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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.

TABLE OF CONTENTS.

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.

II. REVIEW OF TESTS FOR THE MECHANICAL PROPERTIES OF FRUIT.

The mechanical properties of fruit may be defined as the behaviour of this material under applied forces. Forces acting on a fruit cause deformation and flow in it, and the nature of the force is the primary factor deciding a given fruit's response. It has been shown that deformation and flow depend not only on the nature of the force, but also on time (Mohsenin and Gohlich, 1962; Clevenger and Hamann, 1968; Hamann, 1970; Mittel and Mohsenin, 1987; and Mohsenin, 1986). Hence such material is termed rheological (Sitkei, 1987). Rheologically then, mechanical properties of a fruit are expressed in terms of the three parameters of force, deformation and time.

During investigation of these properties, a force-deformation curve is usually employed. This curve can be obtained from compression, tension or shear tests. In the case of the compression test, the load may be applied by cylindrical dies, by spherical indenters or by flat plates. Steel loading dies can be regarded as rigid in relation to the fruit, therefore they may be considered not to undergo deformation. The sample may be a cylindrical specimen or a whole fruit.

Typical force-deformation curves are shown in Figure 1. These were obtained from a compression test employing a testing machine with a

6.35 mm diameter steel plunger on a whole apple with skin intact. Some engineering concepts can be deduced from these curves. The first break in curve (a) refers to the bioyield point. This is the point on the curve at which the stress decreases or remains constant with increasing deformation. This point indicates the

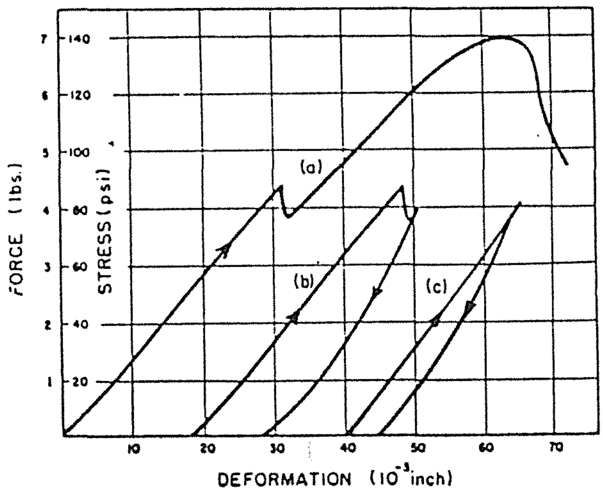

Figure 1 : Force-deformation curves of apple specimens with skin intact : (a) loaded through the bioyield and rupture points, (b) loaded through the bioyield point and unloaded, and (c) loaded up to a point below bioyield point and unloaded (Mohsenin, et al, 1963).

appearance of initial cell rupture in a small volume of a cellular system. The bioyield point of fruit plays an important part in determining their sensitivity to damage. If the load on a fruit does not reach the bioyield point, the cellular system will not be damaged and spoiling of the product will not occur. The straight portion of the curve is an indication of the stiffness or modulus of elasticity or the rate at which the material deforms under load. The area under the curve up to the bioyield point will be the work required to cause yield or initial cell rupture. The second break of the curve (a) is the rupture point. This is the point on the curve beyond which the stress decreases rapidly and significantly with increasing deformation. This point indicates failure over a significant volume of material. The area under the complete curve up to the rupture point can be taken as an indication of toughness of the skin and the supporting tissues.

Curves (b) and (c) were obtained by maintaining the rate of unloading of the testing machine equal to the rate of loading. The ratio of deformation recovered upon unloading to the total deformation at any given load can be referred to as elastic recovery (percent elasticity). The difference between the work of compression and the work of retraction is represented by a loop which can be referred as the hysteresis loop. The size of the hysteresis loop is a measure of elasticity and resilience of the material. The smaller the hysteresis loop, the more elastic is the material. The area under the unloading curve below the bioyield point can be taken as the elastic resilience or energy capacity of the material.

Puncture Tests.

Among the tests, the compression test employing a rigid die (punch), the so called 'puncture test', is the most widely applied for fruit. The first puncture tester for fruit was developed in United States more than 70 years ago (Bourne, 1965). The device consisted of partly embedding a 15.9 mm diameter glass marble in paraffin wax, and measuring the force required to push the exposed portion of the marble into an apple. Adopting the principle of this device, the Magness-Taylor, the Chatillon, the University of California and the Effe-Gi pressure testers were developed.

The first three pressure testers use the same principle. These devices consist of a long punch encased by a cylindrical metal barrel and are attached to it by a steel tension spring. A groove is cut in the barrel to show the punch sleeve on either side of which are scales in the form of Kg, lb or N. A sliding ring of metal encircling the barrel indicates the pressure required to force the punch into the fruit being tested. This force can be interpreted as fruit firmness. The ring is returned to zero prior to each reading. The Effe-Gi is a more compact instrument that can be easily held in the hand. The maximum force required to push the punch into the fruit is indicated on a circular dial. The needle is returned to zero by pushing a button on the side of the dial case. When properly calibrated the Magness-Taylor, the Chatillon, the University of California and the Effe-Gi pressure testers provide comparable data but interchanging these instruments should be avoided.

The performance of the puncture test may be explained by mounting a punch in an instrument that automatically draws out a force-deformation curve produced by the test. Typical curves produced by the puncture test in fruit are shown in Figure 2. These curves indicate that as the punch tip moves onto the fruit, there is an initial rapid rise in force over a short distance of movement. During this stage the fruit is deforming under load, but there is no puncturing of the tissues. This stage ends abruptly when the punch begins to penetrate the fruit (marking the bioyield point). The punch causes irreversible crushing or flow of the underlying

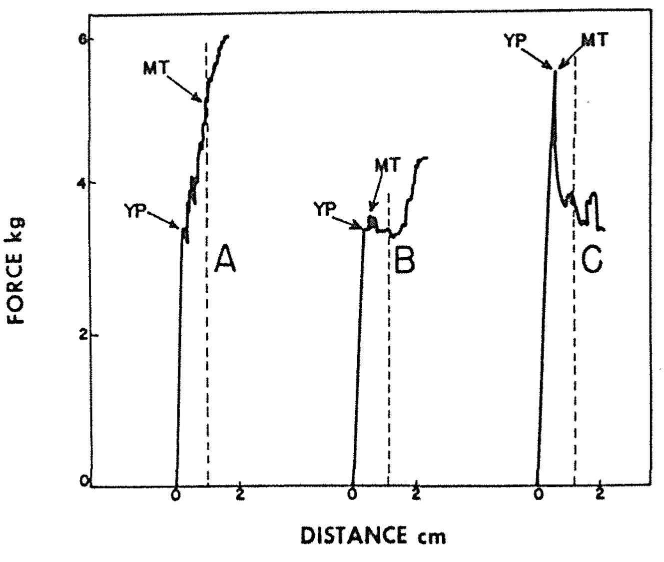

Figure 2 : Characteristics of force-deformation curves produced from the puncture test using a 7.9 mm diameter punch on apple specimen without skin (Bourne, 1965).

tissue. After the bioyield points the puncture curves separate into three basic types : the force continues to rise (A), the force is approximately constant (B), and the force decreases. Type A is found in freshly harvested apples while types B and C are typified by cold stored apples, ripe pears and peaches.

Theoretical Analysis of Puncture Tests.

(a). Pre-bioyield Point.

Morrow and Mohsenin (1966) employing elasticity theory, demonstrated that when a rigid punch is employed against the plane boundary of a semi-infinite elastic solid fruit, the distribution of the pressures at the surface of the semi-infinite body is not uniform and its intensity is given by the Boussinesq equation :

$$P = \frac{F}{2 \pi a \sqrt{a^2 - r^2}} \qquad (1)$$

where P is the pressure at any point A at the surface, F is the total force acting on the punch, a is the radius of the punch and r is the distance from the centre of the punch to A. The pressure distribution over the circular base of the cylinder is illustrated in Figure 3.

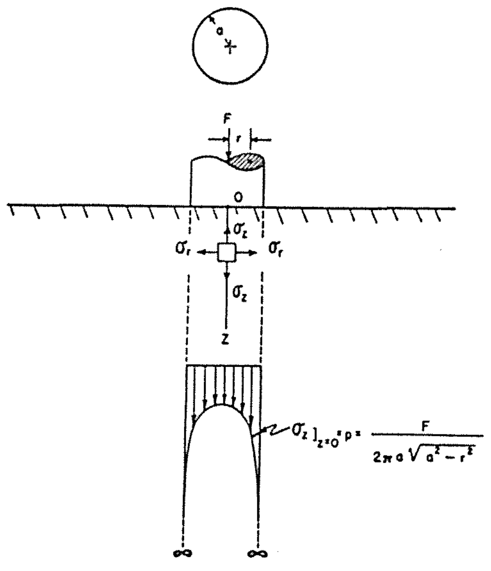

Figure 3 : Theoretical pressure distribution loading by a cylindrical die (Morrow and Mohsenin, 1966).

The Boussinesq equation is only applicable before the bioyield point is obtained.

Bourne (1966) postulated that the bioyield point force within a puncture test is built up of two factors i.e. : the compressive strength of the fruit times the area under the punch, and the shear strength of the fruit times the perimeter of the punch. He formulated his postulate :

$$F = K_C A + K_S P + C \qquad (2)$$

where F is the measured puncture force, K_C is the compression coefficient of the fruit, K_s is the shear coefficient of the fruit, A is the punch area, P is the punch perimeter, and C is constant.

The coefficient K_c was obtained from the slope of the puncture force-area curve while the coefficient K_s was found from the slope of the puncture force-perimeter curve. Knowing the area and the perimeter of the punch it was then possible to calculate C. Bourne (1966) found that K_c, K_s and C values for Libertwig apples are 73.75 N/cm , 1.57 N/cm and 0.29 N respectively while those for yellow bananas are 4.22 N/cm , 0.59 N/cm and -0.59 N respectively.

Using different sized punches, it has been demonstrated that the puncture test is comprised mainly of compression and a minor shear component (Coggins and Lewis, 1965; Bourne, 1965; and Yang and Mohsenin, 1974).

Employing the theories of inelasticity and piercing problems Yang and Mohsenin (1974) formulated two theoretical equations describing the factors involved in the first deformation stage of a puncture test and the second stage of penetration. The equation that describes the force changes that occur between zero force and the bioyield point is expressed as :

$$F = - 2(\pi/3)DRh_1(a\mu)[(a^2/R^2)\surd X-(Y/Z)+(1/2)\ln X-2X+(3/4)X^2$$

$$+(1/2)(a^4/R^4)+5/4)] \qquad (3)$$

where $X = 1 - a^2/R^2$, $Y = - 5X^2 - 14X^3 + 9X^4$, $Z = \sqrt{X}\{2-(3a^2/R^2)\}^3$, F is the force, D is deformation at axis of symmetry, R is the radius of curvature of the punch face, h_1 is a function of strain, a is the radius of the surface of contact, and μ is a value between 0 and 1.

(b). Post-bioyield Point.

Yang and Mohsenin (1974) expressed the force changes during penetration as :

$$F = - \pi a^2 k \ (\sqrt{3} + nC_a \ln D_0/2a) \qquad (4)$$

where k is shearing strength, C_a is a correction factor, D_0 is the diameter of assumed cylinder, and n is an Unksov correction factor which is a correction for the practical condition due to the bulging effect on the region surrounding the punch. This factor was calculated from :

$$n = 1.9 \ (1 + 0.2 \ (H - h) \ / \ h) \qquad (5)$$

where H is the height of the assumed cylinder after a certain penetration, and h is the height of the inner cylinder under the punch.

Using Rome Beauty cultivar apples that had been held in controlled atmosphere storage for six months and the 7.9 mm punch, the authors indicated that the force predicted by these relations at the point of penetration where penetration just took place differed by 1.5% from the experimental values for the first stage of deformation. The difference for the second stage of deformation was 2.2%. For the 11.1 mm punch, the differences at this point were 2.7% and 5.9% for the respective stages of deformation.

The above equations are deduced with an assumption that the test sample is semi-infinite in which the sample is so large in comparison with the size of the punch that the edge effects are insignificant and that the punch does not break the bottom of the sample. In the case of fruit skins, Ahmed et al (1973) calculated the shear stress of the skin employing the following formula :

$$S = F/\pi DT \qquad (6)$$

where S is the shear stress, F is the puncture force, D is the punch diameter, and T is the thickness of skin.

He found that shear stress calculated using this formula was sensitive in distinguishing mechanical properties of irradiated citrus from non irradiated citrus regardless of citrus variety.

Punch Face Shape Effects.

Effect of the shape of the punch face has been investigated by some workers. Holt (1970) compared a tapered punch and cylindrical punch in measurements of tomato firmness. He stated that a punch that tapered from 1 mm diameter at the face down to 0.5 mm diameter was preferred to the cylindrical punch. It was because this typical face resulted in little distortion of the fruit and avoided the friction on the sides of the punch which was contributing significantly to the resistance of penetration. Furthermore he claimed that when the punch penetrated into the fruit, the punch shaft would be travelling through a hole twice its own diameter so that the force on the punch should be due only to the penetration of the tip.

In puncture testing strawberries, Ahmed and Fluck (1972) employed a flat face punch, a 4 point star face punch, and a Phillips screwdriver face punch. They stated that the shape of the punch face could affect the results, but no particular shape was recommended.

Effect of Removing Skin.

There has been considerable discussion in practice as to whether the skin should or should not be removed at the site in puncture tests. Bourne (1980) tried to find an explanation for this by devising a schematic representation from thousands of tests with the Instron. This is shown in Figure 4.

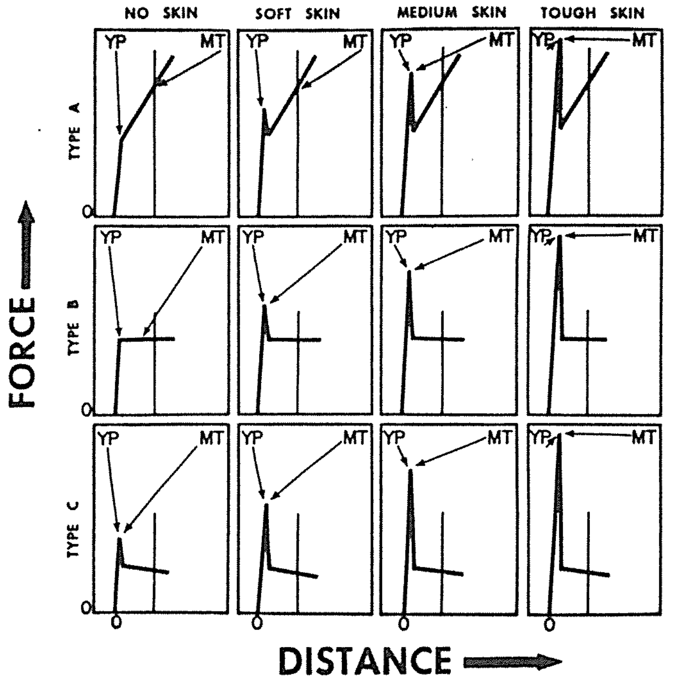

Figure 4 : Schematic representation of force-distance curves obtained when puncturing produce with and without skin. YP is yield point and MT is force reading that would have been obtained on a hand operated pressure tester (Bourne, 1980).

The left hand side of the graphs show schematically the three different shapes of force-distance curves that were obtained on products with skin removed. It can be seen that whenever skin is present, it has to be sheared through by the punch before penetration of the tip into the product can occur. The shear strength of the skin adds an extra component to the pressure test. This appears as a peak in the yield point force which is superimposed upon a regular type A, type B or type C force-distance curve. The height of the superimposed peak depends on the toughness of the skin, the more tough the skin the higher the superimposed peak.

In type B and type C products, if the yield point force is measured, the increase in the yield point caused by the shear strength of the skin is always reflected in a higher pressure test. When the skin is very soft, the increase may be negligible. In the case of a type A product the increase in the yield point caused by soft skin will still be less than the force required at the 7.9 mm penetration depth as used in the Magness-Taylor pressure tester. In the case of moderately tough skin, the increase in the yield point caused by the skin will bring the yield point force up to about the level of the Magness-Taylor force and a small increase in the test reading results. On the other hand if the skin is quite tough, the yield point is increased well beyond the normal Magness-Taylor force and the pressure test will be significantly increased.

So if it is proposed that the shear strength of the skin is not necessarily related to the characteristic of the underlying flesh, then the skin should be removed before a puncture test is made, unless it has been known that the skin is so tender that it causes a negligible increase.

Other Puncture Tests.

Puncture tests have been applied to explore the mechanical properties of various kinds of fruit under various conditions. Schomer and Olsen (1962) developed a 'mechanical thumb', a modified Magness-Taylor pressure tester, to give 1.5 mm penetration on apples with the skin intact. The aim of this experiment was to measure the firmness of apples without obviously damaging the fruit so that the fruit could be marked after being tested. Mohsenin, et al (1962) attempted to identify the bioyield point in puncture testing of apples and indicated that this was the point at which bruising of the tissue occurred. Brennan, et al (1977) compared puncture tests on whole apples with compression tests on cylindrical specimens of apple tissue and showed that the two methods gave comparable high correlations with sensory tests.

