USE OF THE OTTAWA TEXTURE MEASURING SYSTEM FOR TESTING FISH PRODUCTS

A PRELIMINARY INVESTIGATION
CONDUCTED FOR:

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Peter W. Voisey
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1.0. Introduction

The current "state of the art" in objective measurement of the texture of solid and semi-solid food products is mainly restricted to methods based on empirical concepts. Samples are deformed in some arbitrarily selected manner and the resulting forces analyzed to determine if they indicate the texture of the food. The data must correlate with sensory analysis before the objective method can reliably replace subjective techniques.

The purpose here was to conduct a preliminary experiment to determine if the Ottawa Texture Measuring System (O.T.M.S.) could be used to measure the texture of fish products.

The OTMS consists of a simple screw operated press which deforms test samples at a constant rate and records the force, time and deformation precisely during this process (Voisey 1971). Test samples can be subjected to a variety of operations such as shear, compression and extrusion by using different texture test cells in the press. The system is based on test cells which shear and extrude the sample through either a wire grid or a perforated plate (Voisey 1970). These have already been used successfully for fresh and cooked fruits and vegetables.

2.0. Methods and Materials

2.1. Test Samples

Samples of frozen cod filets and scallops were supplied and stored at -10^{o}F. Sensory tests had been conducted with the following results:

Sample	Texture Score
Cod A	86
Cod B	41
Cod C	57
Scallops F	83
Scallops 8	53

2.2. Test Procedure Cod Filets

The following procedure was followed in testing all the samples:

1. Cut each package of cod in half.
2. Weigh each half.
3. Seal each half in plastic bag.
4. Boil sample (rolling boil) for 30 min.
5. Drain free fluid from plastic bag.
6. Remove fish from bag and weigh sample.
7. Allow sample to cool for 10 min after completion of cooking.
8. Break filets into lumps and place in 20 cm^2 O.T.M.S. texture cell equipped with a wire shearing grid. Sample size controlled by weight.
9. Compress sample into cell at 10 cm/min and record force Vs time (i.e. deformation).

Instrument Parameters

500 Kg load cell

Chart calibrated at 115 Kg (250 lb) for

full scale pen deflection

Time base of chart 1 in = 10 sec.

After preliminary tests to establish instrument settings (see 2.4) two experiments were performed.

Experiment 1 - To artificially induce a variation in texture of the cooked product samples were tested after cooking for times ranging from 20 to 60 min in 5 min increments. This was repeated for samples A, B, & C.

Experiment 2 - To determine the repeatability of the measurements and establish the difference between samples A, B, and C. 10 samples of each fish were tested using a 30 min cooking time.

2.3. Test Procedure Scallops

1. Select sufficient pieces to fill test cell.
2. Weigh.
3. Seal in plastic bag.
4. Cook for 30 min (rolling boil).
5. Place bag in room temperature water for 3 min to cool sample.
6. Drain bag and allow liquid to cool to room temperature before measuring its pH.
7. Weigh sample.
8. 9 minutes after completion of cooking place sample in test cell, controlling sample size by weight using 20 cm^2 9 wire cell.
9. Compress sample into cell at 10 cm/min and record force Vs time.

Instrument Parameters

Same as for cod filets except full scale pen deflection corresponded to 68 Kg (150 lb).

A limited quantity of test material was available, therefore, it was only possible to perform one comparison between samples 8 and F.

2.4. Preliminary tests

Before the main tests were performed, samples of cod and scallops were tested in the 20 cm^2 OTMS test cell using first a wire grid (9 wires) and then an extrusion plate to determine if either of these cell inserts offered any advantages over the other.

3.0. Results

3.1. Preliminary tests

a) Scallops - The force required to compress and extrude the sample and the fluctuations of the force during compression were much higher for the plate than the wires (Fig. 1). About 75% of the sample was extruded between the compression plunger and the test cell walls. This was because the forces required to shear and extrude the sample through the plate in the cell bottom exceeded those required to extrude the material through the 0.75 mm wide gap between the piston and cell walls. Also the plate was extremely difficult to clean after each sample. The plate method was, therefore, discarded for scallops.

b) Cod filets - The curves for the wire and perforated plate were almost identical in shape except for larger fluctuations about the mean in the case of the plate (Fig. 2). The forces produced in using the plate were, however, over twice those of the wires. The perforated plate was, therefore, discarded for testing cod filets because it was difficult to clean betweem samples.

c) Preliminary comparison scallops

Using the 20 cm^2 9 wire test cell there were definite differences between samples 8 and F (Fig. 3). In each case the force-deformation curve had an initial portion that was markedly curvalinear. This was assummed to be produced by packing of the sample into the cell and expelling air. There followed an approximately linear portion as the sample was compressed as a mass against the wires. The slope of the curve then changed fairly abruptly, this point coincided with the onset of shearing of the sample and extrusion through the wires. The force then continued to increase and fluctuated about the mean until compression stopped. The fluctuations were greater for sample F.

d) Preliminary comparison cod filets

There were marked differences between samples A, B, and C (Fig. 4). The curves were similar in character to those obtained for scallops.

