The FFL olive pressure tester: An instrument for measuring the firmness of Spanish-type green olives [1] - [2]

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RESUMEN

El texturómetro FFL: Un aparato para medir la firmeza de las aceitunas verdes tipo español

Se describe un aparato simple, barato y de fácil manejo en las pruebas de presión, apropiado para medir la firmeza de las aceitunas verdes fermentadas tipo español, dándose las instrucciones detalladas para su uso. Se ha desarrollado una escala de clasificación numérica en gramos de la firmeza, que incluye descripciones subjetivas para las diferentes clases de firmeza numérica registradas. La escala de clasificación está basada en medidas de firmeza, simultáneamente con observaciones sensoriales en muestras recogidas directamente del muelle de cerca de 350 barriles de aceitunas importadas y de un número similar de muestras de aceitunas en salmuera obtenidas experimentalmente. Se informa sobre la influencia de diferentes variables —tales como tamaño del émbolo, variedad de la aceituna, acidez de la salmuera, tamaño de la aceituna, tiempo de almacenamiento y tratamiento térmico— de las lecturas obtenidas, sobre la firmeza de las aceitunas.

SUMMARY

The FFL Olive Pressure Tester: An Instrument for Measuring the Firmness of Spanish-Type Green Olives

A simple, inexpensive, portable pressure testing device that is suitable for measuring the firmness of Spanish-type, fermented green olives is described and step-by-step directions for its use are illustrated. A numerical firmness rating scale in grams has been developed which includes adjective descriptions for the different numerical firmness ranges listed. The rating scale was based on simultaneous firmness measurements and sensory observations on dock-side samples from nearly 350 casks of imported olives and from a similar number of samples of experimentally brined olives. Information on the influence of several variables —such as plunger size, olive variety, brine acidity, olive size, storage time, and heat-shock treatment— on olive firmness readings obtained is presented.

RESUME

L'essayeur de pression FFL: Un appareil pour mesurer la fermeté des olives vertes type espagnol

Un appareil simple, bon marché et de manipulation facile dans les essais de pression et approprié pour mesurer la fermeté des olives vertes fermentées type espagnol a été décrit, en donnant les instructions détaillées pour son usage. Une échelle de classification numérique en grammes de la fermeté a été développée, laquelle contient des descriptions subjectives pour les differents classes de fermeté numérique enregistrée. L'échelle de classification est basée en mesures de fermeté, simultanément avec des observations sensoriales en échantillons ramasées directement du quai de 350 tonneaux d'olives importées et d'un nombre similaire d'échantillons d'olives en saumure obtenues expérimentalement. On informe sur l'influence de différentes variables des lectures obtenues dans la fermeté des olives, telles que grandeur du piston, variété de l'olive, acidité de la saumure, grandeur de l'olive, temps de stockage et traitement thermique.

ZUSAMMENFASSUNG

Das Texturometer - FFL: Ein Gerät zur Messung der Festigkeit der grünen Oliven spanischen Typs

Man beschreibt ein einfaches, billiges und in den Texturproben leicht handhabbares Gerät, das geeignet ist zur Messung der Festigkeit der gegorenen grünen Oliven spanischen Typs, bei Angabe einer genauen Gebrauchsanweisung. Man entwickelte eine numerische Klassifikationsskala in Festigkeitsgrammen, einschliesslich subjektiver Beschreibungen für die diversen Klassen registrierter numerischer Festigkeiten. Die Klassifikationsskala beruht auf Festigkeitsmessungen, bei gleichzeitiger sensoriellen Beobachtung in Proben, die direkt aus am Kai gelagerten 350 Fässern importierter Oliven entnommen wurden, und aus einer annähernd gleichen Zahl von experimentellen Proben von in Salzlake eingelegten Oliven. Man berichtet über den Einfluss der unterschiedlichen Varianten —solche wie Kolbengrösse, Olivenvarietät, Säuregehalt der Salzbrühe, Olivengrösse, Lagerzeit und thermische Behandlungen— der angefallenen Ablesungen bezüglich der Festigkeit der Oliven.

1.—INTRODUCTION

When our pure culture fermentation process for cucumbers and others vegetables was successfully applied to Manzanilla variety olives (1) it stimulated a keen interest for us in the Spanish-type, green olive fermentation process; this interest has continued over a period of several years. Our research effort has covered a number of chemical and microbiological facets of the green olive fermentation, as well as certain chemical and physical properties of the green olive itself (2-6). Early in our work, the need for objective measurement of the firmness or texture of whole (unpitted) olives became apparent. Further, we wanted a simple, inexpensive, practical, texture-testing device that was readily portable, yet would yield meaningful data that would be amenable to statistical analysis.