Bourne (1965) investigated the performance of the Magness-Taylor punches mounted in a universal testing machine for apples and found that three types of force-deformation curves could be distinguished according to the direction the curve takes after passing the bioyield point. He also showed that skin on apples increased the pressure test while the speed of travel of the punch affected the pressure test only a small degree. Voisey (1977) compared the Magness-Taylor and Effe-Gi pressure testers on Red Delicious apples and recommended that a suitable calibration was needed to correct the errors of using these two different testers.

Many workers have employed puncture tests on strawberries (Kimbrough, 1930; Darrow, 1931; Overholser, et al, 1931; Cochran and Webster, 1931; Rose, et al, 1934; Haut, et al, 1935; Burkhart, et al, 1943; Bradly, 1966; and Ahmed and Fluck, 1972). Ourecky and Bourne (1968) mounted a star-shaped punch in the Instron testing machine to measure texture of strawberries and found that it was a good index of firmness between varieties of strawberries, and of maturity within a given variety.

Relationship Between Puncture Tests and Quality.

Puncture tests have been found effective in measuring the degree of maturity of peaches (Blake, 1928; and Rood, 1957). Finney and Abbott (1972) employed the Magness-Taylor pressure tip mounted on the Instron to measure the texture of Elberta-free-stone peaches. Operating in the force range of 2.2 N to 76.5 N they found a correlation coefficient (r) against ratings of firmness based on a modified scale ranging from 1 for soft and 7 for hard of 0.96. Bourne (1974) also found that the six texture parameters of the General Foods texture profile (elasticity, hardness, fracturability, chewiness, gumminess and cohesiveness) of peaches following the fruit ripening had high correlations with the puncture test.

For pears, Claypool et al, (1958) claimed that the best quality (in terms of texture, flavour, aroma or appearance) of canned pears was obtained by harvesting the pears at 71 N to 80 N puncture force and storing at less than 4.4 °C for some days followed by ripening at room temperature to 8.9 N to 13.3 N puncture force. Bourne (1968) showed that the six texture parameters of the General Food texture profile decreased in the same direction at approximately the same rate as the puncture test as pears ripened.

Stec, et al (1989) conducted puncture test employing the Effe-Gi fruit tester to measure fruit firmness in relation to the sensory evaluation of kiwifruit. They found that there was a significant relationship between the fruit firmness and overall fruit acceptability in which the soft fruit were more acceptable.

Use of Puncture Tests for Determination of Fruit Properties.

Cherries have been found to be amenable to puncture testing (Brekke and Sandomire, 1961). Fischer, et al (1969) employed a puncture test on cherries to obtain the mechanical properties of yield stress, work per unit displaced volume, modulus of compressibility, distance of compression to yield point of the flesh, shear yield stress, and the shear strength of the skin. Von Elbe et al (1967) conducted a puncture test to determine the instantaneous force required during the removal of pit from a cherry. The instrument consisted of a pitting device which was a single standard Dunkly cherry pitting needle mounted on the rod of the hydraulic cylinder, moving with a velocity of 8 cm/s. The cherry to be pitted was held in position on a pivot beam directly below the pitting needle by a cup which had a hemispherical recess at one end and a hole at the bottom of the recess which permitted passage of the pit. The fruit was pitted with the suture side facing the pitting needle and with the suture side horizontal. It was found that the orientation of the cherry affected the results, suggesting that the suture of the cherry should be kept in a horizontal orientation for the pitting test. Puncture tests employing a single Dunkly cherry pitter have also been used by Bourne et al (1966) and La Bella et al (1964) to study the bruising of cherries.

Jackman, et al (1990) compared a puncture test with flat-plate compression and constant area compression in studying tomato firmness with respect to chilling injury. They found that the puncture test was more sensitive than the flat-plate compression and was comparable to the constant area compression in measuring differences in tomato firmness that were characteristic of slightly chilling-injured fruit.

Puncture tests have been used to investigate characteristics of the skin of citrus fruit. Cahoon, et al (1964) conducted a puncture test to obtain 'rind oil rupture pressure' i.e. the force needed to express free oil from the flavedo. A correlation was found between the puncture test and the spotting index (r) of 0.836. Coggins and Lewis (1965) employed puncture testers for the firmness of Naval orange rind while Ahmed, et al (1972) determined the change in strength of the skin of citrus fruit due to irradiation by punching out a cylindrical specimen from the peel. The puncture test has been employed to determine the firmness of flesh and skin of plums and prunes (Carnegie and Fridley, 1965).

Peleg (1974) investigated the texture of papaya flesh using puncture tests and found that the major mechanism of texture failure in papaya was compression. Furthermore, Peleg and Brito (1975) indicated that the puncture force consisted of both compression and shear components. They also found that for tropical fruit, shear contribution was in the order of 20% for papaya, 6% for mango, 32% for pineapple and 14% for plantains.

Problem with The Puncture Test.

Although puncture tests using hand pressure testers have been widely used, some discrepancies about this test are still encountered. Among them are :

1). The test does not measure a clearly defined mechanical parameter, but an arbitrary mixture of shear and compression factors.

2). The test measures the properties close to the surface, and cannot provide information about the inner parts of the fruit.

3). The test seems to produce biased results if the physical properties vary significantly with depth, such as for mango in which the tissue is more fibrous as it approaches the stone

(Singh, 1960). The removal of the skin before the test can have a major effect on the result.

4). Puncture tests employ a force measuring system which may stick as juice builds up, and which can be expensive.

5) High risk of human error. It is difficult to operate the device in a uniform and reproducible manner. Since most devices operate with a spring gauge, erratic motions can cause jerky movements of the spring gauge thus producing spuriously high readings.

An Alternative Twist Testing Method.

Recently Studman (1991) proposed an alternative test which may help overcome some of the above discrepancies. The device measures the force required to rotate a small rectangular blade inserted into the fruit specimen using a simple mechanical system. Other advantages of this test are that the test can be easily done and only takes a few seconds. This twist test is described in full detail below.

III. FRUIT MATURITY ASSESSMENTS.

Many climacteric fruits destined for unprocessed market need to be harvested at a suitable stage of maturity to minimize possible damage during packing and shipping, but which is sufficient to ensure that they will ripen to an acceptable quality at the terminal market. Fruit destined for processing must also be harvested in an adequate manner and at a sufficiently uniform stage of maturity to ensure acceptable quality and process efficiency.

In practice, maturity is assessed by one or more of the following methods : (a) visual means such as skin colour, size, presence of dried outer mature leaves, drying of the plant body, and fullness of fruit; (b) physical means, for example : ease of separation from the fruit spurs or abscission, firmness, and specific gravity; (c) chemical analysis, for instance, solids, acids, solid to acid ratio, and starch content; (d) computation such as days from full bloom and heat units; (e) physiological methods such as respiration measurement.

Apple.

Despite considerable research to find a suitable index for apple maturity, no consensus has emerged. Some of the most common methods of measuring apple maturity are : flesh firmness, soluble solids, titratable acid, soluble solids/acid ratio, starch (iodine method), respiration rate, ethylene production, colour of seeds, ground colour, percentage of red colouring, calendar date, number days from full bloom and accumulated heat units. Using McIntosh apples, Smock (1948) conducted an intensive study on methods of determining fruit maturity including : fruit firmness, ease of separation, surface colour, ground colour, soluble solids, days from full bloom, calender date, respiration rate and starch-iodide test. He stated that ground colour (the change in ground colour from green to yellow) was the best index followed by the calender date (had a 10-day range), of when to pick McIntosh apples. On the other hand, Haller (1942) found the pressure test, ground colour, seed colour and starch test to be unreliable as a maturity index for Williams, Jonathan, Grimes Golden and Yellow Newton apples. For these varieties the number of days from full bloom has been a more reliable index of maturity. On the basis of these results he suggested that harvest should not begin until at least 70 days from full bloom for Williams, 130 days for Jonathan, 135 days for Grimes Golden, and 150 days for Yellow Newton.

Tukey (1942) developed Tables for various cherries, peaches, pears and apples showing days from full bloom to harvest and the maximum seasonal differences between these dates for individual varieties. He found that the elapsed period gave a relatively accurate method of predicting harvest and was more accurate with crops and varieties requiring a longer rather than a shorter growing season.

Working on McIntosh apples, Eggert (1960) found a correlation coefficient of -0.96 from the relationship between the length of elapsed time from full bloom to the heat units calculated by the daily mean temperature minus a base temperature of 0 °C. He claimed that the heat unit could be used as prediction of optimum storage maturity. With respect to different growing areas in US and Canada, Fisher (1962) analyzed heat unit accumulation and the number of days required to mature pome and stone fruit, and found that growing areas with late bloom required fewer days from bloom to harvest and fewer heat units for maturity.

Working on Golden Delicious apples, Hammett et al (1977) attempted to correlate fruit pH, inflection pH, soluble solids, percentage of acid content at the inflection point pH and percentage of acid content at pH 8.1. He found that all these parameters were not correlated with days from full bloom, but the ratio of soluble solids to the percentage of acid content at pH 8.1 was highly correlated with days from full bloom. In a separate experiment Hammett et al (1977) indicated that the ratio of soluble solids to % acid content at pH 8.1 can be applied to Stakrimson Delicious, Ryon Red Delicious and Top Red Delicious but did not apply for Law Rome apples. The ratio of soluble solids to acid has also been correlated with product quality and heat unit accumulation. Greatest taste panel acceptance of Delicious apple products occurred when the soluble solids to acid ratio was between 28 and 45 (LaBella et al 1960).

Mattus (1966) combined a sliding scale of fruit firmness and soluble solids as an index for harvest of apples. He suggested sliding the scale 3.9 N in firmness for each 0.5% soluble solids and 82.4 N fruit firmness and 11% soluble solids as the index for harvest. This occurred in the range of 135 to 140 days from full bloom for Red Delicious. On the other hand Chalmers et al (1973) used changes in anthocyanin synthesis as an index of maturity in red apple varieties, and found that the transition from the immature to mature stages with respect to anthocyanin accumulation occurred rapidly and preceded the normal harvest date by about two to three weeks.

Beattie and Wild (1972) and Beattie et al (1973) used the starch iodine test to assess harvest maturity for export of Granny Smith apples growing in New South Wales. The test was done by cutting apple equatorially and then placing them in an iodine solution. The action of the solution on any starch present in the apples turned the cut surfaces blue. The greater the starch content the greater the areas of blue colouration. The fruit was then graded according to the degree of blue colouration as the starch-iodine index in which 0 represented immature and 6 was fully ripe. They found that fruit with a starch-iodine number of 3 or higher was acceptable for immediate eating, while fruit with a lower index was unacceptable. Working with the same method and apple variety Watkins (1981) suggested a value of 3 as the optimum index for harvest for New Zealand conditions.

The above description shows that no single index is available to assess apple maturity. Days from full bloom can be more generally applied for coloured apple varieties, while the starch-iodine number is applicable for Granny Smith.

Kiwifruit.

The period of fruit maturation is the time elapsed between the final stages of fruit growth and the beginning of ripening. For kiwifruit, this period commences after the fruit has completed its rapid growth phase and continues until the fruit starts to ripen slowly (Harman, 1981). During maturation the size of the fruit is only slightly increased although the vine is still contributing nutrients to the fruit and many changes occur inside the fruit which enable it to ripen independently. When these changes are complete the fruit is called physiologically mature.

A kiwifruit intended for the fresh market needed to be harvested after it has reached physiological maturity, otherwise it will lack nutrient, acid and carbohydrate levels sufficient to ensure good flavour and texture when ripened (Harman, 1981). It is necessary, therefore, for the industry to have a standard method which can objectively assess fruit maturity so that crops are harvested at the correct time. To find a suitable method for assessing fruit maturity one usually traces the sequence of changes which occur in the fruit during maturation, and then only those changes which occur in a regular fashion and reflect physiological maturity are adopted as maturity indices.

During maturation, kiwifruit are characterized by slow, irregular growth (Hopping, 1976), negligible flesh and seed-colour changes, and no significant change in shape (Pratt and Reid, 1974). Therefore, no visual parameter can be used as a method for assessing maturity.

Harman (1981) found that calender date was not a completely satisfactory criterion for assessment of maturity. Pratt and Reid (1974) showed that the respiration rate and the onset of ethylene also proved unsuitable as a maturity index. On the other hand, decreasing flesh firmness and conversion of starch to sugar have been found to occur over the period of maturation (Harman, 1981, Brohier, 1986), and these two parameters show promise as a maturity index of kiwifruit.

In practice, the conversion of starch to sugar is measured by the change in soluble solids concentration. Ford (1971) found that fruit harvested with a soluble solids concentration of less than 6% failed to give a satisfactory flavour when ripe. Subsequently, Reid (1977), Harman (1981), and other workers further researched the relationship between the soluble solids concentration at harvest and the final eating quality of 'Hayward' kiwifruit from individual orchards by using taste panels. They concluded that the fruit which was harvested early did not develop a good kiwifruit flavour, and might even develop unpleasant off-flavours. In contrast, the fruit harvested at a high soluble solids concentration had a healthy internal appearance and ripened to a very acceptable flavour. Further studies by Reid and Harman (Harman, 1981) led these workers to recommend a soluble solids content of 6.2% as the maturity index for harvest of Hayward kiwifruit.

It should be stressed, however, that the maturity index of 6.2 is a minimum value for harvest, not the optimum. Warrington and Weston (1990) indicated that fruit harvested with a higher maturity index, between 7 and 10, have an even better storage life and eating quality. Even with very late harvests, when the maturity index is around 12, the fruit produces excellent storage and eating qualities. A study by Sawanobori (1983) reached similar conclusions.

IV. OBJECTIVES.

This research study rigorously investigated the twist test and compared this new test with the penetrometer test and the Brix test for testing apples and kiwifruit. In testing the fruit as they matured, these three tests were correlated with harvesting dates for apple while the twist and the penetrometer test were correlated with soluble solids content measured by the Brix test for kiwifruit. The three tests were also used for testing cool stored fruit.

The aims of this experiment were :

1). To study the twist test for characterizing mechanical properties of fruit.

2). To investigate if the twist test could be used as a means of assessing fruit maturity.

3). To study the use of the twist test to trace the change of mechanical properties of fruit with respect to fruit softening during cool storage.

V. DESCRIPTION OF TWIST TESTER.

Principle.

The principle of the twist tester is illustrated in Figure 5. Two blades are mounted on a shaft which is free to rotate on a bearing. On one end of the shaft an eccentric arm is mounted, so that as the shaft is twisted from its resting position with the arm vertical, the unbalanced mass of the arm produces an opposing couple. When the blade is rotated, its rotation is identical to the movement of the arm. This rotation produces a moment within the arm which is equal to the moment acting on the blade. This moment is opposed by the force of the fruit tissue acting against the blade. The greater the movement the bigger the moment and so the bigger the force on the fruit.

Theory.

In testing fruit, the twist force can be interpreted as the force used to crush the fruit against the blade. The angle at which the fruit fails completely is taken as a measure of the crushing strength. For an element of the fruit flesh with a width da and length b (Figure 5b), the magnitude of the twist force on the element can be expressed as :

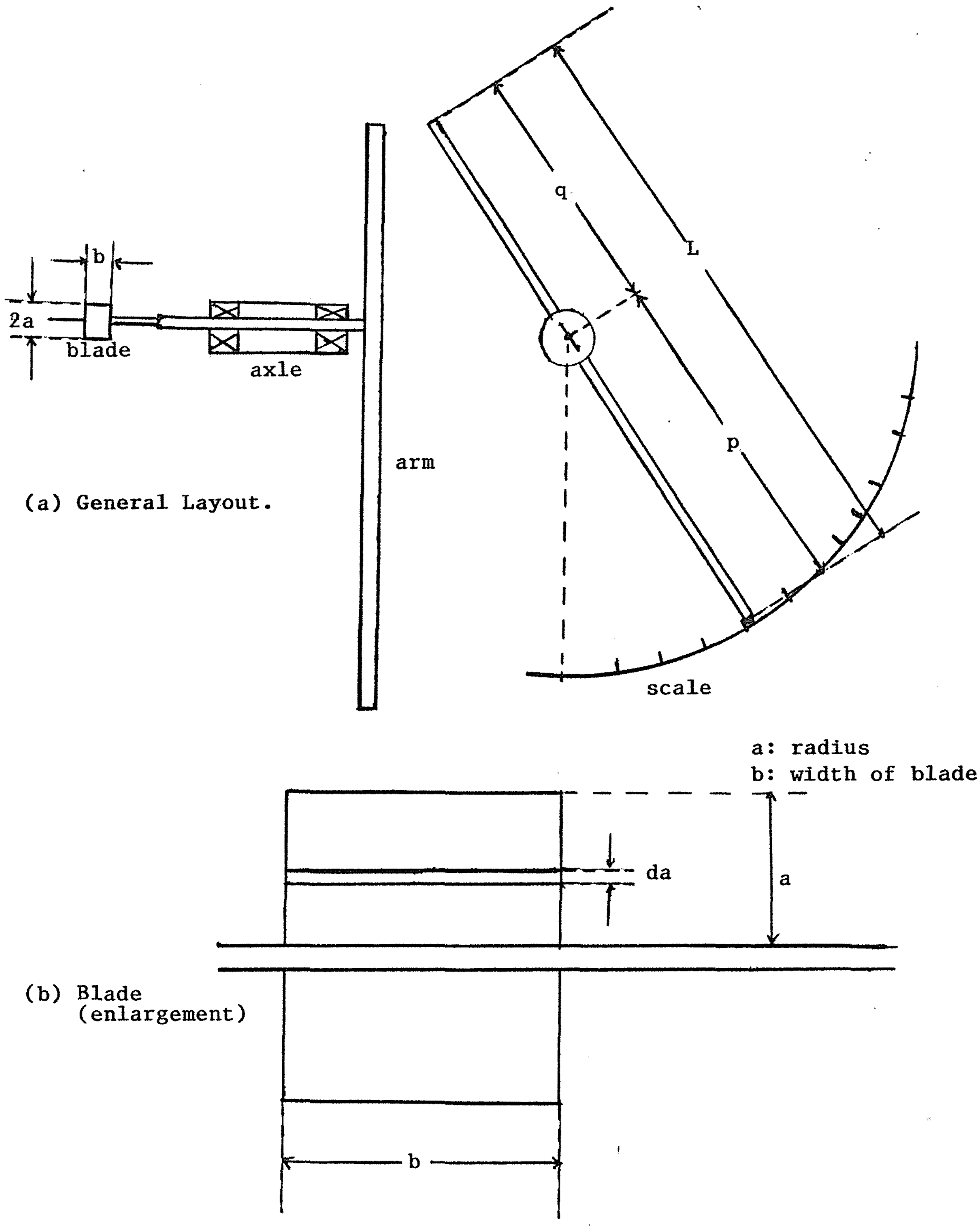

Figure 5 : Principle of twist tester.

$$dF = b \, da \, \sigma \qquad (7)$$

where σ is the crushing strength of the fruit (Pa), a is the radius of blade (m) and b is the length of the blade (m). The moment on the whole blade is found by integrating from +a to -a and is therefore given by

$$M_b = 2 \int_0^a \sigma \, a \, b \, da$$

ie; $M_b = \sigma \, a^2 \, b \qquad (8)$

The moment of the rotating arm is :

$$M = m \, g \, (p^2 - q^2) \sin \Theta / 2 L \qquad (9)$$

where m is the mass of the arm (kg), L is arm length (m), p and q are the lengths of the arm as shown in Figure 5 (m), Θ is the angle of rotation (degrees) and g is the gravity constant (9.807 m/s^2). Since $M_b = M$, therefore $b \, a^2 \, \sigma = M$,

$$\sigma = M / (a^2 b) \qquad (10)$$

In this last equation M is in N m while σ is in N/m^2.

