QUALITY ESTIMATION OF GELATINOUS PRODUCTS. I.

THE ATTEMPTS OF OBJECTIVIZATION OF THE PROFILE TEXTURE ATTRIBUTES*

By

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One of the important quality factors of food is their texture or mouthfeel. A great number of objective methods for measuring texture have been developed, and these measure many different properties of food. The methods for the objective measurement of textural properties of foods are classified according to the examined variable or variables. Physical methods can be classified as measurement of force, distance, time, energy, ratio. There are multiple-variable instruments in use (BOURNE, [2]. Some instruments will be listed in each category in order to illustrate the principle of the classification system with concrete examples (Table 1).

BOURNE [3], HENRY [6], BREENE [5] adopted the Instron universal testing machine for use in textural studies and applied it to some semi-solid food. The mowing plate compresses a cylinder of the specimen, then it rises to its starting position and moves down to compress the specimen again. A typical force vs. distance curve for Texture Profile Analysis of some semi-solid

Table 1

Classification of objective methods for measuring texture and consistency

Property measured		Examples
Force		Tenderometer
Distance	(a) distance	Penetrometers
	(b) area	Grawemeyer Consistometer (bread volume)
	(c) volume	Seed Displacement
Time		Ostwald Viscometer
Energy		Farinograph
Ratio		Cohesiveness (G. F. Texture Profile)
Multiple-variable		Durometer
Multiple		G. F. Texturometer, Instron

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* Based on a research program at the Department of Biochemistry and Food Technology.

food is shown in Fig. 1. The chart of the Instron gives a force vs. distance curve and many varibles:

firmness (F)
elasticity (E) = d
cohesiveness (C) = A_2/A_1
gumminess (G) = F · C   C = compression
chewiness (Ch) = F · C · E

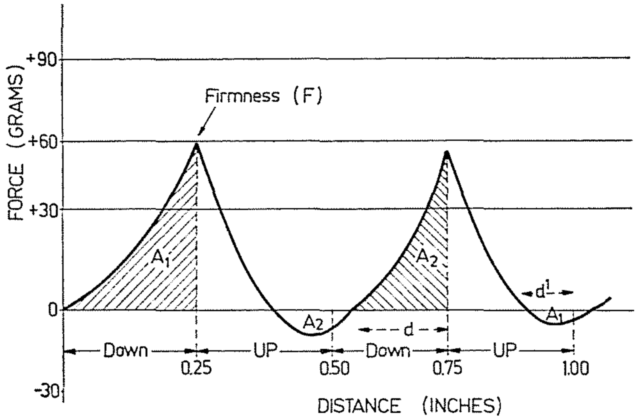

Fig. 1. Typical force–distance curve obtained by TPA of semi-solid food (custrads, gelatin)

Dimensional analysis of the General Foods Texture Profile is shown in Table 2 according to the work of BOURNE [2].

The rheological properties of sugar-acid-pectin gels, although of considerable importance, have been studied largely by empirical methods (WATSON [8]; BOURNE [1, 4]; HENRY and et al. [6]; SZCZESNIAK and GORGESON, [7];

Table 2

Dimensional analysis of the G. F. texture profile

Mechanical parameter	Definition	Measured variable	Dimension
Brittleness	the force resisting chewing	force	mlt^{-2}
Hardness (firmness)	the force resisting compression (firmness to semi-solid foods)	force	mlt^{-2}
Cohesiveness	the work (cohesiveness)	ratio	—
Gumminess	the force (cohesiveness)	force	mlt^{-2}
Chewiness	the ratio of the work done during the first and second bites on the food	work	ml^2t^{-2}
Elasticity	return tendency to first dimension	distance	1

WATSON, [8]). It was felt that a more comprehensive study, using recently developed methods of measuring impact and creepstress=strain relationships, would provide a better insight into these rheological properties.

A variety of devices have been developed for measuring gel strength. However, the rheological properties of these gels are complex and therefore have been poorly understood. Consequently, the testing methods were often based on unsound premises, commonly taking the form of procedures intended to duplicate as closely as possible the actual commercial use of the material. The correlation of rheological properties with sensory evaluation of gel texture has not yet been achieved. Because the rheological properties of gels are time-dependent, the empirical nature of many earlier "rheological-type" measurements has led to some confusion.

Although work on the rheological properties of pectin gels has progressed farther than work on other gels, this work has not included extensive rhelological evaluation.