The information contained herein describes and illustrates such an instrument, and gives step-by-step directions for its operation, together with examples of a number of factors or conditions that can influence olive firmness and thereby the readings obtained for a given sample. A rating scale for scoring the firmness (texture) quality of the olive

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(2) This paper was prepared by invitation for presentation at the «IV International Congress of Food Science and Technology», September 23-27, 1974, in Madrid, Spain.

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sample being tested has been developed, as well as a detailed data sheet that is used routinely by us to record the chemical and physical data on the olive sample being examined, together with its brine.

An earlier publication of ours, dealing with the pure culture fermentation of green olives (1), first described the olive pressure tester, but the nature of that article did not permit presentation of the details pertinent to its operation given herein. More recently, Frois *et al.* (7) determined the texture of naturally ripe, black olives with an identical pressure tester provided these Spanish workers by our laboratory. They found results of the tester to be very reproducible when obtained by the same well-trained operator, but, significant variation resulted among different operators. Values obtained were more highly correlated with Shear-Press (Allo-Kramer) values when they were expressed on a «stress per 100 grams of olives basis» than when expressed on a «per fruit basis». Use of plunger size no. 3 resulted in the highest correlation with Shear-Press values.

It is our desire that the information presented here will encourage the use of the olive pressure tester and, hopefully, will be useful in developing and maintaining high quality table olives with benefits to grower, briner, bottler, and consumer alike.

2.—EXPERIMENTAL

2.1.—*Description of the tester*

The olive pressure tester (see Figure 1) consists of a 1,000 gram capacity spring tester (model 516-1000, John Chatillon and Sons, 80-30 Kew Gardens Road, Kew Gardens, New York 11415) mounted vertically, in an inverted position, on an inexpensive, lever operated, cast aluminium, 0.25-inch drill press stand (model 2Z040, Dayton Electric Manufacturing Company, 5959 West Howard Street, Chicago, Illinois 60648). In order to properly mount the tester, the circular holder (built to support the drill) was sawed off close to the face of the drill press, ground smooth, and polished. Next, the centering bracket at the top of the drill rack was suitably modified to accomodate the tester tube, which was bolted to the bracket through a 3/4-rounded-out piece of hard rubber or plastic, just below the embossed numerals and graduations.

2.2.—*The plungers*

The tester comes supplied with five, small metal rods that serve as plungers (see Table 1). For use, a plunger is inserted in the adapter-chuck and tightened by hand. The chuck is held in place at the end of the original rod of the instrument by a hex, set-screw (see Figure 1). If desired, the chuck can be easily removed by use of the hex wrench supplied with the plungers.

2.3.—*Making the test*

(a) First, be sure that the maximun reading disc or rider is at zero. This means that the lift-arm must also be at this position. Adjustment of the lift-arm is made by turning the column screw (with the milled edge) located at the bottom of the tester tube. In the photos, it is recognized by the black tape covering. This was done to prevent changes, chiefly by vibration, curiosity and meddling.

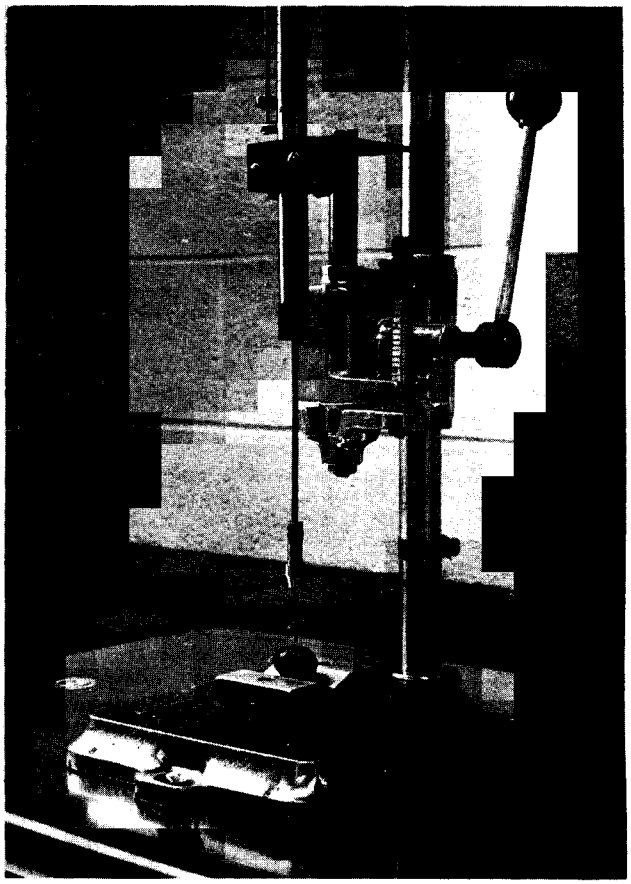


Fig. 1.—No. 4 plunger is properly centered over the olive.