This analysis assumes that the resistance to moment is due entirely to the crushing of fruit cells by compression. However, for the penetrometer test, Bourne has suggested that a shear component may be affecting the results (Equation 2).

In this case we may postulate that the resisting couple is given by the compression strength over the blade, plus a shear component at the edge of the blade. This can be written as

$$M = A\tau + B\sigma + C \qquad (11)$$

where M is the moment defined in Equation (9), τ is the shear coefficient, σ is the compression strength and C is constant. Within this equation the value B is equal to a^2b as before, but the value of A is unclear since it is the area sheared by the edge of the blade. This value can be found by looking at the total moment generated by the edge of the blade. Let F be the force acting on the edge of the blade. This force can be expressed as

$$F = C'\tau l \qquad (12)$$

where l is the length of the segment of the edge being considered (m), and c′ is a dimension representing the distance over which the shear stress acts in the direction of movement of the blade. The total moment caused by shear is the sum of the moments around the perimeter of the blade (Figure 5b). Along the outer edge the moment is given by $M_1 = C'\tau$ ba for each edge while along the sides the moment can be found by integrating the force from -a to +a. This is given by $M_2 = 2\ C'\tau\ (a^2)$, so the total moment caused by shear is given by

$$M_a = 2M_1 + M_2 = 2\ C'\tau\ (ab + a^2) \qquad (13)$$

Let $K_s = C\ \tau$ and then,

$$M_a = K_s\ 2(ab + a^2) \qquad (14)$$

where K_s will be proportional to τ and $2(a\ b + a^2)$ will be equal to A in Equation (11).

The moment produced by the blade is therefore

$$M = \sigma\ (a^2 b) + K_s\ (2(a^2+ab)) \qquad (15)$$

The values of σ and K_s can be determined by conducting tests employing two different sizes of blades then solving Equation (15).

Another estimate of the values of σ and K_s can be obtained by doing tests using a set of blades with constant b and varying values of a. The solution of Equation (15) can be written as

$$M/a^2 = b\ \sigma + 2\{1 - (b/a)\}\ \ K_s \qquad (16)$$

If b is constant, plotting $\{1 - (b/a)\}$ against M/a^2 produces a straight line in which the slope gives an estimate of $2\ K_S$.

Finding the value of K_S, the value of σ can be obtained by rewriting Equation (15) as

$$\sigma = \{M - 2a(a + b)\ K_S\}/ab \qquad (17)$$

VI. MATERIALS AND METHODS.

Twist Tester.

A simple prototype twist tester was developed. For experimental purposes, the device consisted of a 1.05 m, long hollow rectangular aluminium tube with a mass of 0.1798 kg. Rectangular twist blades were fitted in the axis where the arm rotates, and a large radial scale was used. The arrangement of this tester is shown in Figure 6. The position of the axle can be adjusted along the arm to produce a suitable moment needed for testing. In the rest position, the arm is vertical in which the radial scale indicates a zero degree reading.

For each test, the blade was inserted into the fruit specimen. The fruit was then rotated slowly at a speed of approximately 6 ° per second and the movement of the arm was monitored on the radial scale. Readings were taken (in degrees) when the arm started to turn back. This normally took around 5 seconds. Two blades of different size (with rectangular dimensions of 9.82 mm by 7.82 mm, and 6.70 mm by 4.10 mm) were employed depending on the hardness of the fruit being tested.

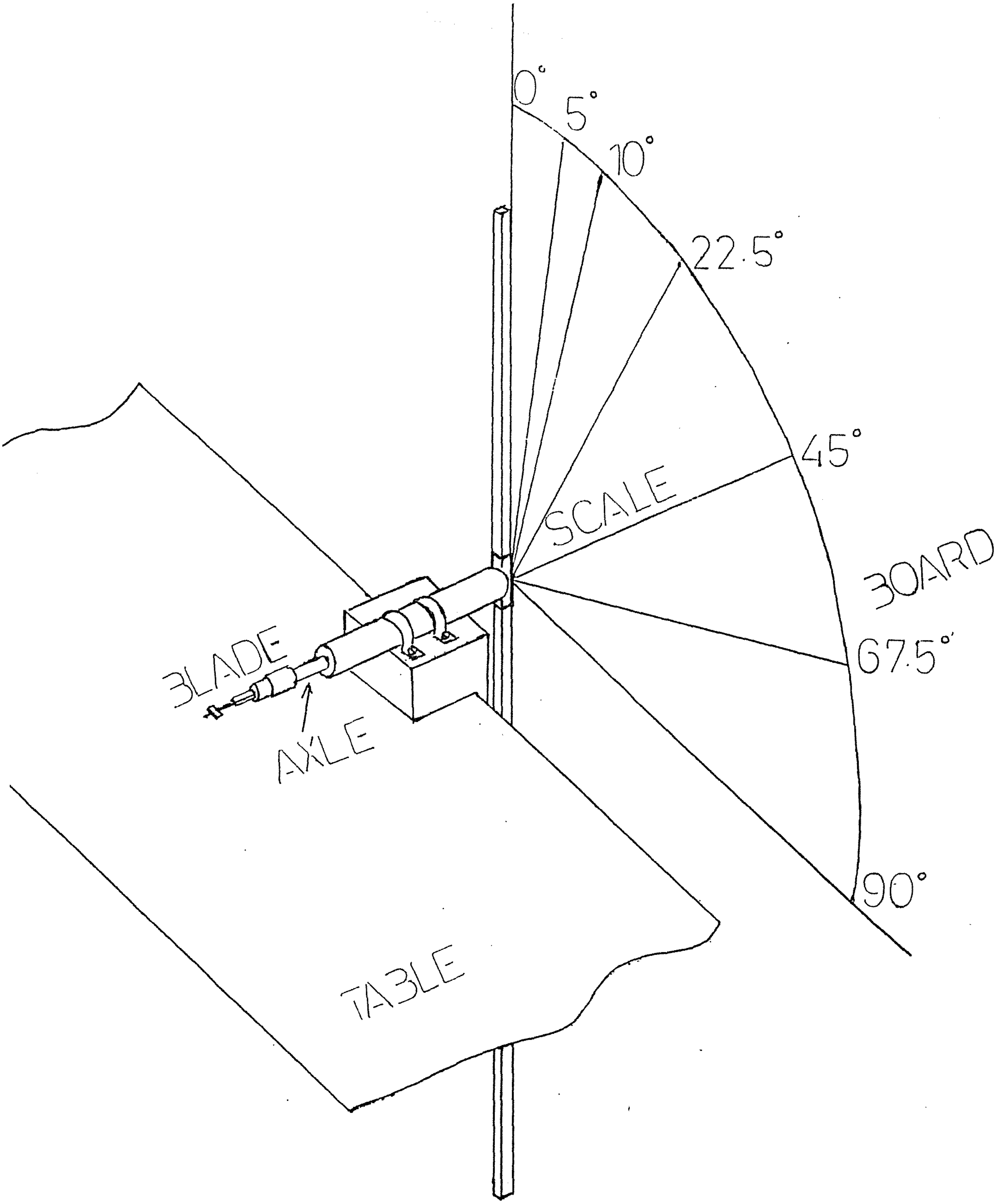

Figure 6 : Prototype of twist tester.

Other Tests.

Penetrometer tests and Brix tests were taken in the same fruit. The Effe-Gi firmness tester with a 7.9 mm tip was used. For these tests, the skin was removed from the test site. The fruit was laid on the surface of a heavy bench and the test surface was kept perpendicular to the punch face. The tester was held in the right hand with the side of hand resting on the hip and the tester was then pressed into the fruit. Penetration was stopped after the depth marking had reached the fruit surface.

The Brix test was done by directly taking the juice coming out from around the punch before it was pulled out. The juice was therefore only exposed to air for a few seconds. Both the punch tip and the Brix tester were cleaned before each measurement.

Samples.

Apples and kiwifruit were used for testing. There were four series of experiments with apples and two series of experiments with kiwifruit.

Apples.

In the first series of experiments, Granny Smith apples grown in the Hawkes Bay area and picked on 1/5/1990 were used. A sample of

20 apples was taken to the laboratory and tested on the day of picking while the rest of fruit was stored at 0 °C. With each fruit the twist test was done twice by inserting the blade in two opposite cheek sides. The Penetrometer test and Brix test were taken from another side of the cheek. Two weeks later another sample of 20 apples was taken from the storage for the same tests. There after,the third, fourth and fifth tests of this series of experiments were done at monthly intervals. The results of these experiments are given in Appendix 1.

The second series of experiments were done on 10/9/1990. Royal Gala and Gala apples of two different harvest dates, stored at 0 °C, were tested. Twenty Royal Gala apples were taken from those harvested on 26/2/1990 and 20 were brought from those harvested on 15/3/1990. For Gala apples, the fruit were harvested on 15/2/1990 and 26/2/1990. Samples of 20 apples were used for each harvest date. After the fruit had reached room temperature, they were tested with the twist, penetrometer and Brix tests as in the first series. Data for these experiments is presented in Appendix 2.

In the third series of experiments, Royal Gala and Gravenstein apples were harvested from trees grown in the Massey University experimental orchard, in Palmerston North. For each variety, a sample of 40 apples were used for every testing. For Royal Gala the sample was collected from 6 trees by randomly hand picking 7 apples from each tree while for Gravenstein the sample was taken from 3 trees by randomly hand picking 14 apples from each tree. The first samples were picked on 21/12/1990. These samples were brought directly to the Biomaterial Laboratory, Agricultural Engineering Department, for testing. The types of test were the same as those previously outlined. The second test in this series was done 2 weeks later, while the next tests were conducted at 1 week intervals as the fruit matured. From the first harvest, the tests were conducted at the same time as harvesting dates. It should be noted that for Royal Gala apples the fruit lot on the trees was kept undisturbed until the second harvest while for Gravenstein apples, the fruit lot on the trees was deliberately permitted to be disturbed by normal harvesting events. Data for these experiments is given in Appendix 3.

The Fourth series of experiments was done on 4/3/1991 using Gravenstein apples picked on 5/2/1991 and Royal Gala apples picked on 4/3/1991. Two blades of different size were used. The test using these two blades was done on the same cheek sides of the fruit being tested, one close to the other. The penetrometer and Brix tests were also taken from the same fruit. Data for these experiments is presented in Appendix 4.

Kiwifruit.

The fruit samples were the Hayward variety grown in the Massey University experimental orchard, Palmerston North. In the first series of experiments, the fruit were randomly picked from 6 vines and then directly brought to the laboratory for testing. Tests were conducted in the same manner to those for apples, with increasing fruit maturation. The first, second and third tests were done at 2 week intervals starting on 18/4/1990 while the fourth, fifth and sixth tests were carried out at 1 week intervals. The last test was taken on 28/6/1990. A sample of 20 fruit was used for every test. Data for this experiment is presented in Appendix 5.

In the second series of these experiments, all the fruit were harvested from the same vines on 28/6/1990. A sample of 20 fruit was then taken for testing, and the rest were stored at 2.5 °C. The same sample size was taken each week for testing. Every test was conducted after the fruit had reached room temperature. Data for this series is given in Appendix 6.

Measurements.

For the twist test, angle readings from both sides of the fruit cheek were averaged. Using this average value, together with the measured p and q, the value of the maximum moment (M) was obtained from Equation (9), while crushing strength value was calculated from Equation (10). Penetrometer readings were converted to Newtons by multiplying by g (9.807 m/sec^2). Results of the calculations were then tabulated.

Regression analysis employing a spread sheet computer program was used to analyze the relation between the twist test, penetrometer test and Brix test, and storage time for Granny Smith apples and kiwifruit. This statistical analysis was also used to analyze the relation between the twist test, penetrometer test and Brix test, and harvesting dates for Royal Gala and Gravenstein apples, and the relations between the twist test, penetrometer test, and soluble solids contents obtained from the Brix test for kiwifruit.

ANOVA employing the Randomized Block Design in the SAS package was used to analyze the effect of harvesting date on the twist test, penetrometer test and Brix test for Royal Gala and Gala apples.

VII. RESULTS.

Tests on Apples.

The averages of crushing strength (Cs) together with penetrometer reading (Pr) and soluble solids content (SSC), and their standard deviation for the first series of experiment are presented in Table 1.

From this Table, the relationships between Cs, Pr, and SSC with number of days within storage were found. The trends of the Cs, Pr and SSC were shown in the form of graphs.

Average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation for the second series are given in Table 2.

ANOVA of randomized block design was employed for every variety to see the effect of harvest date.

From the third series of experiments, average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation for Royal Gala apples are given in Table 3 whereas those for Gravenstein are presented in Table 4.

From these Tables, the values of crushing strength, penetrometer reading and SSC were correlated with the first, the second and the third harvests. Harvesting is based on observation of fruit colour.

In the case of Gravenstein, to correlate with the third harvest, data from the test on the second harvest were excluded because the fruit lot on the trees had been disturbed by the first harvesting event. The trend of the crushing strength, penetrometer reading and SSC with fruit maturation are illustrated in the form of graphs.

The practical first, second and third harvests for Royal Gala apples were conducted on 01/03/1991, 14/03/1991 and 26/03/1991 respectively.

The first, second and third harvests for Gravenstein apples were done on 28/01/1991, 05/02/1991 and 12/02/1991 respectively.

Average values of moment, penetrometer reading and soluble solids content, and their standard deviation obtained from the fourth series of experiments are given in Table 5.

The ratios of moments produced by the two different blades were calculated and compared with the ratio of volumes of fruit crushed by these blades. This was to see if the measured moment was simply a representative force to crush the cutting fruit material.

Table 1 : Average values of crushing strength, penetrometer reading and soluble solids content and their standard deviation for Granny Smith apples.

Date of Test	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
01/5/'90	677.578	28.230	35.48	2.042	10.65	0.594
14/5/'90	652.297	29.199	35.92	2.978	11.40	0.700
18/6/'90	633.090	41.144	33.32	2.802	11.90	1.020
18/7/'90	591.671	29.601	30.52	2.729	11.85	0.868
16/8/'90	523.787	30.169	26.95	1.921	11.90	0.583
10/9/'90	510.314	39.495	26.09	1.805	11.70	1.177

Notes :

Cs = σ = Crushing strength.

Pr = Penetrometer Reading.

SSC = Soluble Solids Content.

Std = Standard deviation.

Table 2 : The average of crushing strength, penetrometer reading and soluble solids content, and their standard deviation of Royal Gala and Gala apples.

Variety	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
RG(15/3)	348.122	30.249	18.16	2.413	11.48	1.043
RG(26/2)	441.137	64.426	23.59	4.501	11.80	1.111
GL(26/2)	503.977	46.635	24.08	3.599	12.23	0.858
GL(15/2)	465.258	49.809	22.70	3.393	11.98	0.715

Note :

RG(15/3) = Royal Gala apples harvested at 15/3/1990.

RG(26/2) = Royal Gala apples harvested at 26/2/1990.

GL(26/2) = Gala apples harvested at 26/2/1990.

GL(15/2) = Gala apples harvested at 15/2/1990.

Table 3 : The average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation for Royal Gala apples.

