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Effe-gi, Magness-Taylor, and Instron Fruit Pressure Testing Devices for Apples, Peaches, and Nectarines[1]

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Abstract. **Pressure test values obtained on various fruits with 2 manual fruit pressure testers (the Magness-Taylor and the smaller Effe-gi) and the Instron Universal Testing Instrument were compared. Tests were made on 5 apple, 1 nectarine, and 3 peach cultivars on an individual fruit basis. Differences in pressure readings were marked among instruments. Responses to the instruments differed among cultivars. Some apples were classified in different ripeness categories according to different pressure testers. For nectarines and peaches, high correlations, but not complete agreement, were obtained among instruments. For all 3 fruits, differences were sufficient to require specification of instrument and method of measurement when fruit pressure test values are reported and to necessitate compensation when measurements made with different types of instruments are compared. Regression equations such as we report should be used to permit accurate comparisons.**

Measurements of firmness are used in the produce industry as indicators of the maturity of fruits. One of the most widely used manual testers is the Magness-Taylor[2] (MT) fruit pressure tester, also called the USDA or D. Ballauf pressure tester. The Effe-gi (E) fruit tester, recently introduced from Italy, is gaining popularity because of its small size (Fig. 1). Probes for the E have the same dimensions as those for the MT but differ slightly in contour. E indicates pressure in kg and lb. on a maximum-force dial.

Tests of the same MT on uniform sheets of expanded polyethylene showed that values differed among operators and that values for the same operator differed among days (4). Those differences apparently are due to differential rates and depths

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[2]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products mentioned.

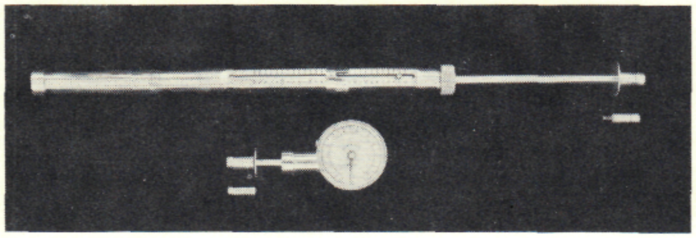

Fig. 1. Magness-Taylor (upper) and Effe-gi (lower) fruit pressure testers.

of penetration of the probe into the fruit. The MT instrument has no direct control of *penetration* rate although *force* application rate can be regulated (1, 2); this is also true for the E. Probes of either MT or E move only 7.9 mm in a measurement, but to produce the greatest force that can be measured on each instrument, the handle moves about 12.5 cm for the MT and about 2 cm for the E. Because this design difference may influence the rate and depth of penetration, we compared the MT and E testers with each other and with an automated pressure tester, the Instron Universal Testing Instrument. The only movement on the Instron is the 7.9 mm movement of the probe into the tissue; there is no direct control of the *force* application rate on the Instron (1, 2).

Materials and Methods

Both the MT and E are supplied by the manufacturers with 11.1 mm (7/16 inch) and 7.9 mm (5/16 inch) diam probes, used for apples and for peaches or other soft fruits, respectively.

As a reference for the manual portable testers, the MT and E probes were mounted in an Instron which controls depth and rate of penetration and provides highly accurate pressure readings. The terms "MT" and "E" refer to manual tests made with those instruments as supplied by the manufacturers, while "IMT" (Instron Magness-Taylor) and "IE" (Instron Effe-gi) refer to tests made with the probes from the MT and E mounted in the Instron. For manual measurements, the operator inserted the probe into the fruit to the scribed 7.9 mm line at a fairly slow, uniform rate with the fruit steadied against a wall, as recommended by Bourne (1). Penetration rate of the Instron was set at 25.4 mm/min (1 in/min); fruit was held in a bevelled ring on the load cell. All tests were performed by the same operator.

Fruits were picked at about their commercial harvest times. Pressure tests were made at various times after harvest to obtain a wide range of pressures. The apple cultivars were 'McIntosh', 'Delicious' (unspecified strain), 'Golden Delicious', 'Jonathan', and 'York Imperial'. The nectarines were an unspecified, large-fruited commercial cultivar. The peaches were 'Garnet Beauty', 'Redhaven', and 'Rio Oso Gem'.

Puncture tests were made on freshly pared sites of slightly greater diameter than that of the probe being used. The sites were spaced about 25 mm between centers so that the bruised areas would not overlap. For apples, measurements were made on the blush and opposite sides. In 1972, measurements were made with IMT, MT, and E in triangular patterns centered on the equator, and in 1973, with IMT, IE, MT, and E in diamond patterns. Nectarines were tested on each cheek with the IMT and both manual testers. Peaches were too small to permit more than 2 puncture tests per cheek so all fruit were tested with the IMT and half of the lot was tested with the MT, the other half with the E.