(b) The plunger, usually no. 4, is centered about 0.5 to 0.75 cm over the olive, perpendicular to its long dimension in the aluminum centering groove (see Figure 1). If the plunger is aligned too high over the olive, maximun readings cannot be made.

TABLE 1

Plunger diameters

Plunger no.	Diameter in		
	Inches	Mils*	Millimeters
1**	0.125	125	3.18
2	0.063	63	1.60
3	0.058	58	1.47
4	0.0468	47	1.19
5	0.0320	32	0.81
6***	0.0260	26	0.66

* Refers to thousandths of one inch.

** This plunger constitutes the original rod of the Chatillon spring tester to which the other plungers are attached by an adapter.

*** We have not, so far, found use for plunger nos. 1 and 6 with olives.

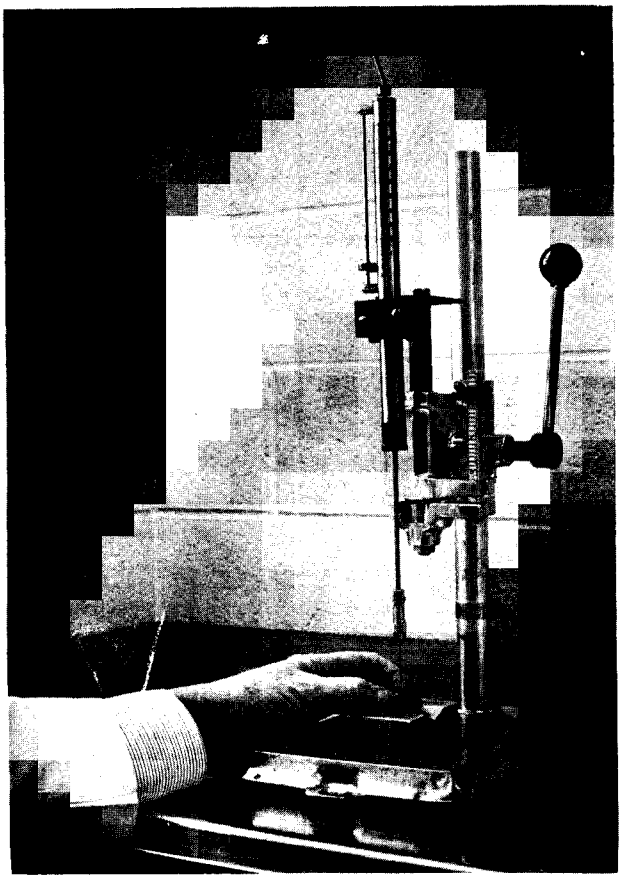


Fig. 2. — Centered and aligned olive being held in position.

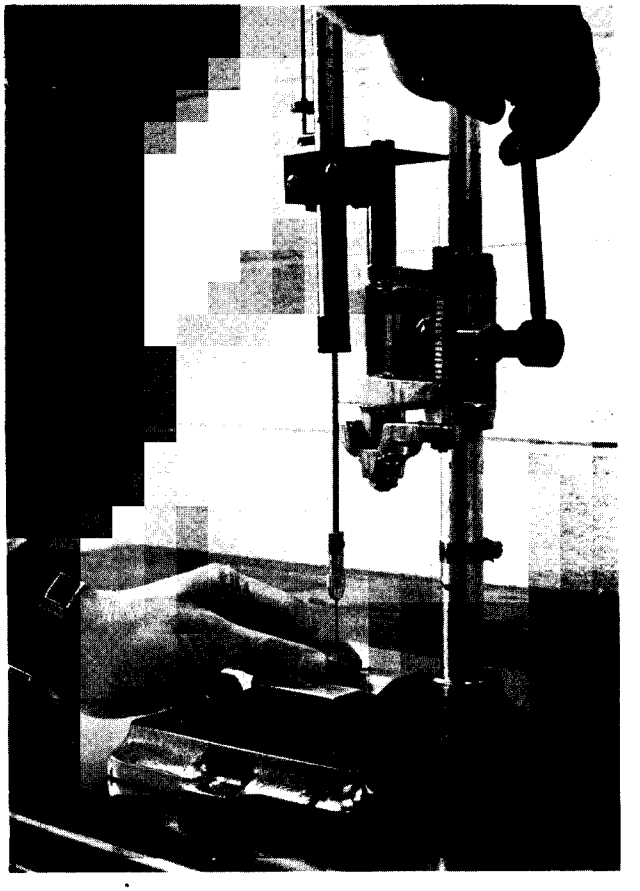


Fig. 3. — Beginning of the smooth, downward pull of the lever.