3.2. Analysis and interpretation of records for cod filets

For the purposes of this preliminary study it was arbitrarily decided to take the following measurements from the curves.

A. The average slope of the initial approximately linear portion of the curve in Kg/cm.

   Using the definitions for mechanical characteristics of foods proposed by Szczesniak (1963) the slope could be interpreted to indicate hardness.

   "Hardness, defined as the force necessary to attain a given deformation."

B. The force at which shearing and extrusion initiated in Kg interpreted as the cohesiveness.

   "Cohesiveness, defined as the strength of the internal bonds making up the body of the product."

C. The average slope of the curve after the onset of shearing and extrusion in Kg/cm.

   This is related to the combined effects of compression, shearing and extrusion, i.e. hardness and cohesiveness.

D. The maximum force during the test which in general coincided with the point at which compression was stopped in Kg. Since the overall shape of the force deformation curves was triangular and the sample deformation was constant, the area under the curve was assummed to be proportional to the maximum force to a first approximation. The area under the curve is the energy used to compress, shear and extrude the sample. This may be interpreted to indicate chewiness of the sample.

   "Chewiness, defined as the energy required to masticate a solid food product to a state ready for swallowing. It is related to the primary parameters of hardness, cohesiveness and elasticity."

It was observed that the test sample emerging through the wires had an appearance similar to fish after it had been masticated ready for swallowing.

It should be noted that experimental verification of the above interpretations was not attempted.

3.3. The effect of cooking time

The effect of cooking time on the four measurements did not indicate any consistent effect (Table 1). This is illustrated in Figures 5, 6 and 7.

3.4. Repeatability tests

Results for 10 tests on each sample (Table 2) indicate that the variation in initial slope, initial shear force and slope during extrusion and shearing are high. Part of this may be attributed to control of the crude processing techniques used. The variation in maximum force was at a much lower level. It would, thus, appear that to establish meaningful comparisons between treatments numerous samples must be tested.

There were marked differences between samples A, B, and C in the four characteristics taken from the curves indicating that the system was able to respond to differences in texture. Proof of statistical significance was not attempted because of the limited sample.

Variation between samples was lower using a constant cooking time (Table 2) than when the cooking time was varied (Table 1).

3.5. Comparison of sensory and objective data

There was agreement in ranking of the three samples in 3 of the measurements taken from the curves indicating that cohesiveness, slope during shearing and extrusion (as defined here) influenced both the sensory analysis and the instrumental measurement (Table 3). Samples B & C were placed in reverse order according to the objective measurement of hardness. Average results from varying the cooking time also ranked the samples in the same order as sensory tests.

4.0. Discussion

The preliminary results obtained indicate that textural differences between fish samples can be indicated by the O.T.M.S. The sensitivity of the measurement may not be as high as sensory analysis which had a range of about 100%. Objective measurement of hardness ranged about 50%, cohesiveness about 30% and chewiness about 30%. However, this may be due in part to the fact that the sensory index combined the effects of these three parameters.

From a practical viewpoint the O.T.M.S. wire shear cell is suitable for the test. Sample preparation, filling and cleaning the cell can be done rapidly.

5.0. Conclusions

It appears that the OTMS wire shear cell is suitable for measuring the textural characteristics of cod. Further work is required to establish the following:

a) Sensitivity of the measurement to changes in texture.

b) Repeatability.

c) To test the correlation between subjective and objective measurements.

d) To establish correct methods of interpretation of the data.

6.0. References

Szczesniak, A. A. 1963. Classification of textural characteristics. J. Food Sci. 28: 385-389.

Voisey, P. W. 1970. Test cells for objective textural measurements. J. Can. Inst. Food Technol 3: 93-102.