Picking date	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
21/12/'90	1671.359	115.868	93.14	8.960	8.663	0.360
04/01/'91	1394.550	72.122	84.78	5.452	9.413	0.386
11/01/'91	1299.347	98.377	76.69	7.483	9.888	0.454
18/01/'91	1185.419	109.636	73.11	6.545	10.05	0.498
25/01/'91	1102.005	90.391	64.87	6.811	10.08	0.380
01/02/'91	1019.895	56.732	62.67	4.868	10.23	0.632
08/02/'91	956.425	55.598	60.70	3.872	10.24	0.698
15/02/'91	875.491	53.194	54.73	4.997	10.29	0.641
24/02/'91	817.614	54.150	54.40	4.703	11.00	0.661
01/03/'91	752.070	50.010	49.06	4.486	11.44	1.102
08/03/'91	716.220	57.236	49.65	3.909	11.89	0.746
14/03/'91	658.209	51.829	50.26	3.796	11.76	0.680
26/03/'91	600.400	55.725	47.96	3.531	12.40	1.080

Table 4 : The average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation for Gravenstein apples.

Picking date	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
21/12/'90	1037.150	75.675	63.80	5.176	8.450	0.498
04/01/'91	838.271	76.313	53.18	5.824	9.638	0.671
11/01/'91	753.949	75.544	49.67	4.158	10.28	0.908
18/01/'91	686.216	66.014	46.36	4.079	10.94	0.903
25/01/'91	617.060	49.213	42.20	4.123	10.98	1.107
28/01/'91	598.426	52.312	42.59	4.647	11.13	1.053
05/02/'91	544.960	46.970	40.21	3.650	10.90	0.700
12/02/'91	541.428	40.347	41.12	3.112	11.66	0.951

Table 5 : The average values of moment, penetrometer reading and soluble solids content, and their standard deviation for Gravenstein and Royal gala apples.

Variety	Blade	Moment (N/m2)	Std (N/m2)	Pr (N)	Std (N)	SSC (%)	Std (%)
Grvst	Big	0.124862	0.010261	41.19	3.35	11.90	1.03
	Small	0.029896	0.002949	41.19	3.35	11.90	1.03
RG	Big	0.163123	0.020886	49.92	4.41	11.40	0.95
	Small	0.039573	0.011097	49.92	4.41	11.40	0.95

Note : Grvst = Gravenstein.
RG = Royal Gala.

Tests on Kiwifruit.

Average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation for Hayward kiwifruit as a function of fruit maturation are presented in Table 6.

Table 6 : The average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation during the fruit maturation.

Harvest Date	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
18/4/1990	1593.202	92.482	84.58	5.692	4.475	0.402
02/5/1990	1491.690	115.037	75.71	3.856	5.225	0.432
16/5/1990	1215.580	140.882	75.02	5.053	7.300	0.828
23/5/1990	1044.871	103.835	67.86	3.716	8.025	0.928
30/5/1990	974.697	133.291	68.94	5.399	8.325	1.132
06/6/1990	837.172	124.716	63.16	6.698	8.800	1.470

The crushing strength and penetrometer reading were correlated with the soluble solids content. Graphs illustrating the relationship between soluble solids content and crushing strength, and soluble solids content and penetrometer reading were drawn. The trends of the crushing strength, penetrometer reading and SSC were also represented in the form of graphs (see discussion section below).

Average values of crushing strength, penetrometer reading and soluble solids content, together with their standard deviation as a function of the storage period are presented in Table 7.

Table 7 : The average values of crushing strength, penetrometer reading and soluble solids content, and their standard deviation as a function of the storage time.

Storage period (days)	Cs (kPa)	Std (kPa)	Pr (N)	Std (N)	SSC (%)	Std (%)
0	321.118	65.293	28.980	10.945	10.90	1.338
7	239.777	31.294	22.066	6.012	10.50	0.851
14	171.216	14.466	10.150	0.941	12.03	0.698
21	119.841	19.122	8.630	1.187	11.33	1.268
28	103.992	7.638	8.091	1.314	11.88	0.687
35	106.062	11.475	6.987	1.177	11.10	0.995
42	96.509	10.008	6.620	0.814	12.18	1.154
49	92.992	14.131	6.816	0.967	12.78	1.383

The values of crushing strength, penetrometer reading and SSC were correlated with storage time. Graphs representing the relationships between crushing strength, penetrometer reading and SSC were drawn (see below).

VIII. ANALYSIS OF RESULTS.

Apples.

In the first series of experiments on Granny Smith apples, the relationship between the crushing strength and storage time had a coefficient of correlation (R^2) of 0.9648 while the relationship between the penetrometer reading and storage time, and between the SSC and storage time produced R^2 values of 0.9678 and 0.4973 respectively. The graphs representing the relationship between the crushing strength, penetrometer reading and SSC, and storage time are shown in Figure 7, 8, and 9 respectively.

Within the second series of experiment, the ANOVA employing randomized block design showed that the crushing strengths and penetrometer readings produced by Royal Gala apples of two different harvest dates with 18 days alternate were very significantly different (observed F value of 0.0001) while the SSCs produced by the same fruit were not significantly different (observed F value of 0.3584).

The ANOVA employing the same design for Gala apples harvested on dates with 9 days difference indicated that only the crushing strength values were significantly different. The observed F values for the crushing strength, penetrometer reading and SSC were 0.0180, 0.2562 and 0.3356 respectively.

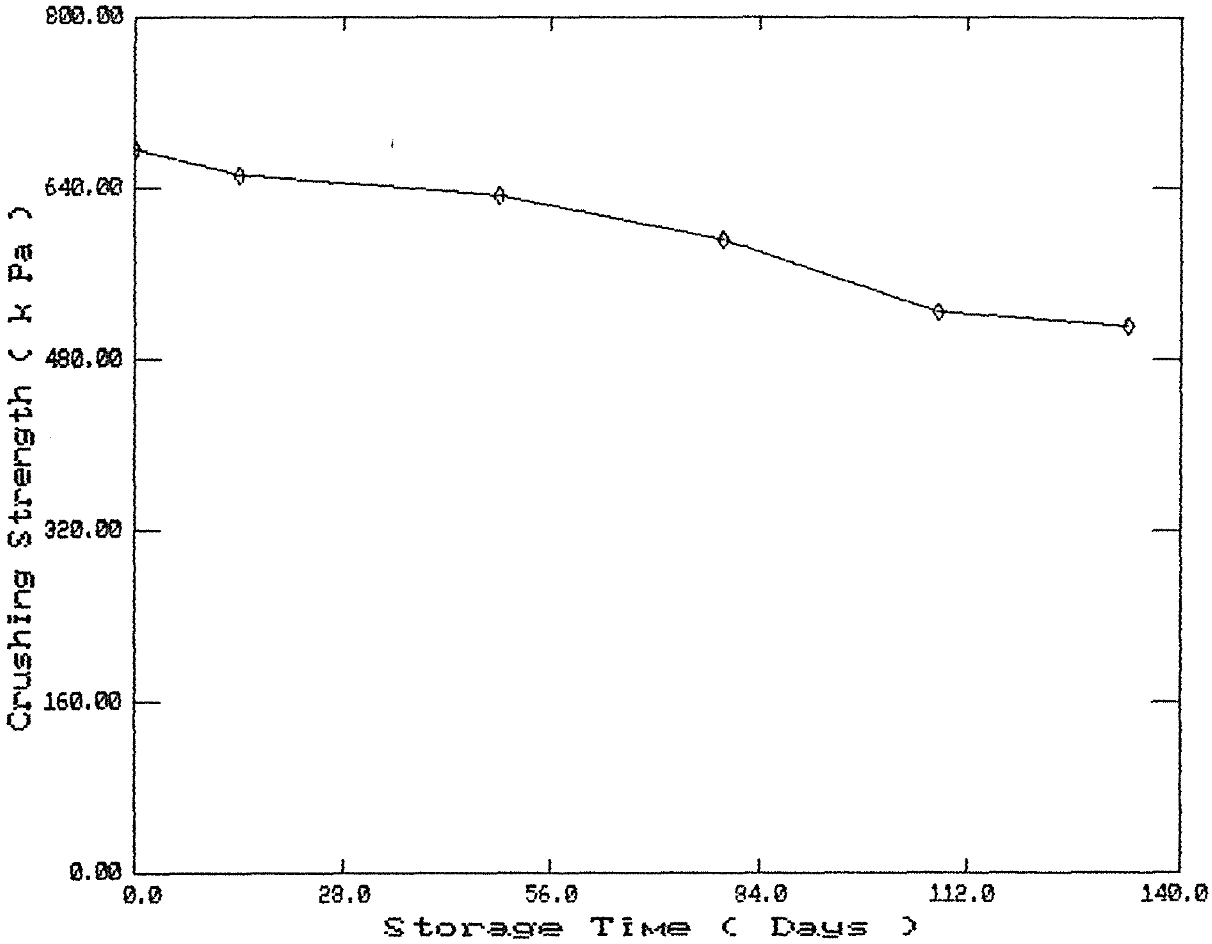

Figure 7 : Graph of storage time against crushing strength of Granny Smith apples.

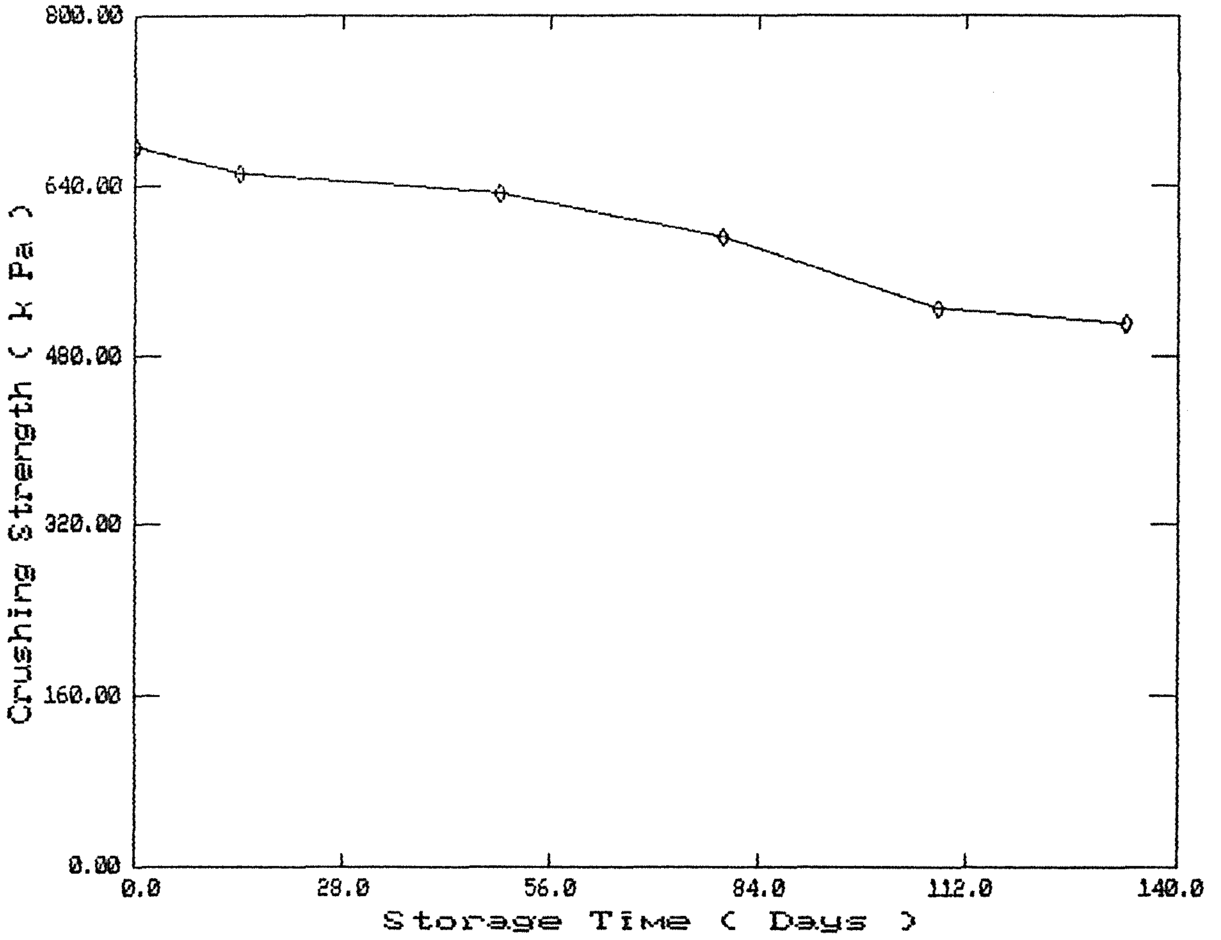

Figure 8 : Graph of storage time against penetrometer reading of Granny Smith apples.

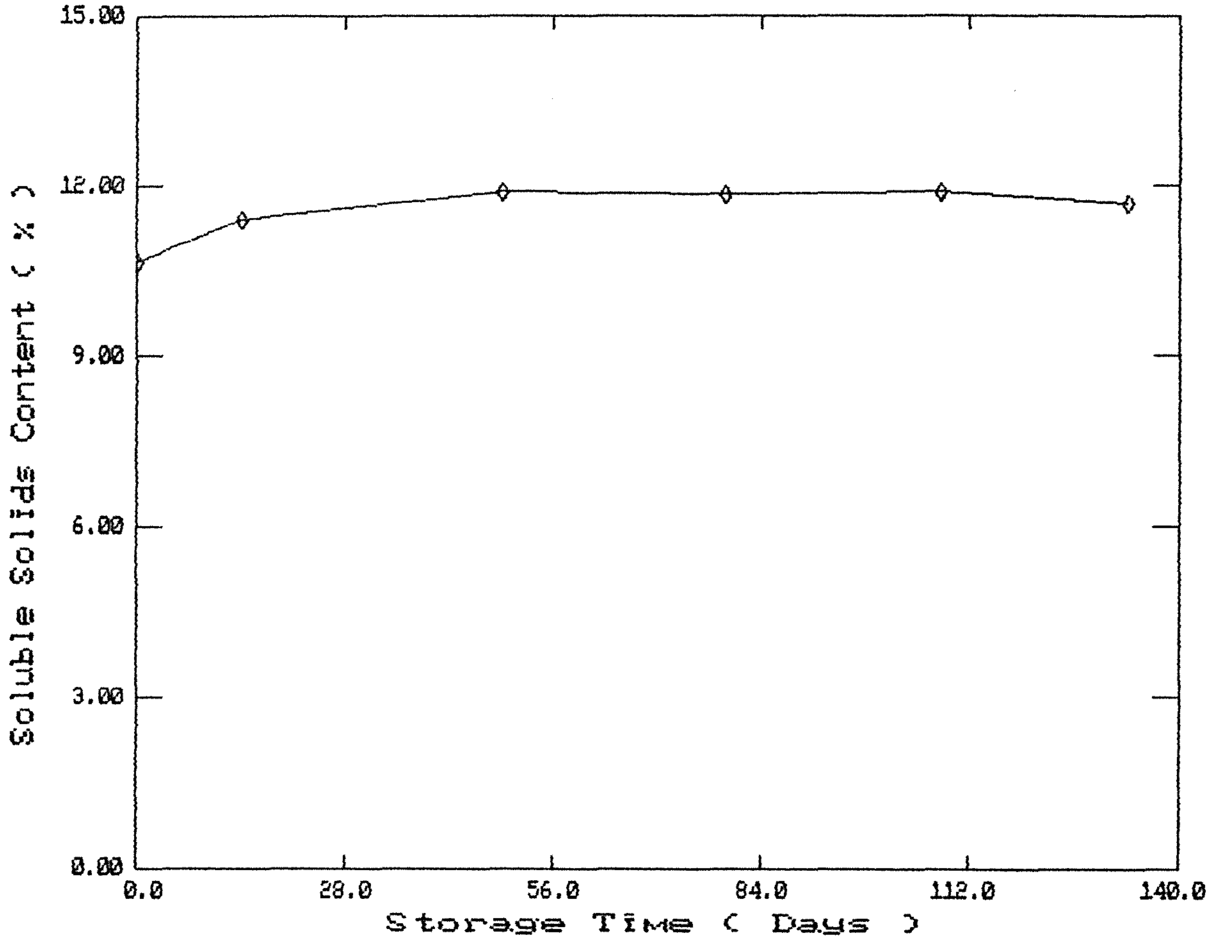

Figure 9 : Graph of storage time against soluble solids content of Granny Smith apples.

The third series of experiments on Royal Gala apples show that the crushing strength, penetrometer reading and SSC correlated with the first and second harvesting dates with R^2 values of 0.9716, 0.9415 and 0.9285 respectively. When the values of crushing strength, penetrometer reading and SSC were correlated with the third harvesting date, R^2 values of 0.9645, 0.9179 and 0.9447 were obtained. The trends of the crushing strength, penetrometer reading and SSC until the last harvest in respect to the first harvesting date are given in Figure 10, 11 and 12.

For Gravenstein apples, the crushing strength, penetrometer reading and SSC correlated with the first harvesting date with R^2 values of 0.9881, 0.9776 and 0.9586. These values correlated with the second harvesting date with R^2 values of 0.9832, 0.9666 and 0.8702 respectively. When the values of crushing strength, penetrometer reading and SSC were correlated with the third harvesting date, R^2 values of 0.9474, 0.8990 and 0.9374 were respectively produced. The trends of the crushing strength, penetrometer reading and SSC until the last harvest in respect to the first harvesting date are shown in Figure 13, 14 and 15 respectively.