(c) The properly centered olive is held in position by the thumb and index finger of the left hand (Figure 2).

(d) Using the right hand (Figure 3), pull the lever down with a smooth, constant motion until the olive flesh is pierced to the pit (Figure 4). This operation (d) should take about one second.

(e) The reading in grams is made opposite the disc-shaped rider that is elevated by the force required to penetrate olive tissue. The lever is eased back to starting position, and the rider is returned to zero.

(f) Next, turn the olive about 90° (1/4 turn), and make a second test. In this manner, the test is made on 20 uniformly sized olives*, two punctures each.

(g) The firmness score, reported in grams for the olive sample, is the average of the 40 readings.

2.4. — *Firmness rating*

In order to organoleptically evaluate the firmness measurements made by the olive pressure tester, a firmness rating scale, using the no. 4 plunger has been prepared (Table 3). The adjective ratings shown have evolved over a period of several years. They resulted from an effort to correlate firmness values with a texture reaction resulting from biting and chewing the olive tissue.

2.5. — *Conversion factors*

The firmness measurements on brine-cured olives are, as mentioned before, usually made with the no. 4 plunger. However, in certain cases, larger or smaller plungers may be required to obtain readings in the desired range (200 to 350 grams). If so, then the values obtained can be converted to plunger size no. 4 by using the factors given in Table 4.

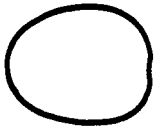
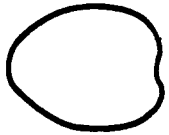
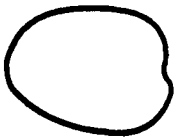
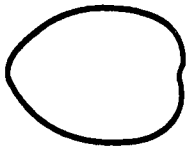
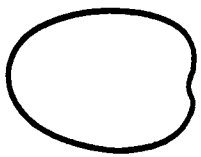
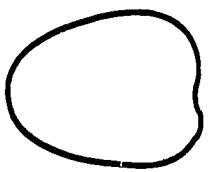
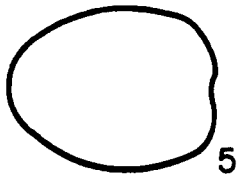
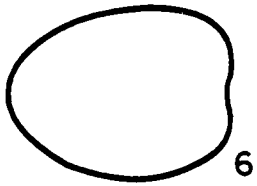
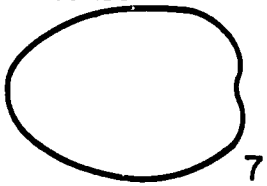
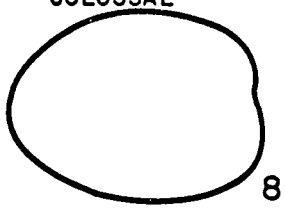
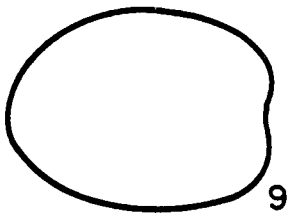
2.6. — *Precision*

Olives from the same pure culture fermentation vary such that the mean of 40 observations (20 olives, 2 punctures per olive) has a standard error of approximately 2.3% per lot when the plunger size selected maintains the range of 200-350 gm values. With such a standard error, the least significant difference (LSD) between lots is approximately 7.0% at the probability level 0.05, and 9.5% at level 0.01.

If measurements are made with a different plunger size and the readings converted to no. 4 size, then the standard errors and LSD's are raised or lowered by the same conversion factors given in Table 4.

* Refer to Table 2 for sizes of olives, including counts per pound and per kilogram. Also, see Figure 6 for an inexpensive, sturdy, plywood carrying case for the olive pressure tester.