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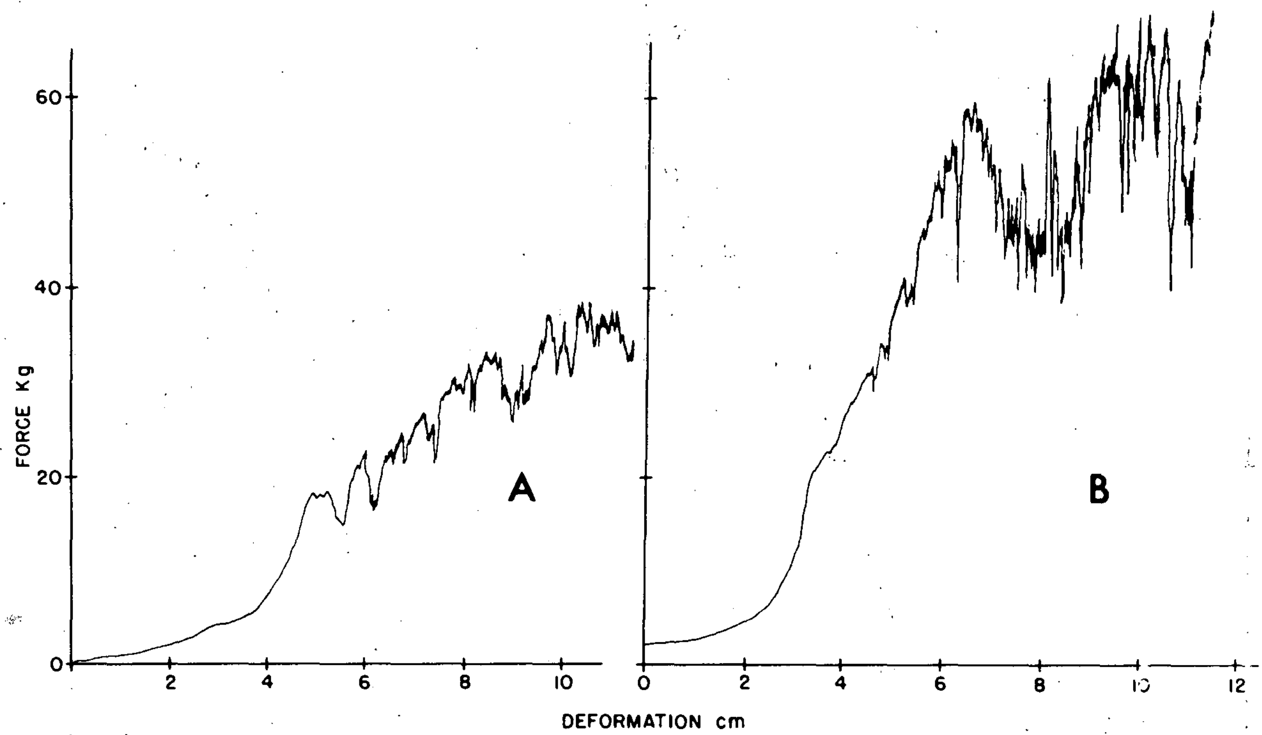

Fig. 1. Comparison of curves obtained for scallops (sample F) using: A. wire insert (10 min after cooking) and B perforated plate insert (20 min after cooking).

Weight frozen	710 g
*Weight after cooking	650 g
*Weight less drip	645 g

Includes weight of plastic bag.