From the fourth series of experiments, the ratio between the volume of cutting material produced by the big blade and that produced by the small blade was 4.092 while the ratiös of the average moments produced by the big blade and those from the small blade were 4.122 for Royal Gala apples and 4.1765 for Gravenstein apples.

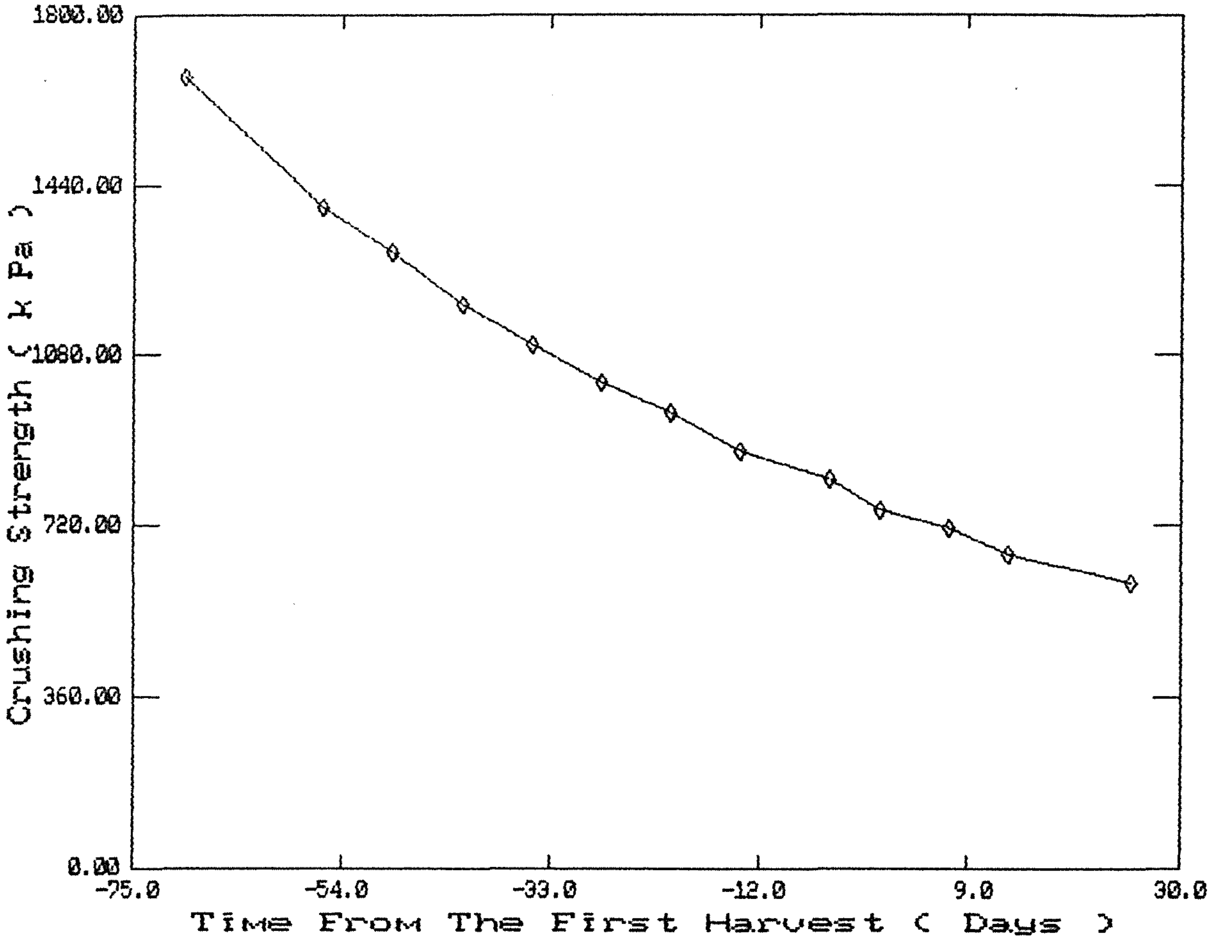

Figure 10 : Graph of time from the first harvest against crushing strength of Royal Gala apples.

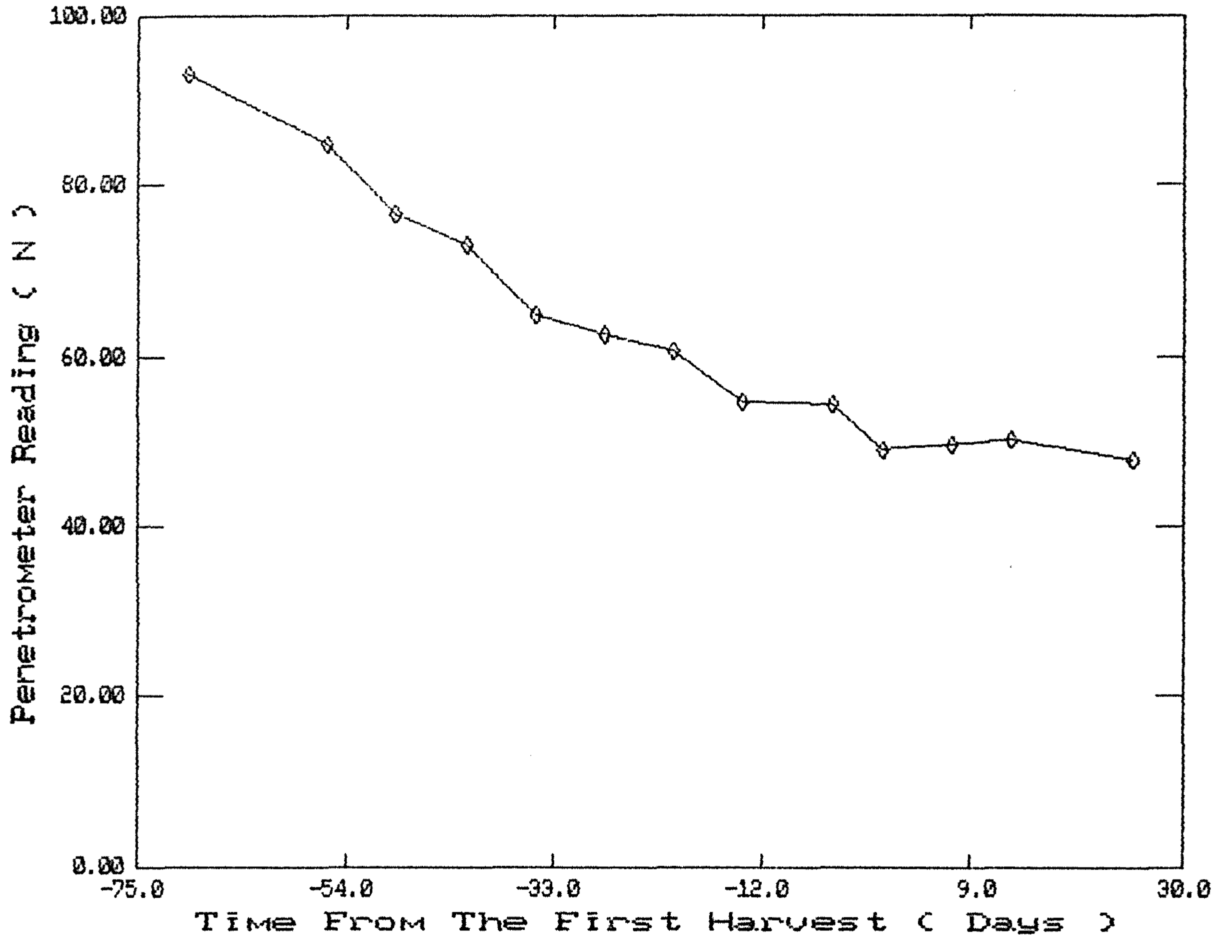

Figure 11 : Graph of time from the first harvest against penetrometer reading of Royal Gala apples.

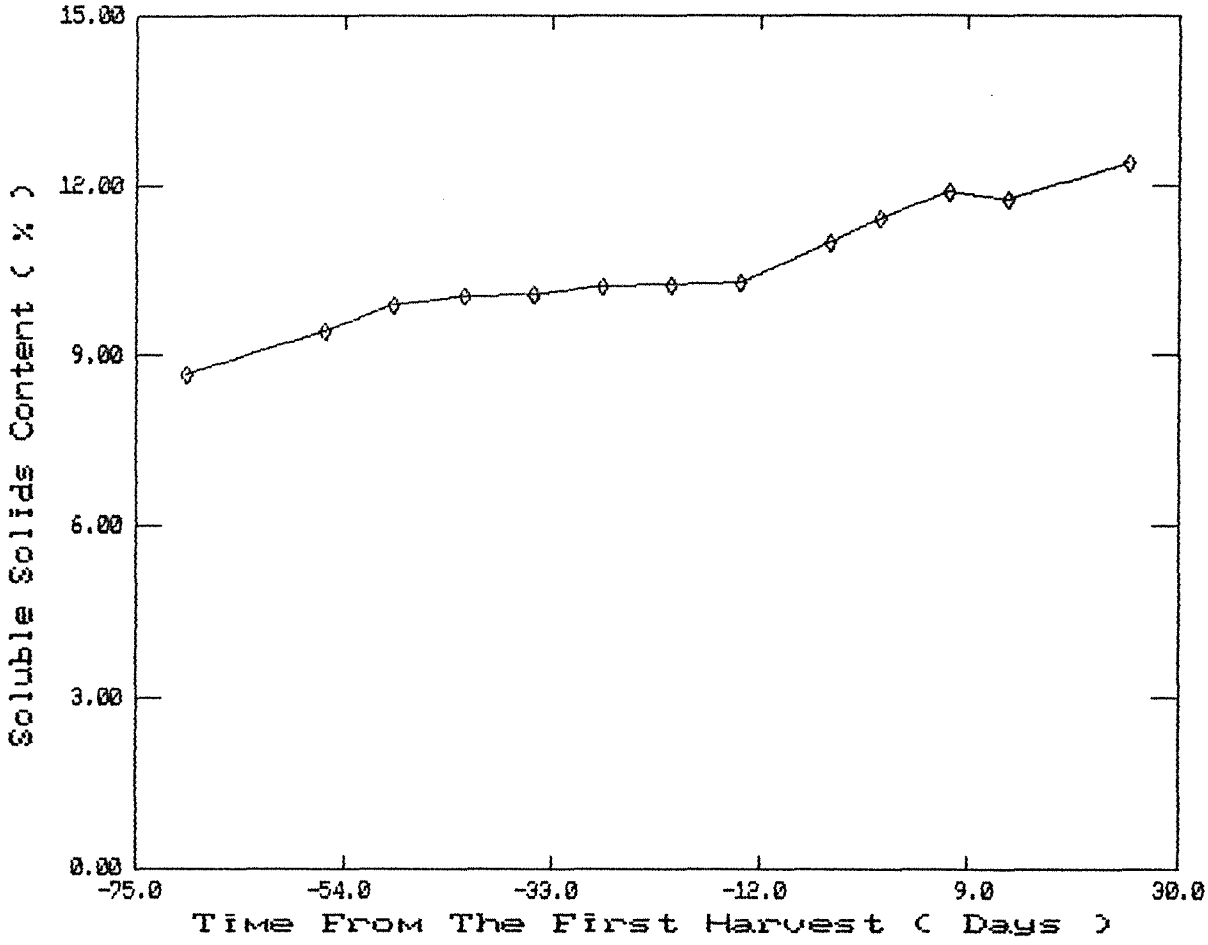

Figure 12 : Graph of time from the first harvest against soluble solids content of Royal Gala apples.

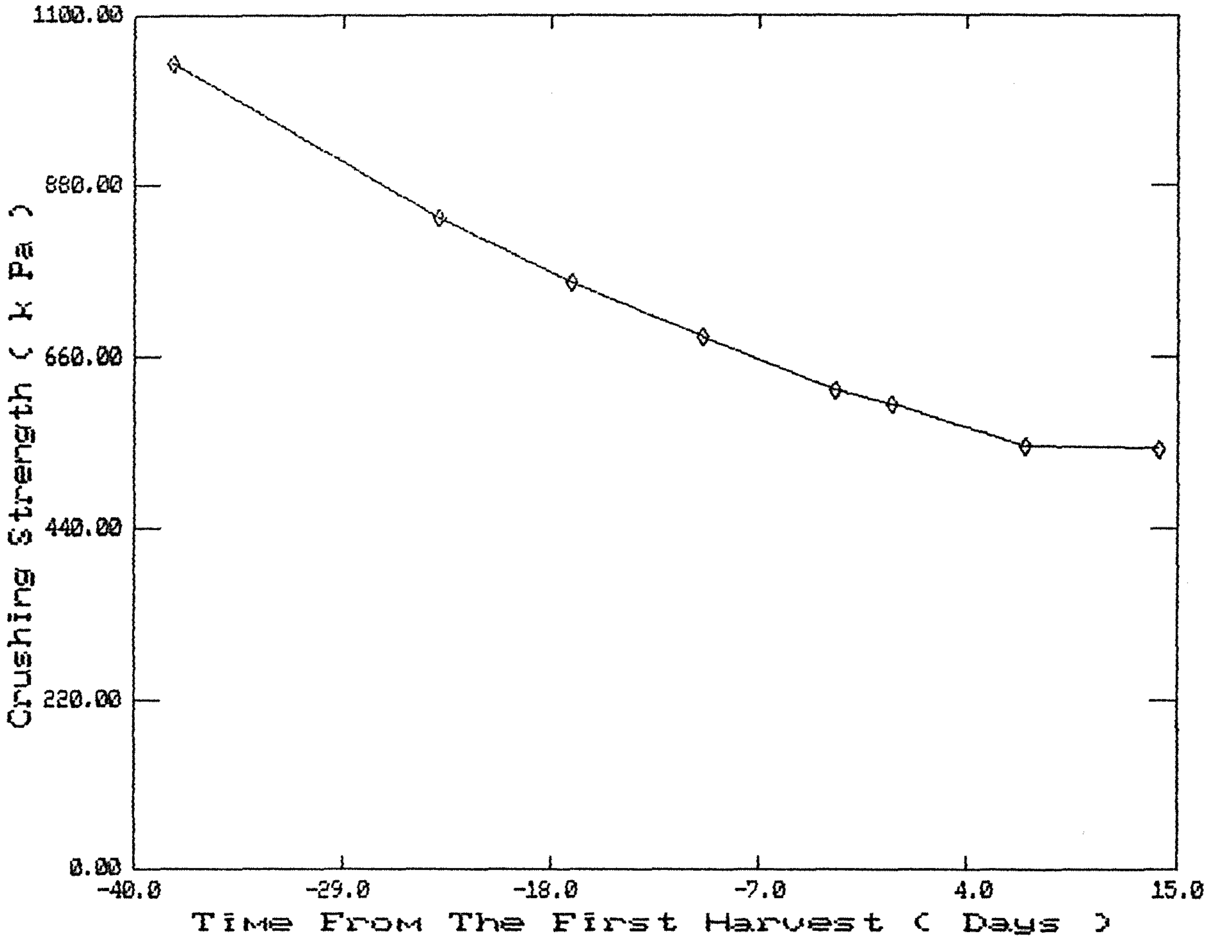

Figure 13 : Graph of time from the first harvest against crushing strength of Gravenstein apples.

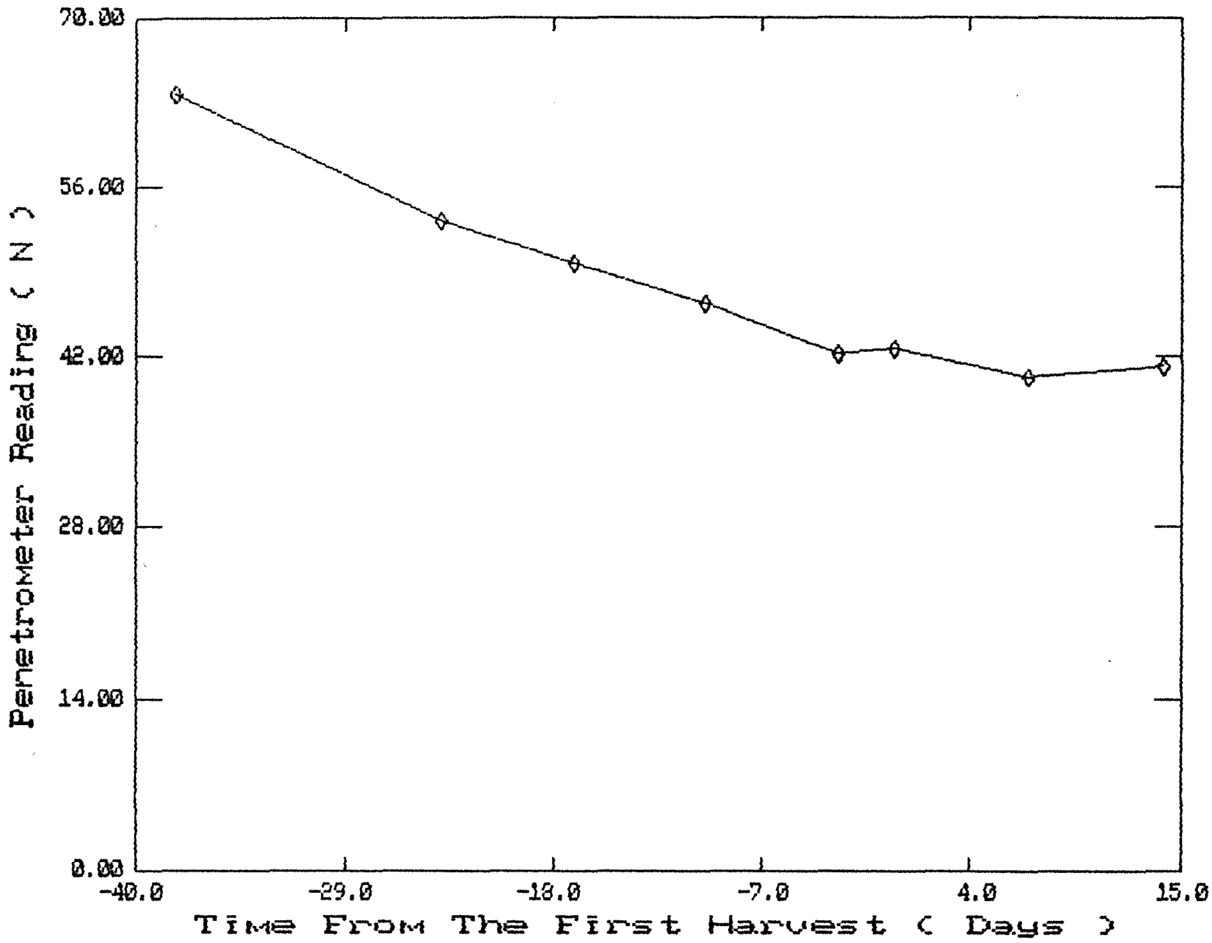

Figure 14 : Graph of time from the first harvest against penetrometer reading of Gravenstein apples.