TABLE 2. SINGLE SIZES OF OLIVES WITH COUNTS PER POUND AND PER KILO

ILLUSTRATION OF SIZES WITH NUMERICAL & SIZE DESIGNATIONS	COUNT PER POUND	APPROXIMATE COUNT PER KILO
SUB-PETITE  00	APPROX. 200 (181-220)	400/420
PETITE OR MIDGET  0	APPROX. 160 (141-180)	380/400 340/360 300/320
SMALL, SELECT OR STAND.  1	APPROX. 135 (128-140)	280/300
MEDIUM  2	APPROX. 113 (106-127)	230/280
LARGE  3	APPROX. 98 (91-105)	200/230
EXTRA LARGE  4	APPROX. 82 (76-90)	180/200 160/180
MAMMOTH  5	APPROX. 70 (65-75)	150/160 140/150
GIANT  6	53-64	130/140 120/130
JUMBO  7	42-52	110/120 100/110 90/100
COLOSSAL  8	33-41	80/90 70/80
SUPER COLOSSAL  9	32 or less	60/70

SOURCE : "United States Standards for Grades of Green Olives," 9 PP., Jan. 3, 1967.
Consumer and Marketing Service, U.S. Dept. Agric., Washington, D.C. 20250

TABLE 3

Firmness rating scale for whole olives using the no.4 size plunger*

Pressure test values	Firmness rating	
Grams	Adjective	Remarks
175 & below	Soft	Not, or barely acceptable
176-200	Inferior	Not good texture, but acceptable
201-250	Firm	Acceptable
251-325	Very firm	Acceptable
326 & above	Very firm to hard	Probably too firm; bordering on a tough reaction when chewed

* All firmness tests should be based on a minimum of 20 olives, with two punctures per olive.

** For conversion of firmness values from one plunger size to another, see Table 4.

TABLE 4

Factors for converting firmness values from one plunger size to another

From: Plunger size No.	Diameter		Factors needed to convert values to plunger size no. 5	4	3	2
	Mils*	mm				
5	32	0.81	X 1.000	X 1.485	X 1.984	X 2.263
4	47	1.19	+ 1.485	1.000	X 1.336	X 1.524
3	58	1.47	+ 1.984	+ 1.336	X 1.000	X 1.141
2	63	1.60	+ 2.263	+ 1.524	+ 1.141	X 1.000

* Equals thousandths of one inch.

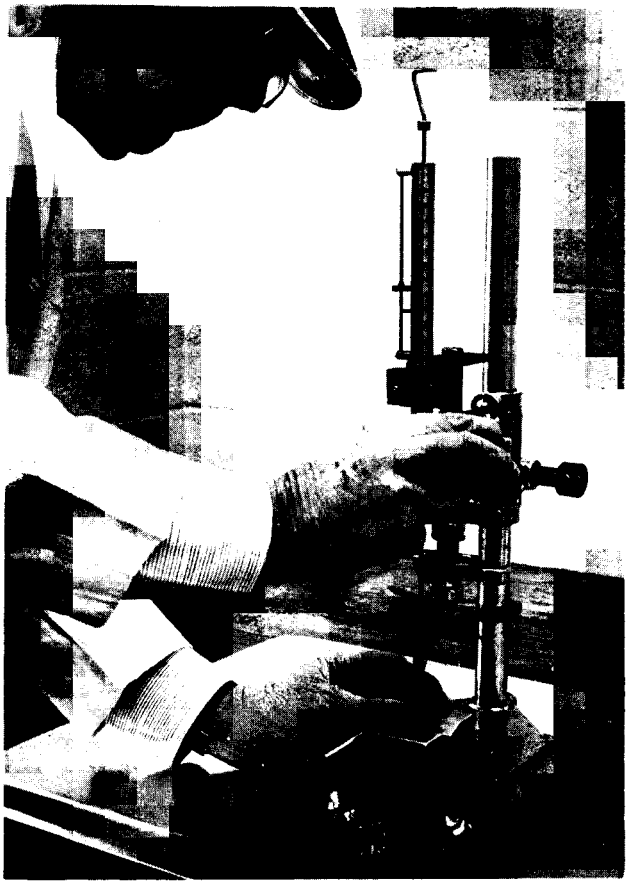


Fig. 4. — Olive flesh has been pierced to the pit, the reading indicated (325 g), and the lever is being returned to the starting position.

3. — RESULTS

3.1. — *Whole and stuffed olives*

Our experience with several hundred samples of fermented, whole green olives — experimental, imported (bulk), and retail — has shown that plunger no. 4 is usually the best size for determining firmness. However, plunger no. 3 may be needed for imported, stuffed olives (bulk), for Spanish-type, table olives (whole or stuffed) purchased from retail stores, or for canned whole, «ripe» olives (California-style). For firmness readings on the latter type of olives, see Table 5. The number of samples of pimiento-stuffed olives we have tested has been limited as compared to whole olives. Even so, we find that firmness readings for stuffed olives are generally 50 to 100 grams less than for the whole. Also, it is much more difficult to make the test on stuffed olives. Part of the problem stems from the difficulty in holding the olive properly. If held too tightly, so as to noticeably press it out of shape, lower values may result. If held too loosely, so as to be squashed by the plunger, the reverse may be true.