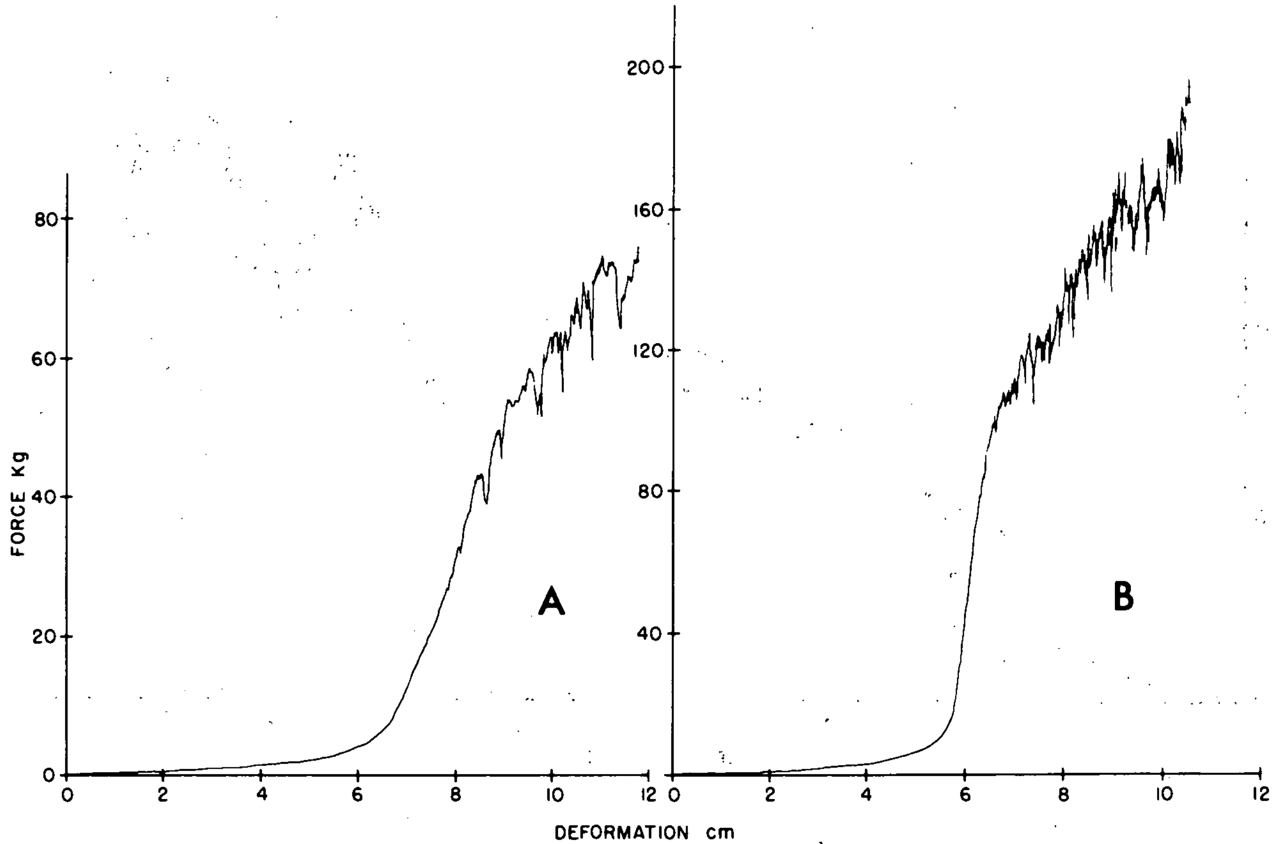

Fig. 2. Comparison of curves obtained for cod filets (sample C) using: A. wire insert (12 min after cooking) and B. plate insert (22 min after cooking).

*Weight frozen	468 g
*Weight cooked	568 g
*Weight less drip	350 g
Test sample weight	155 g

Includes weight of plastic bag.