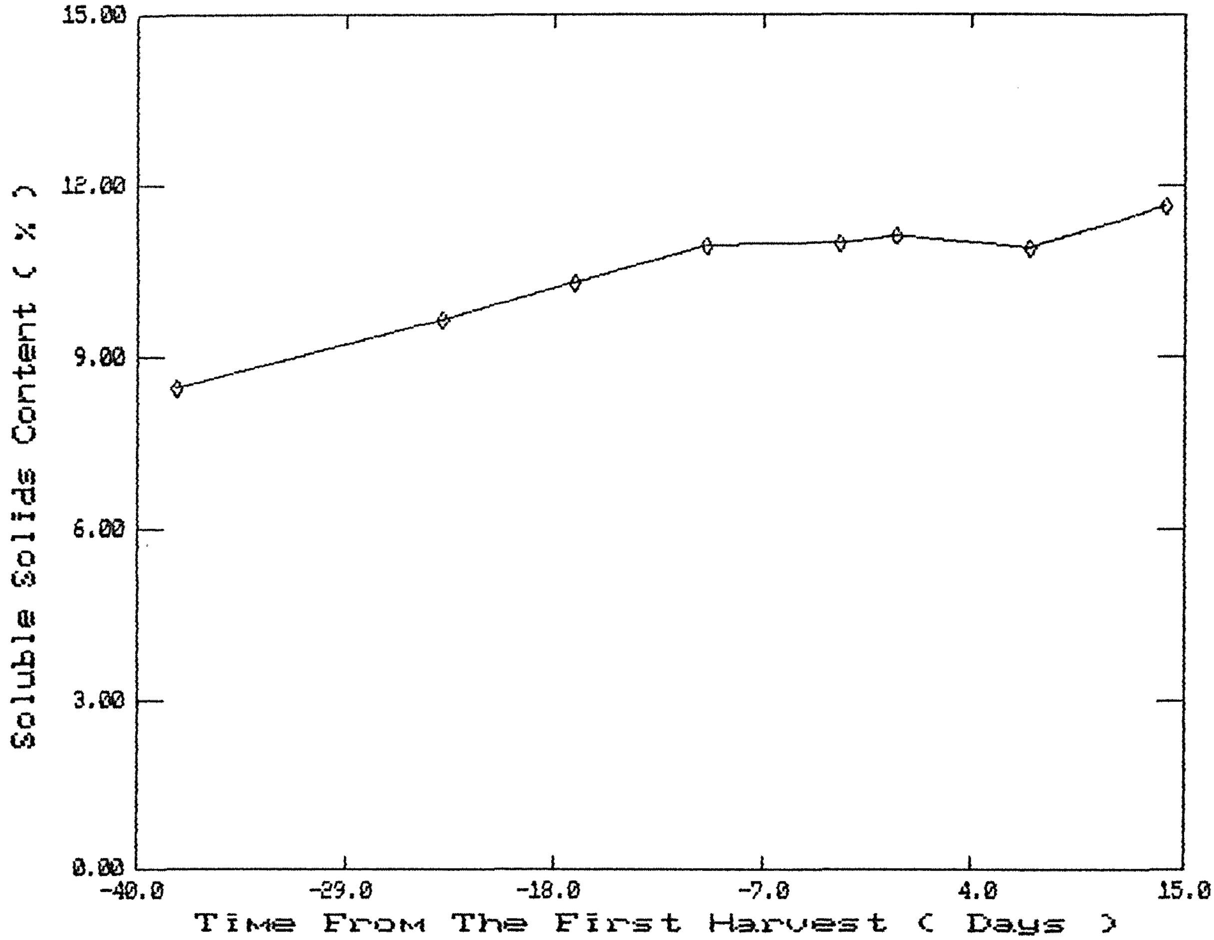

Figure 15 : Graph of time from the first harvest against soluble solids content Gravenstein apples.

Kiwifruit.

In the first series of experiments, the relationship between SSC and crushing strength had a coefficient of correlation (R^2) of 0.9793 whereas the relationship between SSC and penetrometer reading only produced a R^2 value of 0.8575. The graph representing the relationship between the SSC and the crushing strength is given in Figure 16 while the graph representing the relationship between the SSC and the penetrometer reading is given in Figure 17. The trends of crushing strength, penetrometer reading and SSC in respect to the minimum harvest maturity (at SSC of 6.2%) during the fruit maturation are illustrated in Figures 18, 19 and 20 respectively.

In the second series of experiments, the relationship between crushing strength, penetrometer reading and SSC, and storage time produced R^2 values of 0.7817, 0.6996 and 0.5541 respectively. The trends of crushing strength, penetrometer reading and SSC during storage are illustrated in Figures 21, 22 and 23 respectively.

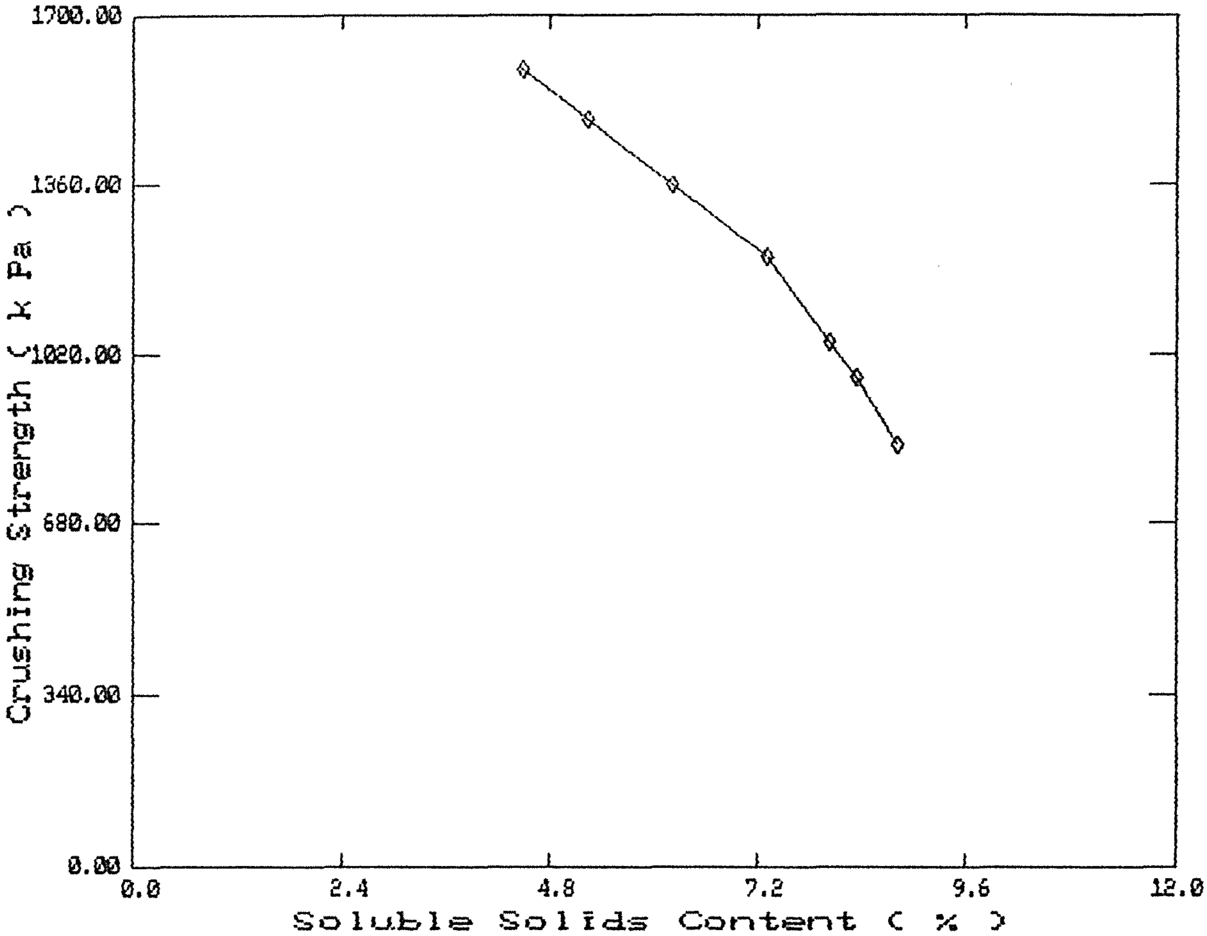

Figure 16 : Graph of soluble solids content against crushing strength of Hayward kiwifruit.

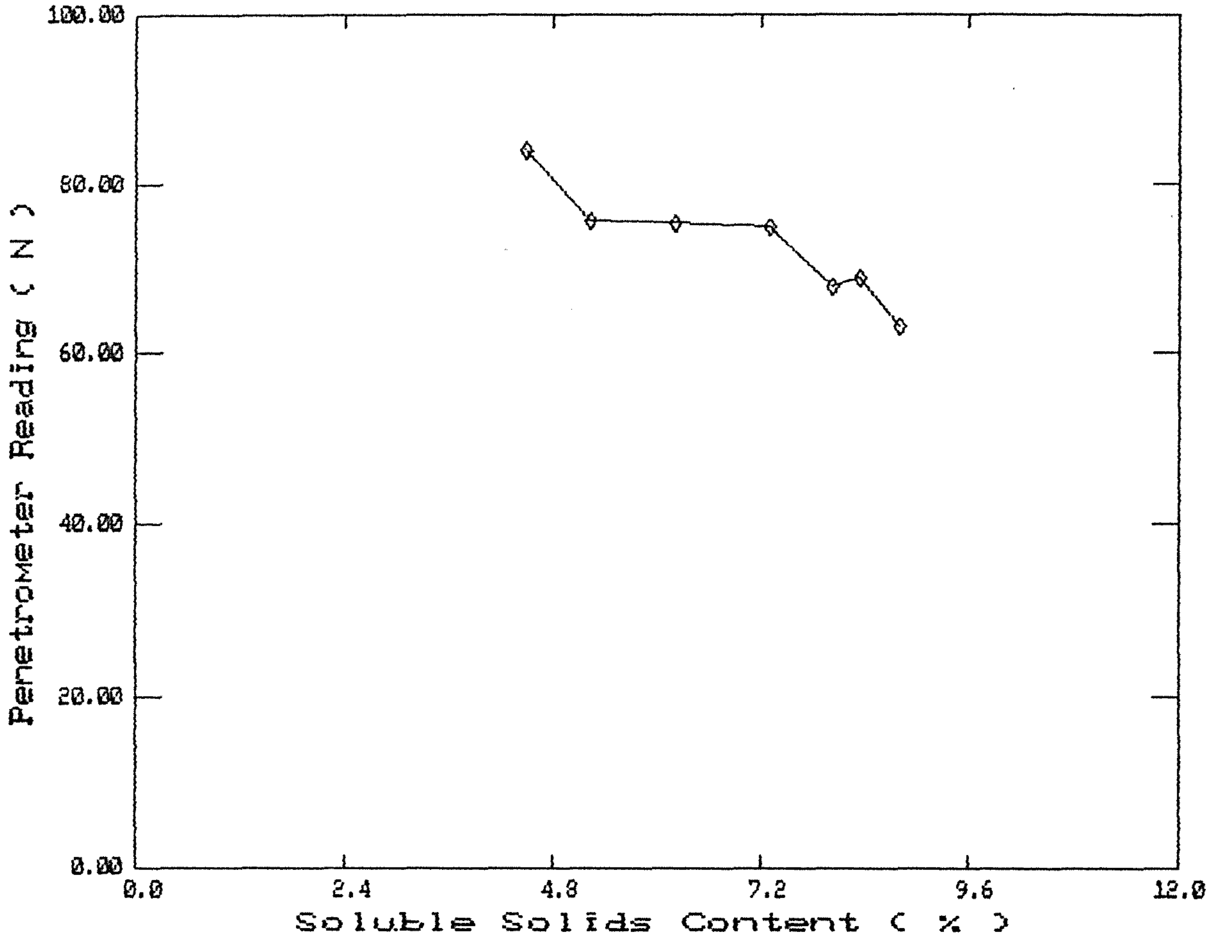

Figure 17 : Graph of soluble solids content against penetrometer reading of Hayward kiwifruit.

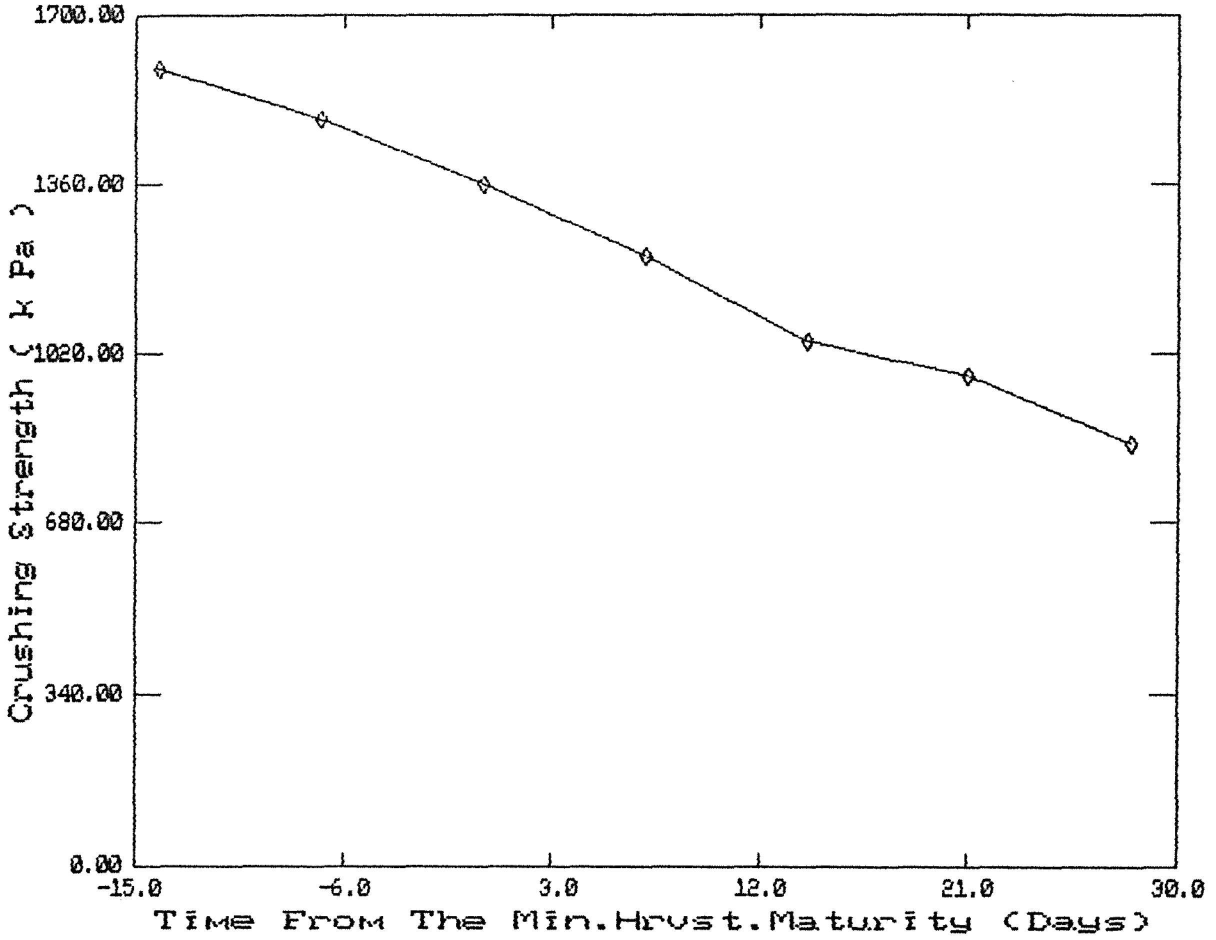

Figure 18 : Graph of time from the minimum harvest maturity against crushing strength of Hayward kiwifruit.