Results and Discussion

The values from opposite sides of each fruit did not differ significantly so we used the averages for correlation and regression calculations.

The effect of probe contour on firmness readings was minimal. Measurements made on apples with the IMT and IE show no significant differences in mean values for any cultivar or for all cultivars combined (Table 1). Means differed among instruments; for example, the difference was 0.8 kg between IMT and E for McIntosh in 1973. Since there were differences among instruments but not between probes, instrument design must be the primary cause of the differences, probably by causing the operator to apply the probes at different rates or to different penetrations (1).

For the apple data, r values (correlation coefficients) were higher for 1973 than for 1972 (Table 2), perhaps because the fruit was softer in 1973 (Table 1). Both the rate and depth of penetration of the manual instruments are difficult to control when penetrating hard tissue. In some cases, r was too low to permit conversions of pressure readings from one instrument to those for another instrument. For example, for 'Jonathan' in 1972, E values should not be predicted from IMT ($r = 0.58$) or from MT values ($r = 0.44$) and, conversely, firmness recommendations based on MT values should not be applied to E.

To demonstrate the hazard of converting readings from one instrument to another, we used the IMT as reference base. Haller's (3) recommended maximum and minimum MT pressures for "hard" and for "ripe" apples were substituted for IMT in the regression equations for 1973 (Table 3). Haller's ripeness categories differ by 0.9 kg (2 lb.). In some cases, reference and predicted values differed substantially e.g. the values were 3.2 kg for IMT and 4.1 kg for E with ripe 'McIntosh' and were 4.5 kg for IMT and 6.6 kg for E with ripe 'York Imperial'. For some hard apples and all ripe apples, the predicted MT and E values were higher than the IMT values, indicating longer potential shelf life than IMT indicated. For those hard apples for which the predicted MT or E values are higher than the IMT values, particularly 'York Imperial', apples would be harvested later if the manual tester were used.

For the apple cultivars in Table 2, *b* values (slopes of the regression equations) were less than 1.0, which indicates that, compared with the Instron, the manual instruments tended to

Table 1. Pressure test ranges and means for various fruits as measured on Instron with Magness-Taylor probe (IMT), Instron with Effe-gi probe (IE), Magness-Taylor pressure tester (MT), and Effe-gi pressure tester (E).

Fruit & cultivar	Year	n[z]	Pressure test range[y] (kg)	Means (kg) IMT	IE	MT	E
Apple							
McIntosh	1972	200	4.8–9.3	6.0		6.1	6.6
	1973	100	2.8–6.9	4.5	4.5	4.8	5.3
Jonathan	1972	50	5.7–9.3	6.8		6.8	7.3
	1973	100	3.3–6.9	5.0	5.0	5.4	5.8
Golden Delicious	1972	100	5.8–8.2	6.7		6.2	6.8
	1973	100	2.8–6.4	4.5	4.4	5.0	5.3
Delicious	1972	100	6.5–9.2	7.3		7.0	7.5
	1973	100	3.7–7.5	5.8	5.8	5.9	6.3
York Imperial	1972	50	7.7–13.1	10.6		10.2	10.4
	1973	100	6.0–12.2	8.8	8.7	9.4	9.2
Apples, combined	1972	500	4.8–13.1	6.9		6.8	7.2
	1973	500	2.8–12.2	5.7	5.7	6.1	6.4
Nectarine		60	0.6–6.7	1.9		2.0	2.3
Peach							
Garnet Beauty		100	0.3–6.5	3.6		4.4	4.3
Redhaven		100	0.3–6.6	3.7		3.8	4.1
Rio Oso Gem		80	0.4–7.7	3.2		4.2	4.0
Peaches, combined		280	0.6–7.7	3.5		4.1	4.1

[z]No. of fruit compared in each regression analysis.

[y]Values given are for IMT, ranges were comparable for IE, MT, and E.

Table 2. Pressure test regression equations[z] and correlation coefficients for various fruits as measured on Instron with Magness-Taylor probe (IMT), Instron with Effe-gi probe (IE), Magness-Taylor pressure tester (MT), and Effe-gi pressure tester (E).