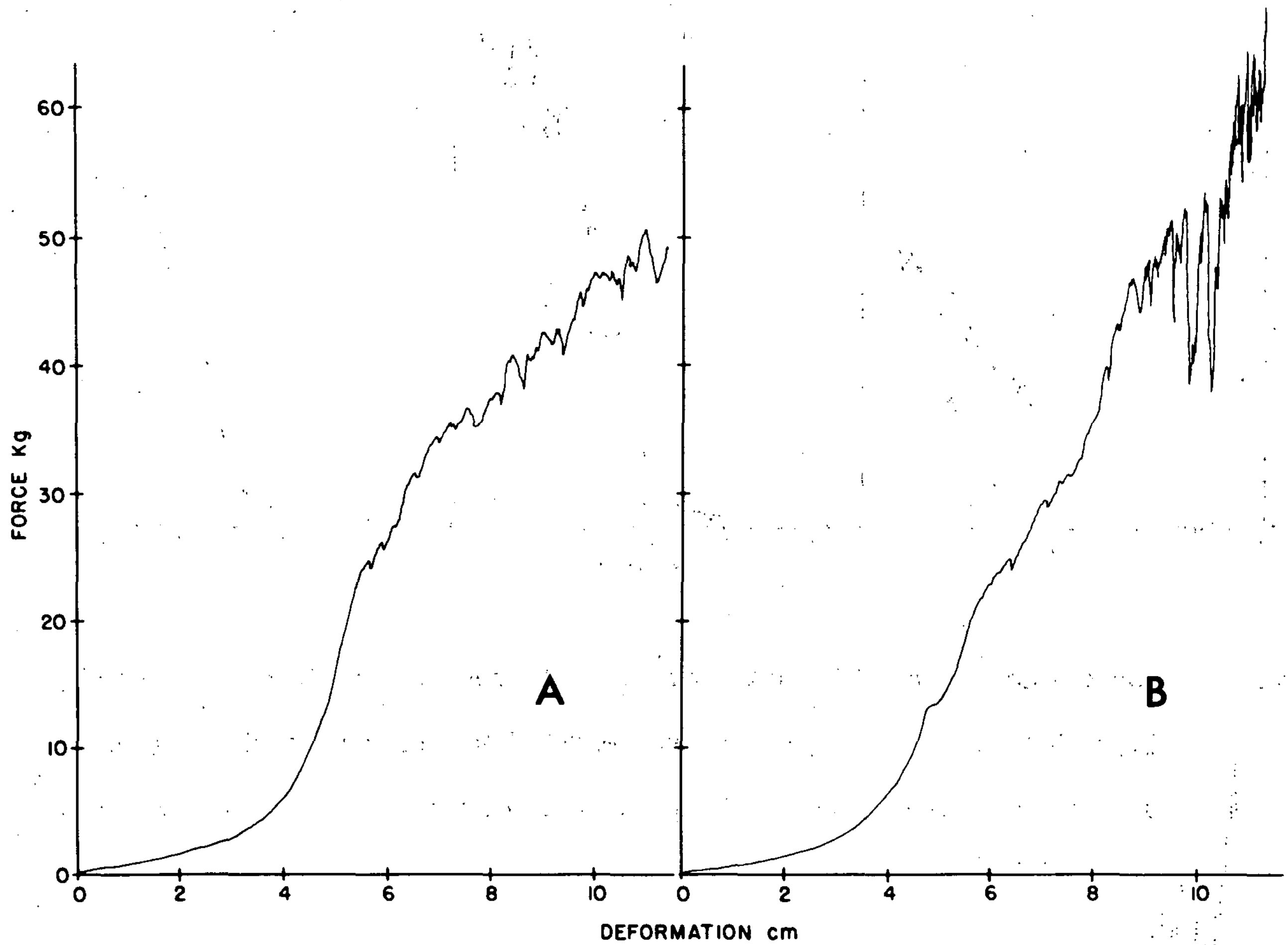

Fig. 3. Comparison of scallops A. sample 8, frozen weight 265g, cooked weight 226g pH 6.25; B. sample F, frozen weight 270g, cooked weight 226g. Test sample weight 180g.

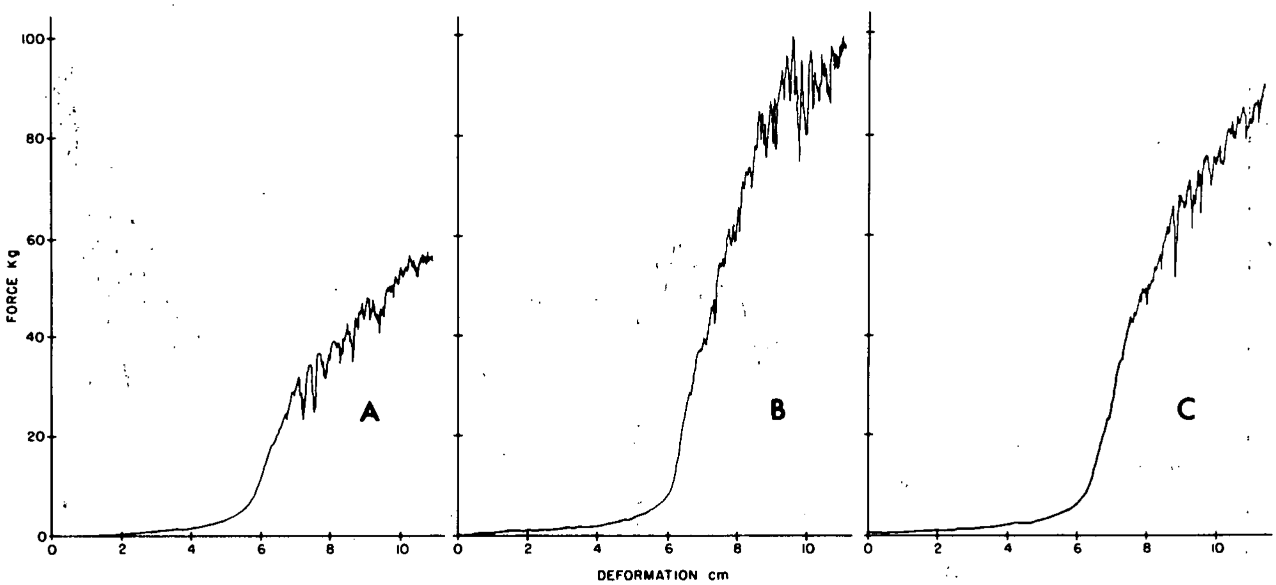

Fig. 4. Comparison of cod filets A. sample A, frozen weight 227g, cooked weight 175g pH 6.7; B. sample B, frozen weight 229g, cooked weight 180g pH 6.7; C. sample C, frozen weight 220g, cooked weight 180g pH 6.7. Test sample weight 155g.

