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ALTERNATIVE TESTS FOR THE MECHANICAL PROPERTIES OF FRUIT

A thesis presented in partial fulfillment of

the requirements for Master Degree

in Agricultural Science

(Agricultural Engineering)

at

Massey University

Yuwana

Agricultural Engineering Department

Massey University

Palmerston North

1991

PREFACE

Motto :

Alloh !. There is no got
But He - the Living,
The Self-Subsisting, Eternal.
No slumber can sieze Him
Nor sleep. His are all things
In the heavens and on earth.
Who is there can intercede
In this presence except
As He permitteth ? He knoweth
What (appreareth to His creatures As)
Before or After
Or Behind them.
Nor shall they compass
Aught of His knowledge
Except as He willeth.
His Throne doth extend
Over the heavens
And the earth, and He feeleth
No fatigue in guarding
And preserving them
For He is the Most High,
The Supreme (in glory)
[**Qur'an 2 : 255**].

To my wife **Ita**, my **Mother** and **Father.**

ACKNOWLEDGEMENT :

The author wishes to express his appreciation to Dr. C.J. Studman who gave a lot of guidance in conducting the experiment and constructing the thesis, Dr. G.L. Wall as Head of Agricultural Engineering Department who gave facilities to do the experiment, and Mr. Ian Painter who helped with equipment construction.

ABSTRACT :

A newly patented twist test for studying the mechanical properties of fruit is described. This test measured the force required to rotate a small rectangular blade inserted into a fruit and was expressed as the twist strength of the fruit being tested. In testing Granny Smith apples during cool storage, the test was highly correlated (R^2 of 0.965) with storage time and comparable with the penetrometer test (R^2 of 0.968). In testing Royal Gala and Gala apples, the twist test was more sensitive in distinguishing the apples of different degrees of maturity than the penetrometer test and the Brix test. The twist test was more highly correlated with harvesting dates based on colour for Royal Gala and Gravenstein apples, compared with the penetrometer test and the Brix tests, suggesting that this test could be used and was more reliable as a means of assessing apple maturity. Utilised during kiwifruit maturation, the twist test was more highly correlated with soluble solid contents (SSC) measured with the Brix tester (R^2 of 0.979), compared with the penetrometer test (R^2 of 0.858), suggesting that this test could also be used as a means of predicting kiwifruit maturity. During cool storage of kiwifruit, the relationship between the twist (crushing) strength and storage time produced a higher R^2 value than those between the penetrometer reading and storage time, or between SSC and storage time. The twist test is accurate, easy, fast and flexible and may be used on a wide variety of fruit to assist in the determination of quality and maturity.

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I. INTRODUCTION.

Fruit texture and maturity are measured by a variety of techniques. These range from physical and chemical measurements to purely visual inspection. While many tests are used, few are entirely reliable, and there is always a need for better or faster testing methods. It is also important to understand and measure the mechanical properties of fruit, particularly in view of the increasing use of mechanical harvesting and handling. In mechanical harvesting, new systems still need to be developed which do not damage the fruit, so that the resulting appearance and quality remains comparable to those picked by hand. Currently, mechanical damage during handling remains a serious problem. For example, Mohsenin (1986) reported that the bruising volume of apples represented 2.8 percent of the total weight while transit losses due to vibration reached 10 percent. Other research has indicated that between 20 and 50 percent of apples are bruised during handling (Holt and Schoorl, 1983). If fruit mechanical properties can be determined and related to the susceptibility of fruit to handling damage, than it may be possible to time handling procedures to avoid periods when the fruit is particularly vulnerable.

For texture determination and quality evaluation, food scientists no longer seem to be satisfied with a correlation between numerical

evaluation and quality of the product (Slater, 1954). Exactly 'What is being measured' needs to be understood, and the objectivity of most texture measurement systems are still in doubt. However, since the structure and condition of cells in fruit can influence such characteristics as firmness, crispness, fibrousness, and the main factors related to textural characteristics are the turgor pressure of the living cell, the cohesiveness of cells and the occurrence of the supporting tissues (Mohsenin, et al, 1963), it can be assumed that certain mechanical properties may be used as an objective measurement of fruit texture.

Compression, tension, and shear tests have been conventionally used to research the mechanical properties of fruit. Practical measurements are made with a portable unit such as the Magness-Taylor and the Effe-Gi pressure testers because of cost, speed measurement and convenience in handling. The peak force required to push a known diameter probe a known distance into the fruit is measured. The main discrepancy of this test is that the result is usually expressed as an arbitrary unit. This value varies with different instruments. Abbott, et al (1976) showed that the Magness-Taylor and the Effe-Gi were not entirely interchangeable even though the probes and indicated force ranges are essentially the same. The different sizes and shapes of the two instruments and the fact that the spring rates are different because of space limitations produce differences in results. Concern has been expressed about the risk of human error in using this test. Voisey

(1977) observed that during operation, the operators generally prepared themselves for sudden probe penetration so that the energy stored in the spring caused a large jerk. The operator was concerned with being splashed with juice in spite of wearing a laboratory coat. Voisey also found that the female operators increased the force at almost twice the rate of male operators. The lack of roundness of fruit also caused occasional difficulties in aligning the tester, the fruit and the compression surface by the operator. Therefore, when reporting the result of these tests, the instrument used and the method of operation should be specified.

According to Bourne (1979) fruit can be classified into fruit that soften greatly such as apricots, black berries, blue berries, raspberries, strawberries, sweet cherries, figs, nectarines, peaches and plums, and fruit that soften moderately such as apples, cranberries and quinces. The hand pressure test (familiarly called the penetrometer test) was originally designed for use on fruit that soften moderately as they ripen (that is, for firm, crisp fruit) but it is now used widely on all types of fruit. For some fruit this test is not reliable. With kiwifruit, which may be included in the category of the fruit that soften greatly, the penetrometer is not preferable. This fruit is harvested with a flesh firmness of 8 - 10 kg, using a 7.9 mm penetrometer head while for eating it has a flesh firmness of below 0.5 kg (Harman and McDonald, 1983). When the penetrometer test is employed to assess kiwifruit maturity, the operator has to exert extra effort since

the fruit being tested are still very hard. If the test is used to assess eating quality, the operator must take extra care since the fruit is getting very soft, and may have already deformed to some extent before the penetrometer enters the fruit. Currently, the industry prefers working with the Brix test for this fruit.

This thesis describes a twist test for studying the mechanical properties of apple and kiwifruit, with particular focus on fruit maturity. First, a reviev of current fruit mechanical tests is given. This is followed by a review of fruit maturity assessment methods. The new twist test device is then described, and the results of various tests on apples and kiwifruit are presented and discussed.