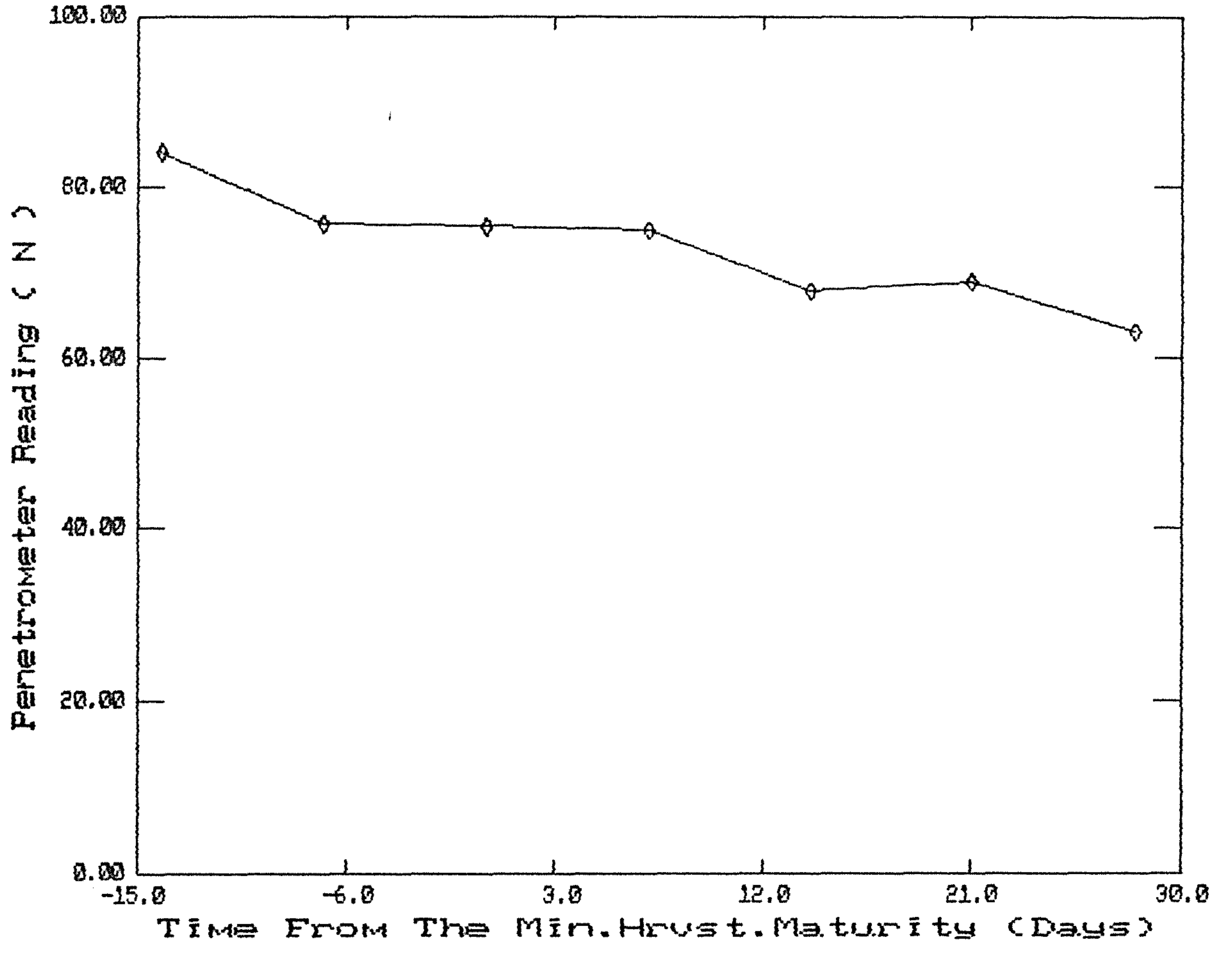

Figure 19 : Graph of time from the minimum harvest maturity against penetrometer reading of Hayward kiwifruit.

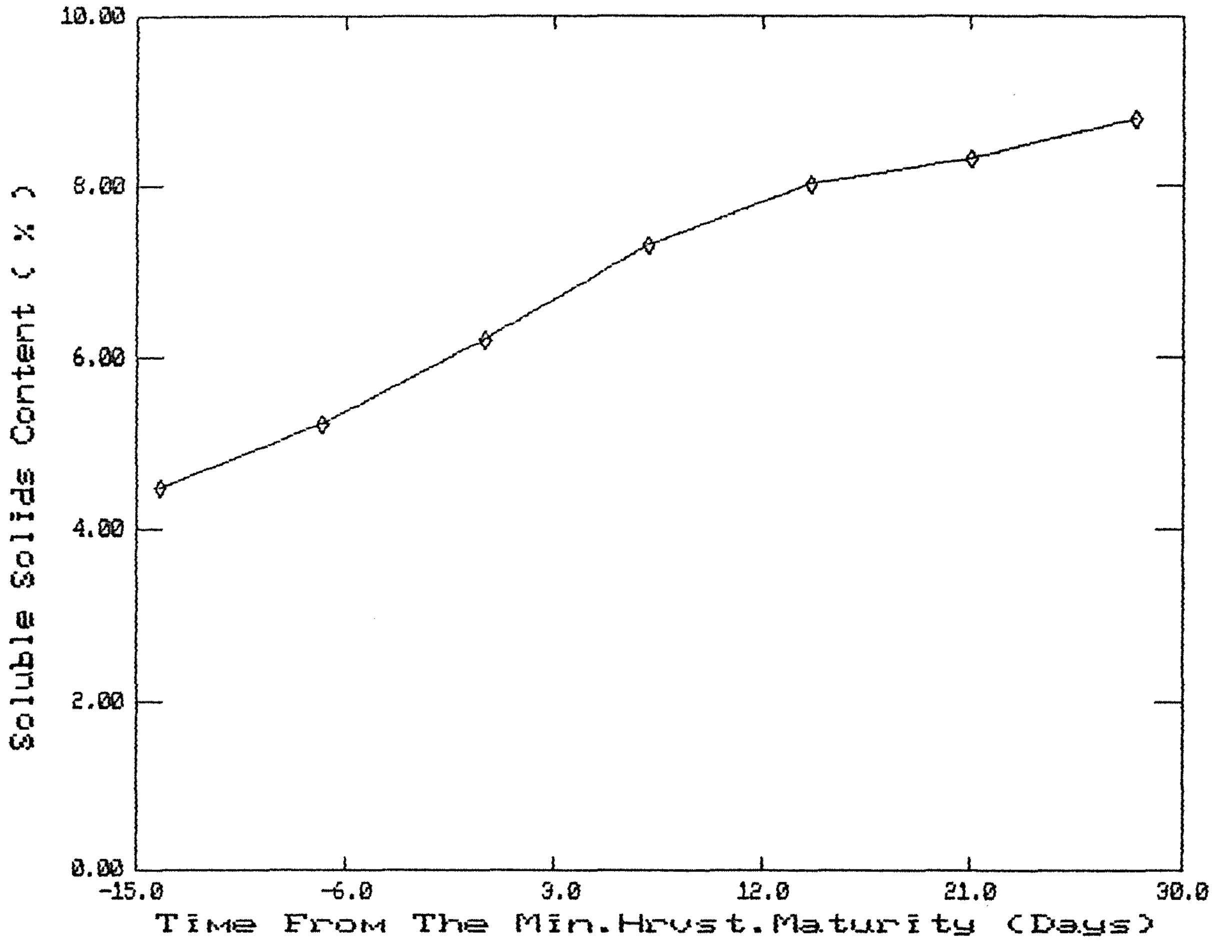

Figure 20 : Graph of time from the minimum harvest maturity against soluble solids content of Hayward kiwifruit.

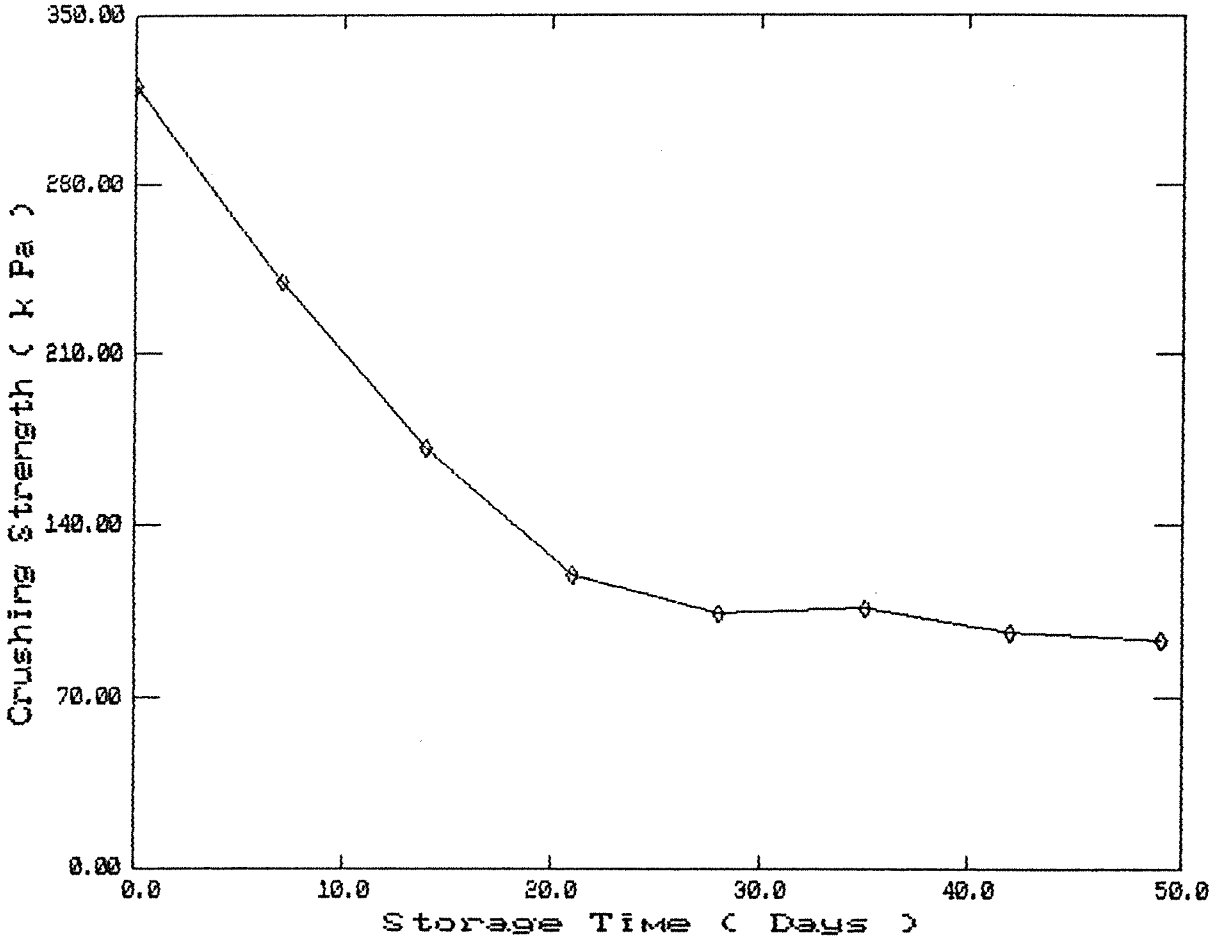

Figure 21 : Graph of storage time against crushing strength of Hayward kiwifruit.

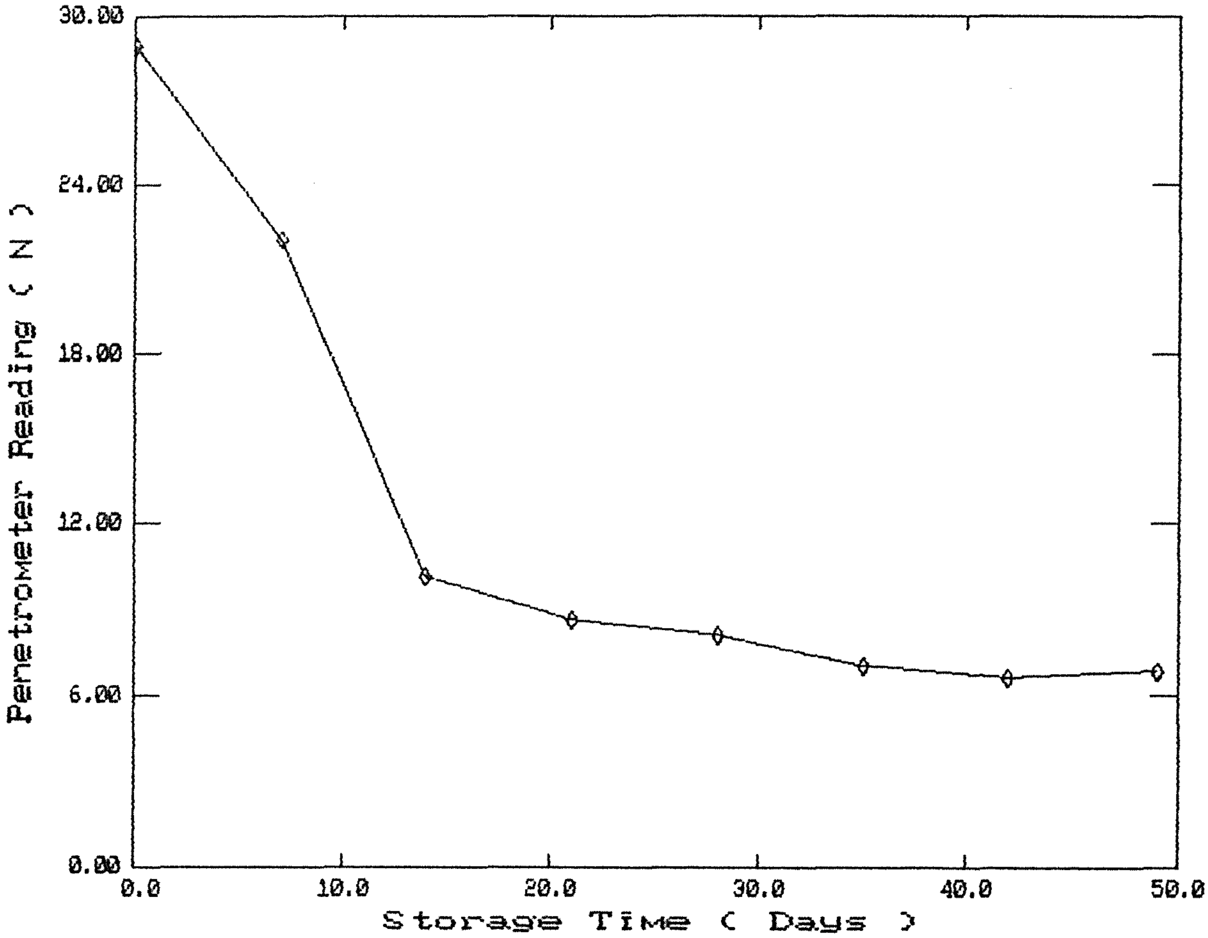

Figure 22 : Graph of storage time against penetrometer reading of Hayward kiwifruit.

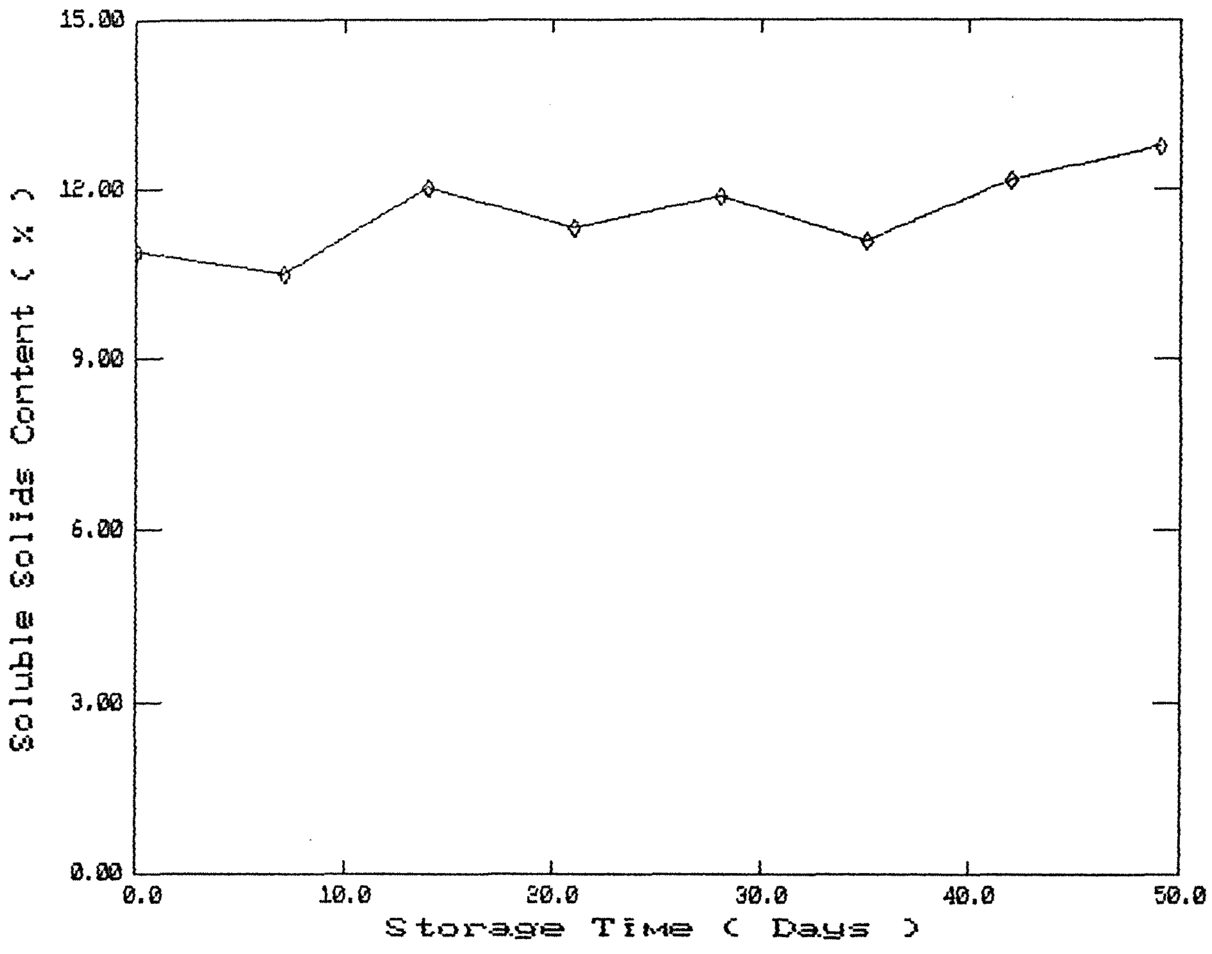

Figure 23 : Graph of storage time against soluble solids content of Hayward kiwifruit.