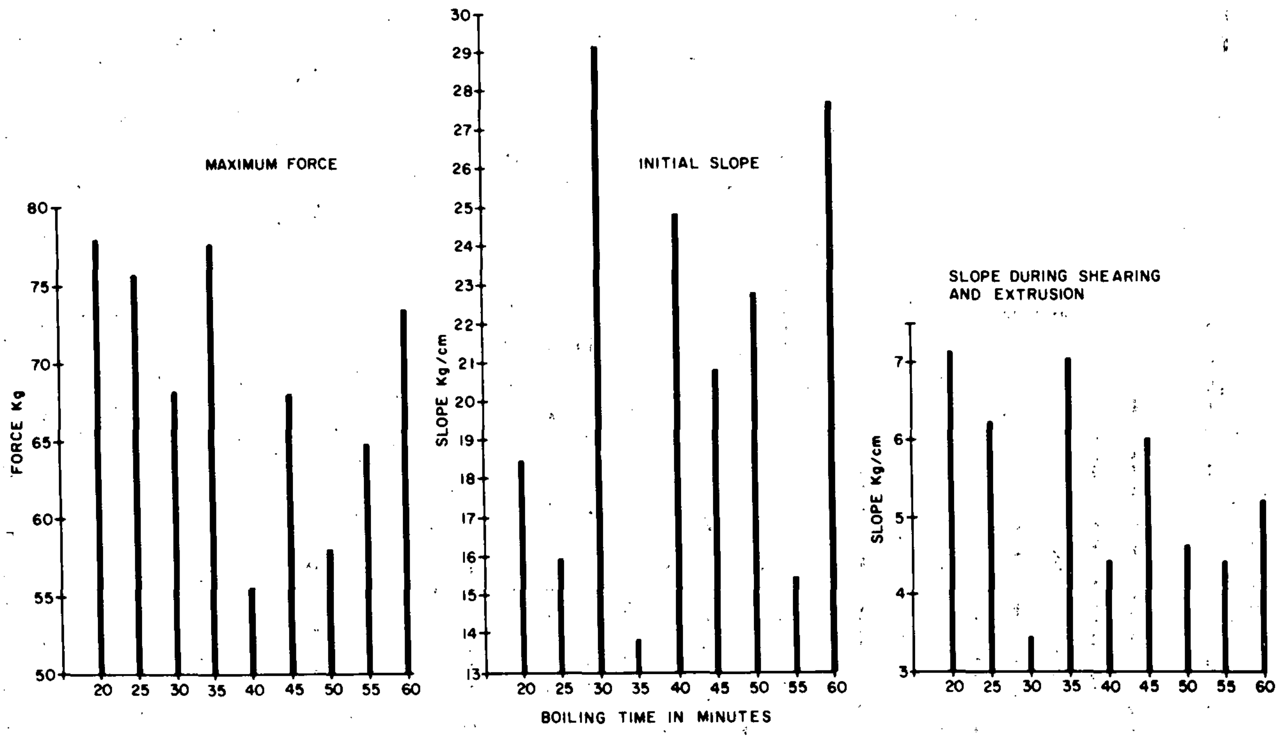

Fig. 5. Effect of cooking time on maximum force and slopes cod sample A.