1. Materials and methods

1.1. *Materials tested*

The gels were prepared with citrus pectin, sucrose and tartaric acid. All gels were prepared under the same conditions of time and temperature. The received mass was poured out into ten glasses of 3.5 cm diameter. The height of liquid level in the glasses was 3.5 cm. Texture measurements were performed after the setting of the gels.

Gel consistency was changed by varying the following factors:

- chemical structure of pectin
- contents of organic acid
- contents of pectin and organic acid.

Chemical structure of the pectin molecule was changed by esterification. It was esterified with ethanol in the presence of benzene and tartaric acid, which acted as catalyst. Upon a chemical modification of pectin, the pectin requirement was reduced to about 25% of the original.

Hundred and twenty gel samples were prepared for texture tests.

1.2. *Methods for the evaluation of consistency*

Simple methods of texture evaluation were suggested for semi-solid and semi-liquid material in pectin gels. Penetration and compression, fluidity and stringiness were measured or calculated.

Penetration and compression test were carried out by the Höppler modified rheoviscosometer. The scheme of the apparatus is shown in Fig. 2. Deformations in time were recorded. The curves illustrate the strain-time relationship. Interpretation of these diagrams has led to cohesiveness and compactness values. Measurement of stringiness was carried out as follows: The gel was put between two parallel plexiglass plates and stretched by removing the plates. The maximum length of sample was measured in five successive operations with the same sample. Stringiness has been defined as ratio of lengths after and before stretching. Fluidity measurement was carried out as follows: The gel was slipped out from a glass of constant height. After a predetermined time the contour of gel area was measured by planimetre or by measuring the area surrounded by contour. Fluidity of the sample was characterized by the measured area.

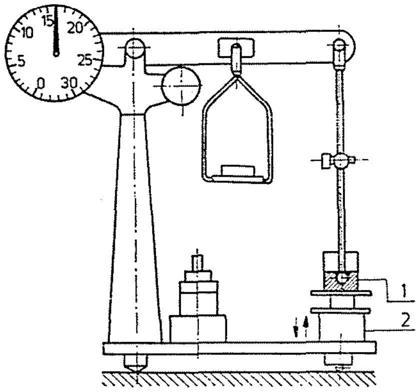

Fig. 2. Modified rheoviscosimeter. 1 — tested gel; 2 — moving table

2. Results

2.1. *Changes of texture caused by chemical modification of the pectin*

Chemical modification of the pectin resulted in solid gels of cylindrical shape. Before esterification semi-liquid gels were obtained. The change of fluidity illustrates this texture change (4.2—2.7 cm^2) (Table 3). Measurement of stringiness was possible only on gels prepared with esterified pectin.

2.2. *Texture changes of gels by increase of pectin and acid content*

Characteristic strain-time relationships are shown in diagrams (Fig. 3). On the basis of this kind of diagrams stress-strain relationships were stated (Figs 4, 5). All gels had semi-liquid consistency Their structure was defined by cohesiveness and fluidity, in the ranges according to Table 4.

Table 3

Texture changes of gels upon modification of pectin

Textural profile attributes	Dates	
	before	after
	chemical modification of pectin	
Cohesiveness (penetration), 80 g, 15 sec mm	10.5	5.6
Compactness (compression), g/cm^2	20	100
Fluidity, cm^2	4.2	2.7
Stringiness, cm/cm	—	1.5

Table 4

Texture changes of gels by:
1. increase of pectin and acid content, 2. increase of acid content

Changing factor	Textural attributes, size range	
	cohesiveness 5 mm, 30 sec stress (g)	fluidity (cm^2)
1	26.5—65.0	33.5—19.0
2	15.0—17.0	34.5—28.5