3.2. — *Factors influencing the test*

Olive firmness readings, even from the same fermentation, can be influenced by a number of things, such as: plunger size; amount of acid developed during fermentation; olive variety; olive size; storage time; storage temperature; and, the heat-shock treatment used *if* the pure culture fermentation process was employed. These influencing factors will be discussed briefly, and some will be supplemented with tabular or graphical material. Also, as mentioned earlier, Frois *et al.* (7) found significant variation in results obtained when different operators used the tester. All values reported herein were obtained by the same operator, thus eliminating this variable.

3.3. — *Plunger size*

As the diameter of the plunger increases, olive firmness values also increase. This is illustrated in Figure 5.

TABLE 5

Firmness of canned, whole, «ripe» olives (California-style)*

Sample no.	Pressure test** # 3 plunger	# 4 plunger***
1	248 g	185 g
2	194 g	145 g
3	240 g	180 g

* Olives were 80/90 ct/kg (36 to 40 ct/lb), probably Sevillano variety.

** Firmness values represent the average of only 10 tests per sample, because insufficient olives to use 20 per test.

*** The no. 4 plunger was not used; however, if it had been used, the values would be close to those which are outside of the desired texture range of 200 to 350 g according to conversion factors shown in Table 4.

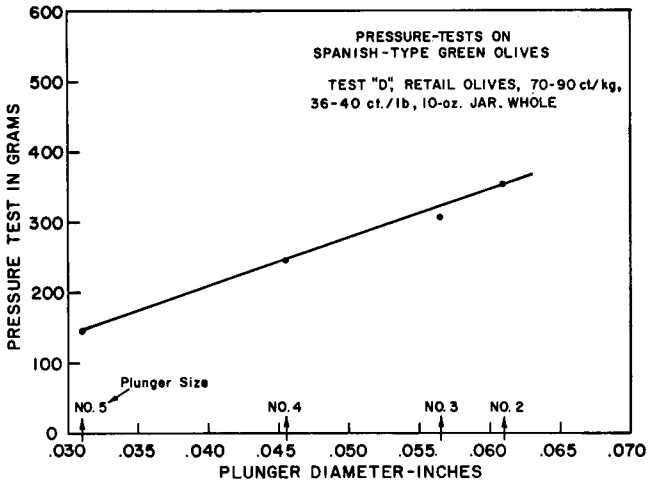


Fig. 5.—Influence of plunger size on firmness of olives.

3.4.—*Amount of acid development during fermentation*

The pure culture process (1) is necessary to effectively demonstrate the influence of brine acidity on olive texture. As the amount of acid produced increases, olive firmness decreases providing a reasonable storage period is involved. This is clearly evident from the data shown in Table 6 and Table 7. The loss in olive firmness was directly related to the ability of lactic acid cultures to ferment and to produce acid with the different varieties.

TABLE 6

Influence of the amount of acid developed during pure culture fermentation on the firmness of Manzanilla variety olives*

Tests made on olives or brine**	Species used*** *L. brevis*	*P. cerevisiae*	*L. plantarum*
Brine acidity	0.11%	0.37%	0.72%
Pressure test	410 g	380 g	340 g

* Olives were 140/160 ct/kg (65 to 75 ct/lb).

** Acidities shown calculated as lactic acid. Firmness values represent the average of 40 readings (20 olives, 2 punctures each) using the no. 4 plunger. Tests made after 208 days' storage.

*** The natural control developed only 0.20% acid and had a firmness value of 400 g.

TABLE 7

Influence of variety on the firmness of brine-cured olives from pure culture fermentations

Species used	Test made on olives and brine*	Olive variety** *Ascolano*	*Sevillano*
Pediococcus cerevisiae	Pressure test	260 g	314 g
	Brine acidity	0.76%	0.71%
Lactobacillus brevis	Pressure test	290 g	340 g
	Brine acidity	0.29%	0.30%

* Firmness values represent the average of 40 readings per variety (20 olives, 2 punctures each) using the no. 4 plunger. Tests made after 208 days' storage. Acidities shown calculated as lactic acid.