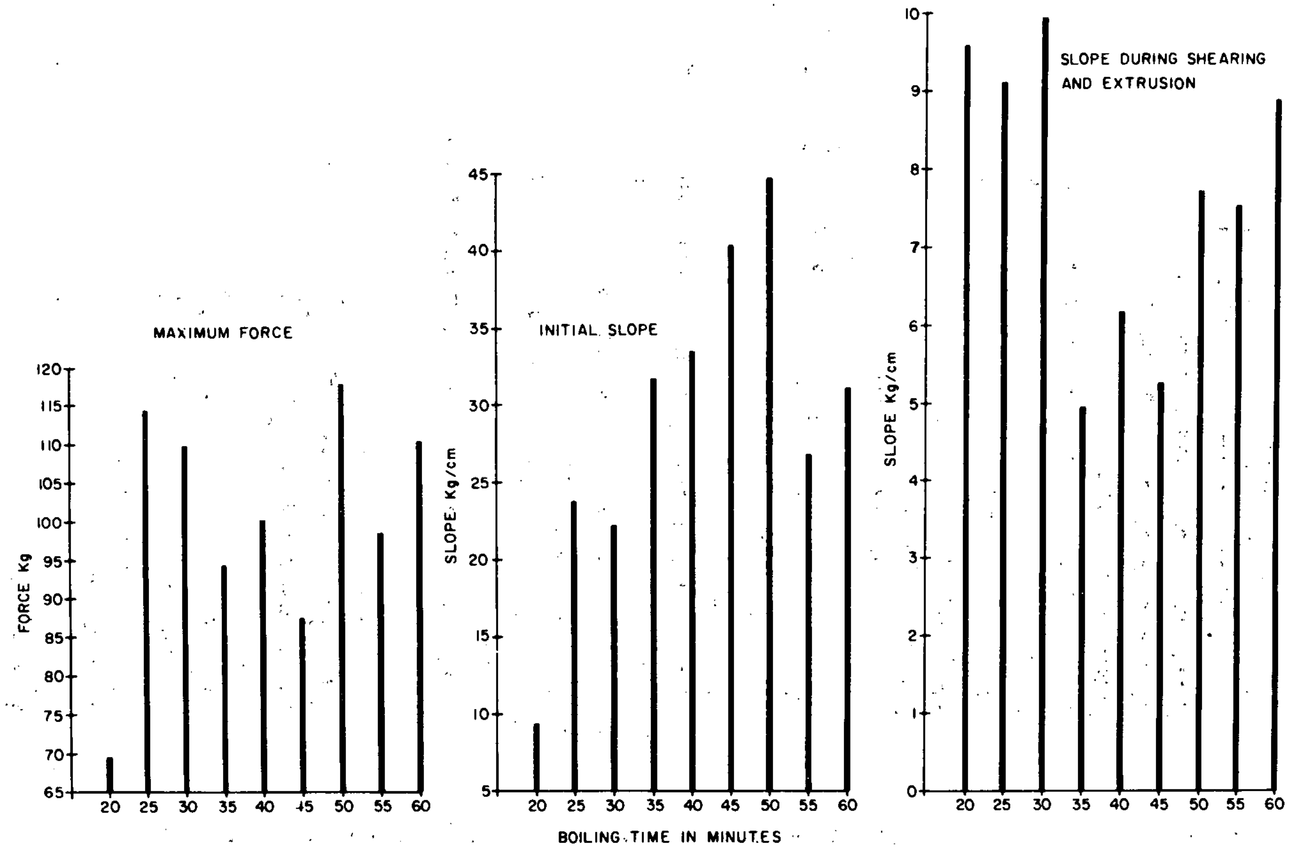

Fig. 6. Effect of cooking time on maximum force and slopes cod sample B.