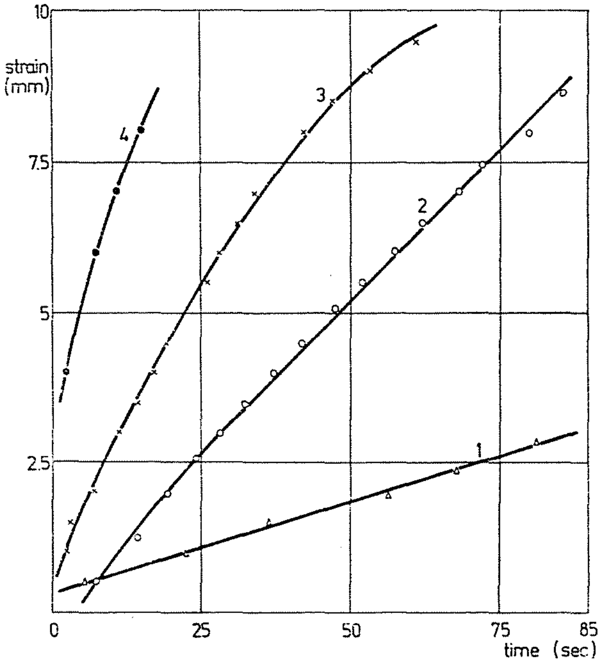

Fig. 3. Strain–time relationships for gel without acid at various stresses. 1 — 12 g; 2 — 14 g; 3 — 16 g; 4 — 20 g

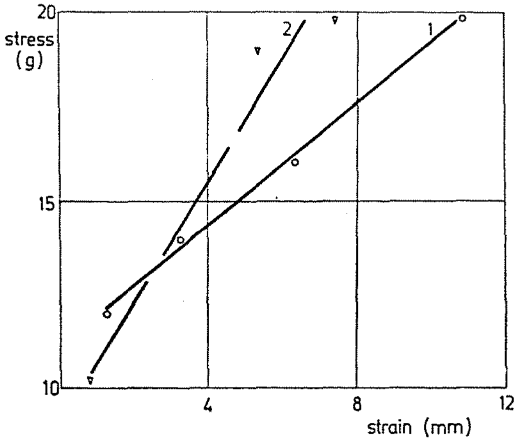

Fig. 4. Stress-strain relationships for gels with various acid contents after 30 sec. 1 — 2% pectin, without acid; 2 — 2% pectin, 0.20% tartaric acid

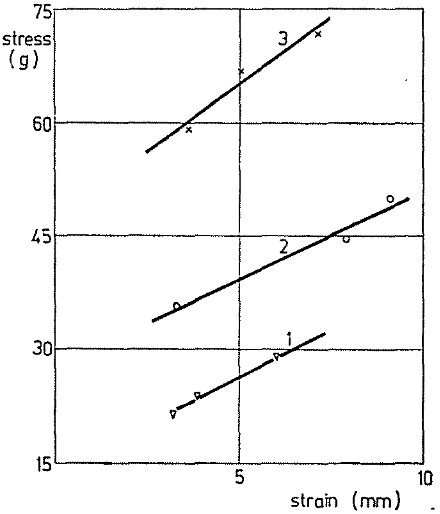

Fig. 5. Stress-strain relationships for gels with various pectin and acid contents after 30 sec. 1 — 2.5% pectin, 0.25% tartaric acid; 2 — 2.7% pectin, 0.27% tartaric acid; 3 — 3.0% pectin, 0.30% tartaric acid

3. Appreciation of the suggested textural attributes

The repeatability of the test is characterized by:

Attribute	Statistical error %
Cohesiveness	1.30
Compactness	1.42
Fluidity	6.80
Stringiness	3.20

The list shows that fluidity has the greatest scatter (statistical error)· But the fluidity has universal worth because it is valid to both semi-solid and semi-liquid materials. Cohesiveness is universal too, but its disadvantage is high consumption of time, provided a simpleness of equipment is used. Its advantage is a low test error. The suggested tests are of use for comparative consistency estimation.

Summary

Methods for determining the textural properties of foods are classified according to the variable(s) measured, indicating typical instruments in each group. Simple methods are presented for testing semi-solid and semi-liquid pectin, gels, made with citrus pectin, sucrose and tartaric acid. Gel consistency was changed in test series involving chemical structure of pectin; organic acid content; pectin and organic acid content. Chemical structure of the pectin molecule was changed by esterification. Measured properties included penetration and compression, overflow and stringiness.

References

1. Bourne, M. C.: J. Food Sci. **32,** 605 (1967).
2. Bourne M. C.: J. Food Sci. **31,** 1011 (1966).
3. Bourne, M. C.: J. Food Sci. **33,** 223 (1968).
4. Bourne, M. C.: J. Food Sci. **32,** 601 (1967).
5. Breene, W. M.: J. Food Sci. **37,** 113 (1972).
6. Henry, W. F.: J. Food Sci. **36,** 155 (1971).
7. Szszesniak, A.—Gorgeson, K.: Adv. Food Res. **14,** 33 (1965).
8. Watson E. L.: J. Food Sci. **31,** 373 (1966).

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