utilised in the evaluation of food texture. The physical test “*has the advantage that the product developer does not have to rely on his own judgement of eating quality, or resort to the cumbersome and time-consuming expedient of using a large taste panel*” (Morris, 1994). This factor was confirmed through work by Szczesniak, *et al*, (1975) and Munoz, *et al*, (1986) who identified relationships between rheological measures and sensorial parameters. This in turn demonstrates that it is possible to replace the need for expert panels by quicker measurements on instruments such as the LFRA Texture Analyser and QTS 25.

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