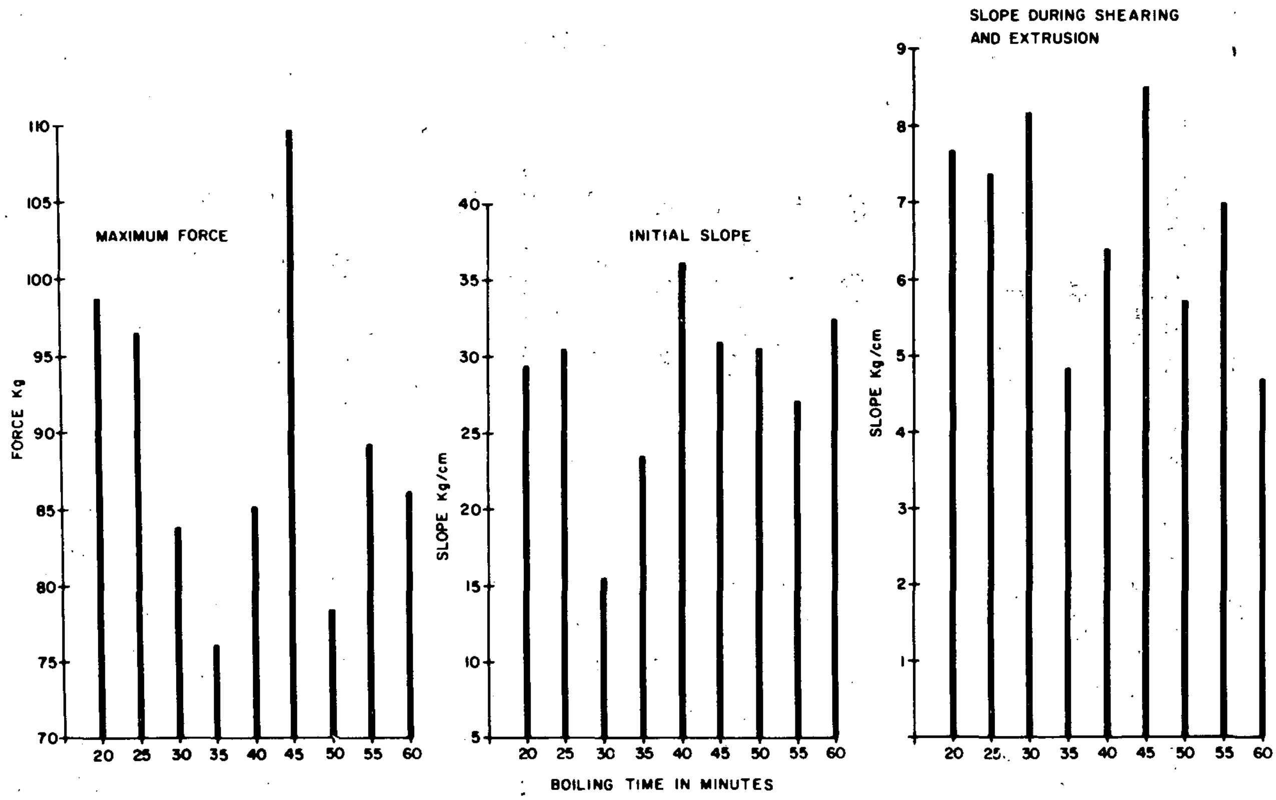

Fig. 7. Effect of cooking time on maximum force and slopes cod sample C.

Table I. Results - Effect of Cooking Time - Cod Filets

Measurement	Initial Slope (Hardness)			Initial Shearing Force (Cohesiveness)			Slope During Extrusion and Shearing			Maximum Force (Chewiness)		
Units	Kg/cm			Kg			Kg/cm			Kg		
Sample	A	B	C	A	B	C	A	B	C	A	B	C
Cooking Time min.												
20	18	9	29	38	41	41	7	10	8	78	69	99
25	16	24	30	37	66	66	6	9	7	76	115	97
30	29	22	15	46	49	49	3	10	8	68	110	84
35	14	32	23	48	60	60	7	5	5	78	94	76
40	25	33	36	29	64	65	4	6	6	56	101	85
45	21	40	31	32	53	53	6	5	9	68	88	110
50	23	41	31	31	71	71	5	8	6	58	118	78
55	15	27	27	40	60	60	4	8	7	64	98	89
60	28	31	32	38	54	54	5	9	5	73	110	86
Mean	21	29	28	38	58	50	5	8	7	69	100	89
C.V.%	26	36	21	17	16	11	24	24	21	12	15	12
SD ±	5.5	10.4	6.0	6.5	9.3	5.3	1.3	1.9	1.4	8.2	15.3	10.7

Note: Data rounded to nearest whole No. after statistics calculated.

Table 2. Results - Repeatability Test - Cod Filets

Measurement	Initial Slope (Hardness)			Initial Shearing Force (Cohesiveness)			Slope During Extrusion and Shearing			Maximum Force (Chewiness)		
Units	Kg/cm			Kg			Kg/cm			Kg		
Sample	A	B	C	A	B	C	A	B	C	A	B	C
Sample No.												
1	24	24	32	31	56	48	6	7	11	72	97	110
2	29	32	25	40	61	45	4	5	9	65	100	102
3	23	33	31	40	73	53	7	5	7	76	108	108
4	23	27	33	44	62	62	4	9	6	73	113	97
5	30	23	23	41	44	44	6	7	7	78	91	86
6	26	28	37	41	23	48	4	11	5	66	102	79
7	30	40	30	43	68	48	5	6	5	72	110	84
8	30	22	36	40	45	63	6	6	8	75	79	110
9	14	26	32	45	50	59	4	10	6	67	113	102
10	22	33	38	45	59	51	4	8	6	71	113	83
Mean	25	29	35	34	52	45	5.0	7.4	7.1	71	102	96
C.V.%	20	19	29	39	39	37	26	27	28	6	11	12
S.D. ±	45.1	45.6	10.0	13.4	20.2	16.5	1.4	2.0	2.0	4.4	11.4	11.9

Note: Data rounded to nearest whole number after statistics calculated.

Table 3. Comparison of Sensory and Objective Data for Cod Filets

Sample	Sensory Score (0 to 100)	Hardness[1] Kg/cm Mean[2]	Hardness[1] Kg/cm Mean[3]	Cohesiveness[1] Kg Mean[2]	Cohesiveness[1] Kg Mean[3]	Slope During Extrusion[1] Kg/cm Mean[2]	Slope During Extrusion[1] Kg/cm Mean[3]	Chewiness[1] Kg Mean[2]	Chewiness[1] Kg Mean[3]
A	86	25	21	34	38	5.0	5.0	71	69
C	57	35	28	45	50	7.1	7.0	96	89
B	41	29	29	52	58	7.4	8.0	102	100

1. See definition in text.

2. Mean of 10 samples each cooked for 30 min.

3. Mean of 9 samples - cooking times ranging from 20 to 60 min.