Fruit & cultivar	Year	n[y]	MT = a + b IMT			E = a + b IMT			E = a + b MT			E = a + b IE		
			a	b	r	a	b	r	a	b	r	a	b	r
Apple														
McIntosh	1972	200	1.35	0.79	0.84	1.64	0.83	0.90	1.45	0.85	0.86			
	1973	100	0.77	0.91	0.96	1.29	0.88	0.97	0.76	0.93	0.96	1.40	0.86	0.96
Jonathan	1972	50	1.95	0.71	0.80	3.47	0.56	0.58	4.04	0.48	0.44			
	1973	100	2.06	0.66	0.92	2.13	0.72	0.95	0.53	0.97	0.92	1.95	0.76	0.96
Golden Delicious	1972	100	2.33	0.59	0.66	3.25	0.52	0.59	3.46	0.52	0.53			
	1973	100	1.20	0.85	0.97	1.63	0.82	0.97	0.63	0.93	0.97	1.58	0.84	0.97
Delicious	1972	100	2.48	0.61	0.86	2.46	0.68	0.86	1.41	0.87	0.78			
	1973	100	1.74	0.72	0.92	2.05	0.74	0.93	0.87	0.92	0.91	2.14	0.73	0.92
York Imperial	1972	50	1.32	0.84	0.75	3.85	0.62	0.70	5.78	0.46	0.57			
	1973	100	3.15	0.71	0.87	3.43	0.70	0.91	2.14	0.79	0.83	3.28	0.73	0.89
Apples, combined	1972	500	0.81	0.86	0.95	1.64	0.81	0.95	1.26	0.89	0.94			
	1973	500	0.61	0.96	0.97	1.08	0.94	0.98	0.41	0.99	0.98	1.06	0.95	0.98
Nectarine		60	0.09	1.01	0.98	0.02	1.20	0.94	−0.06	1.16	0.94			
		39[x]	0.25	0.96	0.97	0.88	0.94	0.94	0.76	0.93	0.92			
Peach														
Garnet Beauty		100	0.46	0.97	0.96	0.65	1.02	0.95						
Redhaven		100	0.63	0.99	0.96	0.78	1.02	0.95						
Rio Oso Gem		80	0.67	1.03	0.96	1.42	0.90	0.90						
Peaches, combined		280	0.63	0.98	0.96	1.00	0.97	0.93						

[z]Y = a + bX where a = intercept, b = slope, and X = measured value.

[y]No. of fruit compared in each regression analysis.

[x]Omitting fruit <1.5 kg on MT or E.

Table 3. Predicted values for Magness-Taylor (MT) and Effe-gi (E) calculated by substituting Haller's recommended pressures (3) for "hard" and "ripe" apples for Instron Magness-Taylor (IMT) pressures in 1973 regression equations given in Table 2.

Cultivar	Predicted values (kg) Hard			Ripe		
	IMT	MT	E	IMT	MT	E
McIntosh	6.8	7.0	7.3	3.2	3.7	4.1
Jonathan	7.2	6.8	7.3	3.6	4.4	4.7
Golden Delicious	7.2	7.3	7.5	3.6	4.3	4.6
Delicious	7.7	7.3	7.7	3.6	4.3	4.7
York Imperial	8.2	9.0	9.2	4.5	6.3	6.6

compress the range of pressure values. The *b* value of the E vs. MT regression shows that E compressed the range more than MT. This observation is further supported by standard deviations of 0.60, 0.60, 0.54, and 0.49 for IMT, IE, MT, and E, respectively.

For nectarines, correlation coefficients among instruments (Table 2) were high, which indicates that the results obtained with any one instrument can legitimately be compared with results obtained with any of the others by use of the appropriate regression equation. When nectarines too soft to register on the 1.5–13.6 kg (3–30 lb.) manual testers were eliminated from the regression analysis, the correlation coefficient was unchanged but *a* and *b* differed.

The 2 manual testers were not directly compared on peaches because of fruit size, but both were highly correlated with IMT. The regression equations for peaches (Table 2) indicate that E would probably read about 0.2 kg higher than MT, based on the differences in *a* values, although the means in Table 1 are about the same for E and MT. The *b* values for peaches approached unity so conversions consist mainly of adding the respective *a* as a correction factor to the IMT reading. For peaches, the ranges were not compressed by the manual testers as they were for apples.

Conclusion

The Magness-Taylor and Effe-gi fruit pressure testers are not entirely interchangeable, even though there is no marked difference in probes or in scales. The physical characteristics of the 2 instruments apparently cause them to be applied differently by the operator, so that pressure test values differ. These differences might be important during grading and in research. Any of the instruments would be satisfactory provided the pressure test ranges used for harvest and storage decisions are based on or adjusted for the operator and the instrument used for measuring the sample. When fruit pressure test values are reported, the instrument and method of measurement must be specified and all measurements for direct comparison should be made with the same kind of instrument.

Literature Cited

1. Bourne, M. C. 1974. Comparison of results from the use of the Magness-Taylor pressure tip in hand- and machine-operation. *J. Texture Studies* 5:105-108.
2. Breene, W. M., I. J. Jeon, and S. N. Bernard. 1974. Observations on texture measurement of raw cucumbers with the fruit pressure tester. *J. Texture Studies* 5:317-327.
3. Haller, M. H. 1941. Fruit pressure testers and their practical application. *U. S. Dept. Agr. Cir.* 627.
4. Nicholas, R. C. 1960. Some observations on the use of fruit pressure testers. *Mich. Agr. Expt. Sta. Quart. Bul.* 43:312-326.