** Olives were 70/90 ct/kg (33 to 41 ct/lb).

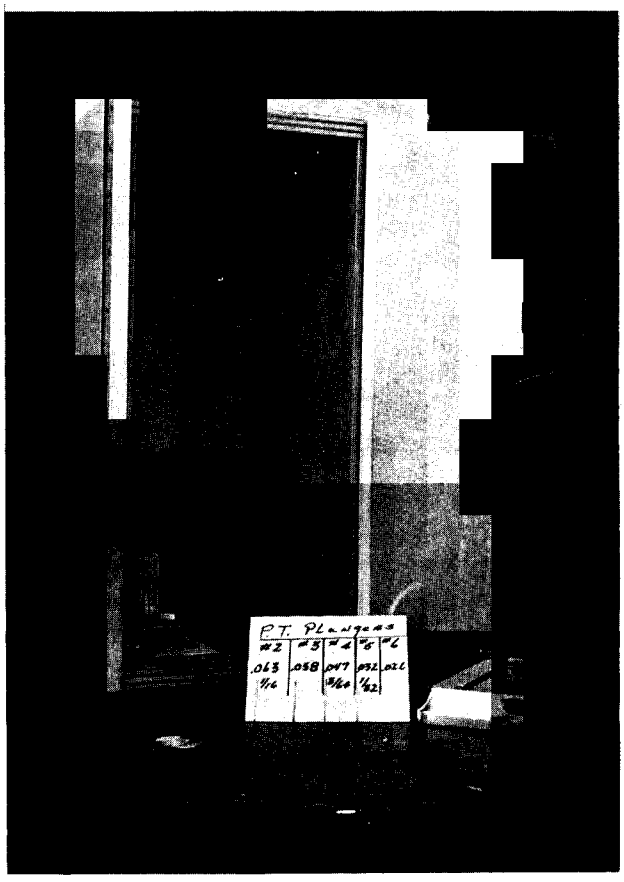


Fig. 6.—An inexpensive, sturdy plywood carrying case for the olive pressure tester. The front panel consists of 16-gauge aluminium sheeting that slides up and down in aluminium channels and may be locked at the top. The front panel is shown at the left, on the outside of the box. A small wooden block, with six drilled holes of appropriate size mounted on the inside of the case (lower left), is used to hold the five metal plungers and the hex wrench. The block is fitted with an aluminum top and wing-nut. For shipping, the bottom of the case has provisions for securely locking the base of the pressure tester, both at the front and the back.

3.5.—*Olive variety*

Certain olive varieties are known for having a firmer texture than other varieties (8-12). The values shown in Table 7 confirm the fact that such texture differences also exist in the brine-cured product. With all other conditions being equal, the Sevillano variety was at least 50 g more firm than the Ascolano variety.

3.6.—*Olive size*

If olives of different sizes from the *same* variety and from the *same* individual fermentation are pressure tested with the appropriate plunger, the trend for higher values is definitely for the smaller olives. This can be illustrated from our pure culture fermentation studies presented in Table 8. It is again emphasized that olives so tested, *must* come from the *same* fermentation.

TABLE 8

Influence of olive size on the firmness of brine-cured olives from pure culture fermentations*

Variety	Size	Firmness values**
Manzanilla	160/200 ct/kg	292 g
	240/260 ct/kg	362 g
Sevillano	60/ 70 ct/kg	284 g
	120/140 ct/kg	307 g

* The Manzanilla variety olives, from the same pure culture (*L. brevis*) fermentation having 0.10% lactic acid and 5.0% sodium chloride, were tested after 230 days. The Sevillano variety olives, from the same pure culture fermentation having 0.26% lactic acid and 3.3% sodium chloride, were tested after 208 days.

** Firmness values represent the average of 20 readings (10 olives, 2 punctures each) using the no. 4 plunger.

Table olives, imported in bulk for bottling in the USA, or olives purchased from retail stores rarely show the above size-firmness relationship. This variability is expected because, most probably, no two olives came from the same fermentation.

3.7. — *Storage time*

As storage time increases, olive firmness decreases. The rate and amount of firmness loss are directly correlated with storage time and amount of acid in the brine. This is clearly shown in Table 9.

TABLE 9

Influence of storage time on the firmness of brine-cured olives* from pure culture fermentations

Culture used	Pressure test 8 months	Pressure test 50 months	Brine acidity**	Loss of firmness
	Grams	Grams	%	%
L. plantarum	330	230	0.69	30
P. cerevisiae	355	290	0.27	18
Leu. mesenteroides	340	290	0.17	15
L. brevis	355	305	0.10	14

* Manzanilla variety olives, 140/160 ct/kg (70 ct/lb).

** The brine acidities, calculated as percent lactic acid, did not change between 8 and 50 months' storage.

3.8. — *Heat-shock treatment*

Our pure culture fermentation process for Spanish-type, green olives (1) calls for a heat-shock treatment of 74° C (165° F) for three minutes for olives that have received the conventional lye treatment to remove most of their bitterness, then washed to remove the lye. The influence of several different heat-shock treatments (60°, 68°, 74°, 79°, and 88° C = 140°, 155°. 165°, 175°, and 190° F, respectively), together with no heat controls, on olive firmness after 8 and 50 months' storage, is shown in Table 10.

All brine acidities were similar and thus would not enter into any differences between the heat-shock treatments. The loss in firmness was similar (25 to 31%) for all treatments. There appeared to be a greater firmness loss after the heat-shock temperature reached 79° C (175° F). But, it appears that the brine acidity and storage time were chiefly responsible for most of the loss of olive texture. The unheated, natural control lost 21% of its texture at 50 months as compared to 25% for the «no heat», inoculated lot. Here, the higher brine acidity (0.33 *vs* 0.62%) may well have accounted for the slight difference in firmness.

TABLE 10

Influence of heat-shock treatment on the firmness of brine-cured olives from pure culture fermentations*

Heat-shock treatment**		Pressure test*** 8 months	Pressure test*** 50 months	Brine acidity****	Loss of olive firmness*****
°C	(°F)	Grams	Grams	%	%
No heat		375	280	0.62	25
60	(140)	375	270	0.68	28
68	(155)	375	275	0.67	27
74	(165)	375	270	0.66	28
79	(175)	360	250	0.63	31
88	(190)	345	240	0.60	30

* Manzanilla olives, 140/160 ct/kg, were lye-treated and washed in the conventional manner, heat-shocked three minutes in water at temperatures shown above, using a continuous, rotary machine. *L. plantarum* no. 442 was used for the pure culture inoculations. Other methodology was as previously described (1).

** The natural control developed 0.21% lactic acid and had a firmness loss of 21%.

*** Firmness values represent the average of 40 readings (20 olives, 2 punctures each) using the no. 4 plunger.

**** Brine acidity calculated as percent lactic acid.

***** Significant difference at the 0.95 level is 4.3%.

3.9. — *Overall ratings of commercial olives*

In order to get an idea of the overall quality of an olive product — experimental, imported in bulk, or retail — it was necessary to first develop meaningful criteria that would be useful in such evaluations. The «Overall Quality Ratings for Commercial Use» (Table 11) are the same as used for cucumber pickle products.

Detailed rating sheets for olive products including various chemical and physical tests were patterned after the one we have used for years for cucumber pickle products.

TABLE 11

Quality ratings for overall acceptability of olives for commercial use

Numerical rating	Adjective quality rating*
1	Not acceptable
2	Barely acceptable
3 - 4	Poor
5 - 6	Fair
7 - 8	Good
9 - 10	Excellent

* The rating given by a judge should consider the various quality characteristics of the olive sample being examined, such as: odor, flavor, color, appearance and texture, as well as certain chemical and physical tests that may have been run on the sample or its brine. The final evaluation should be an effort to determine how close the sample being judged comes to meeting the criteria for the «Ideal» for this particular olive product.

TABLE 12

Quality evaluation of different kinds of Spanish-type green olives

Kind of Spanish-type green olives and source of sample	No. of samples	Rating sheets labelled as:	Overall commercial acceptability rating
		Exhibit*	Numerical**
Whole, green; imported in casks***	5	A, B, C, D, E	5, 8, 1, 7, 8
Stuffed, green; imported in casks***	2	F, G	6,9
Whole, green; .rom retail stores	3	H, I, J	6, 4, 6
Stuffed, green; from retail stores	2	K, L	5, 2
Whole, green; experimental; pure culture fermentation	2	M, N	1, 9

* Rating sheets identified as «Exhibits A, B, C, etc.» correspond as to individual position of the numerical «Overall Commercial Acceptability Ratings» shown in column 4.

** Overall Commercial Acceptability: 1 = Not Acceptable; 2 = Barely Acceptable; 3-4 = Poor; 5-6 = Fair; 7-8 = Good; 9-10 = Excellent.

*** These olives, imported in bulk from Spain, were usually shipped in 10, 6 or 3 fanega casks (1 fanega = 16 U.S. gallons).

This was done in order to give an insight into our manner of operation with regard to the routine examination and evaluation procedure for olive samples.

Table 12 summarizes the results for 14 different samples.

The detailed rating sheet for olive products, including various chemical and physical tests, was patterned after the one we have used for years for cucumber pickle products.

We have made copies of completed rating sheets representing actual evaluations of several different olive products. This was done in order to give the reader an insight into our manner of operation with regard to the routine examination and evaluation procedure for olive samples. Depending on journal policy, these 14 evaluation sheets, summarized in Table 12, hopefully may be fully reproduced in a proposed Appendices Section, either as a part of the published article, *per se,* or as a separate section. Included will be other-related information on imported, Spanish-type, fermented green olives.

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