IX. DISCUSSION.

Apples.

The first series of experiments indicated that both the crushing strength and penetrometer reading of Granny Smith apples decreased whereas the SSC increased during cool storage. Within 133 days the average crushing strength decreased from 678 kPa to 510 kPa while the average penetrometer reading decreased from 35 N to 26 N. The average SSC increased from 10.65% to 11.70%. The relationship between the crushing strength and storage time, and the penetrometer reading and storage time produced comparable R^2 values and nearly twice the R^2 value produced by the relationship between the SSC and storage time. However, the average standard deviation of the crushing strength was smaller than the average standard deviation of the penetrometer reading (5.5% compared with 7.6%). This suggests that the twist test is relatively more reliable when used to trace changing mechanical properties (softening) of apples during cool storage.

From the second series of experiments, it can be seen that both the twist test and penetrometer test were able to distinguish the difference in the mechanical properties of Royal Gala apples of two different harvest dates since both the twist strengths and penetrometer readings were significantly different. With Gala apples, however, only the twist test was able to distinguish the apples of two different degrees of maturity (different harvest dates). For both Royal Gala and Gala apples, the Brix test was not able to distinguish the fruit with respect to maturity difference. This finding suggests that the twist test has higher resolution than both the penetrometer test and the Brix test in characterizing fruit properties.

From the third series of experiments, the crushing strength and penetrometer reading decreased, and the SSC increased during the fruit maturation. For Royal Gala apples, within 95 days, counted from 70 days before the first harvest, the average crushing strength decreased from 1671 kPa to 600 kPa while the average penetrometer reading decreased from 93 N to 48 N. The average SSC increased from 8.66% to 12.40%. The average standard deviation of the crushing strength was smaller than the average standard deviation of the penetrometer reading (7.06% compared with 8.44%). The crushing strength had the highest coefficient of correlation with the first, second and third harvesting dates, followed respectively by the penetrometer reading and then the SSC.

When correlated with the first and second harvesting dates for Gravenstein apples, from 38 days before first harvest to 14 days after, the average crushing strength decreased from 1037 kPa to 541 kPa while the average penetrometer reading decreased from 64 N to 41 N. The average SSC increased from 8.45% to 11.66%. The average standard deviation of the crushing strength was smaller than that of the penetrometer reading (8.59% compared with 9.17%). The crushing strength also had the highest coefficient of correlation, followed by the penetrometer reading and then the SSC. When correlated with the third harvest for these Gravenstein apples, the ranking of the coefficient correlation was crushing strength - the SSC - the penetrometer reading.

This finding suggests that the twist test can be more reliably used for predicting apple maturity than the penetrometer test or the Brix test.

The values of the crushing strengths between the first and the third harvests for Royal Gala apples were in the range of 750 to 600 kPa while for Gravenstein apples they were in the range of 600 to 540 kPa. Compression stress and shear stress values for matured apples obtained by ordinary tests varied too much depending on the methods used (Mohsenin, 1986, and Mohsenin and Gohlich, 1962). The former was in the range of 300 to 1200 kPa while the latter was in the range of 180 to 420 kPa. The values of crushing strength measured by the twist test are clearly consistent with this range of values for the compression strength of matured apples.

The fourth series of experiments analyzed whether the measured moment was a representative force to crush the cutting fruit material or not. This was done by substituting experimental values for the two blades in equation (11). Using two blades with a_1 = 4.91 mm and b_1 = 7.81 mm, and a_2 = 3.35 mm and b_2 = 4.10 mm, the calculated value of A_1/A_2 was 2.504 and the calculated value of B_1/B_2 was 4.092. As has been shown the corresponding measured M_1/M_2 values for Royal Gala and Gravenstein apples were 4.122 and 4.177 respectively. These values were close to the value of B_1/B_2. It was evident that the measured M is comprised mainly of compression.

The values of K_s and K_c can be found by solving Equation (11), assuming C is small, by using the measured M values and the corresponding blade dimensions. The example of this solution is given in Appendix 7. The K_s and K_c values for Royal Gala apples were -24.67 N/m and 0.8734 MPa respectively whereas those for Gravenstein apples were -59.53 N/m and 0.682 MPa respectively.

It can be seen that for both Royal Gala and Gravenstein apples, the K_s values were negligibly small. This confirms that the measured moment was due to compression only. In other words, the twist test merely measured the force to crush the fruit. In this case K_c approached σ in Equation (8), so it is reasonable to say that the twist test measured the crushing strength (Cs) of the fruit being tested.

Kiwifruit.

The first series of experiment for these fruit showed that during fruit maturation both the crushing strength and penetrometer reading decreased whereas the SSC increased. Within 64 days, counted from the minimum harvest maturity, the average crushing strength decreased from 1593 kPa to 837 kPa while the average penetrometer reading decreased from 85 N to 63 N. The average SSC increased from 4.48% to 8.80%. The coefficient of correlation produced by the relationship between the crushing strength and SSC was higher than that produced by the relationship between the penetrometer reading and SSC. The degree of linearity of the relationship between the crushing strength and the SSC was very high (R^2 = 0.979). The crushing strength more steadily decreased with increasing SSC, producing a curve that was almost a straight line (see Figure 16) than the penetrometer reading (see Figure 17). The changes of the crushing strength as the fruit matured was also more steady than the change of the penetrometer reading and the SSC (see Figures 18, 19 and 20). Since the only reliable index of kiwifruit maturity is SSC, this finding suggests that the twist test could also be used reliably for predicting the maturity of kiwifruit.

The second series of experiments indicated that during cool storage, the crushing strength and penetrometer reading decreased while the SSC increased. In 49 days, the average of crushing strengths decreased 321 kPa to 93 kPa, and the average of penetrometer readings decreased from 29 N to 6.8 N. The average of SSC increased from 10.90% to 12.78%. The average standard deviation of the crushing strength was smaller than the average standard deviation of the penetrometer reading (13.86% compared with 23.75%). The R^2 value produced by the relationship between the crushing strength and storage time was highest, followed by that produced by the relationship between the penetrometer reading and storage time, and then the relationship between the SSC and storage time. This finding suggests that even though the R^2 value of the relationship between the crushing strength and storage time was not very high, if a test must be chosen from these three tests to trace softening of kiwifruit during cool storage, then the choice should be the twist test.

Comparison of Twist Test with Other Methods.

On a statistical basis, there is no doubt that the twist test proved to be more reliable when used to assess apple and kiwifruit maturity and to trace softening of these fruit during cool storage than the penetrometer test.

The twist test is easy to operate. Because of this convenience the test has been able to minimize the risk of human error. This can be seen in that in almost all the tests conducted here the average standard deviation produced by the twist tests was smaller than that from the penetrometer tests.

Surprisingly, the average standard deviation of the penetrometer reading for soft fruit was almost twice the average standard deviation of the crushing strength (see during cool storage of kiwifruit). This latter fact suggests the unreliability of the penetrometer for testing soft fruit. There will be a problem of using the penetrometer to assess eating quality of kiwifruit, since this fruit is eaten ripe with flesh firmness below 0.5 kg (using 7.9 mm penetrometer probe). The twist test could solve this problem.

It is important to note that when the twist test is employed for testing soft fruit, the bigger blade should be used. This will ensure that the fruit being tested is more stable in position and thus more easily handled.

There has long been concern about the association of core firmness of kiwifruit with fruit acceptability. Stec, et al (1989) reported that core firmness showed a significant correlation with fruit flavour and aroma intensities in which low core firmness indicated high flavour and aroma intensities. The core firmness measurement was done using a penetrometer with 8 mm conical tip after the fruit had been sectioned longitudinally. Recently, a star penetrometer has been used in New Zealand. This measurement is relatively time consuming. Since the twist test can be operated for measurement at different depths without sectioning the fruit, it would also be convenient for anyone intending to measure the fruit's core, for example, Stec et al.

The effect of testing speed has been discussed by some workers. Bourne (1965) and Holt (1970) showed within the tested range of penetrometer test (0.05 to 50 cm/min) that there appeared to be little effect due to the rate of force application. On the other hand Peleg (1974) indicated that some increase in the resistance of papayas occured if the speed changed from 20 to 50 cm/min. In the twist test here when the testing speed was increased from normal rate (about 3 second for completing the test) to as high as the hand can sustain (less than one second to complete the test) the crushing strength of Royal Gala apples was increased about 30%. Data for this simulation is given in Appendix 8. The effect would be negligible if the speed of the test was only increased slightly above the normal speed, since erratic motion in doing the twist test could be avoided.

The effect of peeling the skin was also simulated within this research study. Using a sample of 20 fruit of Granny Smith variety which had been picked and then cool stored 3 days, it was found that peeling the whole skin significantly reduced the crushing strength of the fruit being tested. Data for this simulation is given in Appendix 9. Statistical analysis employing randomized block design showed that the crushing strength of peeled apples differed from the crushing strength of unpeeled apples with F value of 0.03. This finding suggests that skin removal which is normally done when performing penetrometer tests may affect the result. This evidence also suggests that the twist test has been able to retain the condition of the fruit tissue and therefore produce more reliable results than those produced by other types of destructive test.

It may be useful to relate the twist test to fruit quality. In storage of Granny Smith apples, the fruit started to show less crispness at the fourth test of this series of experiments. This time was coincidental with the average crushing strength of 592 kPa. The rate of the fruit softening in the following month from this point was twice as fast as the rate of the fruit softening in the previous month. This suggests that after a 3 month storage period, Granny Smith apples might experience quite significant changes in their texture which would affect their taste.

For Royal Gala apples, the fruit at the first harvest were very crisp and moderately sweet. The sweetness of the fruit at the second harvest were not very different from the sweetness of the fruit at the first harvest, but they were getting less crisp. The fruit at the third harvest were less crisp and sweeter than the fruit at the first and the second harvest. These fruit started to develop good aroma. The fruit at the first harvest might be suitable for storage while the fruit at the second and the third might be acceptable for direct consumption. The average crushing strengths of fruit at the first, second and third harvests were 752 kPa, 658 kPa and 600 kPa respectively.

For Gravenstein apples, the fruit at the first harvest were very crisp, their green colour was still dominant. These fruit were scarcely mature enough to eat and would have a low consumer acceptability. The fruit at the second harvest were much less crisp than the fruit at the first harvest, but these fruit were getting sweet enough to eat. The crispness and sweetness of the fruit at the third harvest were not very different from those of the fruit at the second harvest. However, these fruit produced a distinctive aroma and their ground colour disappeared. These observations suggest that the first harvest had been done too early. The fruit at the second harvest might be acceptable for storage while the fruit at the third harvest might be suitable for direct market. The averages of the twist test at the first, second and third harvests were 598 kPa, 545 kPa and 541 kPa respectively.

As stated before, the soluble solids content has been adopted as the only reliable maturity index for kiwifruit. For New Zealand conditions the maturity index of 6.2 is a minimum value for the harvest of Hayward kiwifruit. Within this experiment, this degree of maturity occurred at the stage where the fruit had a crushing strength value of 1345 kPa. It was also observed that if the fruit was harvested at the stage where their average crushing strength was 321 kPa (SSC of 10.9%), within about 1.5 months in cool storage they were ripe and produced very good taste and aroma. At this time the average crushing strength was 97 kPa and the average SSC was 12.2%.

These later facts suggest that it is also possible to adopt the twist test as a guide for fruit handling with respect to fruit quality. Royal Gala and Gravenstein apples should be harvested at the stages where their crushing strengths are about 750 kPa and 540 kPa if the fruit were for storage destination whereas they should be harvested at the stages where their crushing strengths are about 660 kPa and more than 540 kPa respectively if they are addressed for fresh market. Kiwifruit are ready to be harvested when their crushing strengths reach about 1300 kPa, and they are ready to be served on the dining table when their crushing strengths are about 97 kPa.

From this it can be concluded that the twist test is more superior than the penetrometer test. This test may be extended for testing fruit which are normally tested using the penetrometer, such as pears, peaches, figs, apricot and mangoes. Since this superiority was proved in both the fruit which softens moderately and the fruit which softens greatly, the twist test may also be introduced to test fruit which are not able to be tested using a penetrometer such as berry fruit, bananas, plums, melon, tomato and pineapple.

Since the twist test measures a clearly defined mechanical parameter, this test will be advantageous in expressing a standard quality of horticultural product. To illustrate, there will be no need to write the maturity standard of pears in the form of maximum pressure with reference to penetrometer probe size such as the standard established by The California Tree Fruit Agreement. Furthermore, if the test invented by Studman can be conducted using a portable unit equipped with a calibrated scale in the form of Pa or Kgf/m^2, this test will be powerful enough to replace all known forms of penetrometer test extant.

X. CONCLUSIONS.

From this experiment 7 conclusions were drawn :

1). During cool storage of Granny Smith apples, both the crushing strength and penetrometer reading decreased, and the SSC increased. The R^2 values produced by relationships between the crushing strength and penetrometer reading, and storage time were comparable and nearly twice the R^2 value produced by the relationship between the SSC and storage time.

2). The twist test was more sensitive in distinguishing apples of different degrees of maturity than both the penetrometer test and the Brix test.

3). The twist test merely measured the force needed to crush the cutting fruit material by the blade (compression component only in the sense of Bourne's postulate) expressed as the crushing strength of the fruit being tested.

4). The twist test more highly correlated with harvesting dates for Royal Gala and Gravenstein apples, compared with the penetrometer and Brix tests, suggesting that this test could be used more reliably as a means of assessing apple maturity.

5). During kiwifruit maturation, the twist test was more highly correlated with the SSC compared with the penetrometer test, suggesting that this test could be used as a means of predicting kiwifruit maturity.

6). During cool storage of kiwifruit, the crushing strength and penetrometer reading decreased whereas the SSC increased. The relationship between the crushing strength and storage time produced a higher R^2 value than those produced by the relationships between the penetrometer reading and storage time and between the SSC and storage time.

7). The twist test is accurate, easy, fast and flexible and might be used to test almost all fruit to assess their defined quality.

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APPENDIX 1 : Data For The First Series Of Experiment For Apples.

Granny Smith Apples, picking date : 1/5/1990.
Testing date : 1/5/1990.

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1751	34	34	3.25	10	34	0.00491	0.00782	0.124239	659.0055
2	0.1795	36.5	36.5	3.5	11.5	36.5	0.00491	0.00782	0.132155	700.9951
3	0.2153	34	35	3.45	11	34.5	0.00491	0.00782	0.125841	667.5063
4	0.2182	40	38	3.55	10	39	0.00491	0.00782	0.139819	741.6503
5	0.1824	36	38	3.55	11	37	0.00491	0.00782	0.133708	709.2354
6	0.1965	37	35	3.4	11	36	0.00491	0.00782	0.130591	692.7014
7	0.1978	34	32	3.2	10	33	0.00491	0.00782	0.121005	641.8538
8	0.2097	35	34	3.45	10	34.5	0.00491	0.00782	0.125841	667.5063
9	0.1665	35	35	4.4	11	35	0.00491	0.00782	0.127434	675.9564
10	0.1635	35	39	3.65	10	37	0.00491	0.00782	0.133708	709.2354
11	0.1811	31	32	3.9	11	31.5	0.00491	0.00782	0.116086	615.7614
12	0.1935	36	37	3.4	10	36.5	0.00491	0.00782	0.132155	700.9951
13	0.2559	34	33	3.5	10	33.5	0.00491	0.00782	0.122627	650.4544
14	0.186	34.5	33	3.55	10	33.75	0.00491	0.00782	0.123434	654.7362
15	0.1726	35	35	4.15	12	35	0.00491	0.00782	0.127434	675.9564
16	0.1661	34	35	3.8	11	34.5	0.00491	0.00782	0.125841	667.5063
17	0.1711	35	36	3.5	11	35.5	0.00491	0.00782	0.129018	684.3549
18	0.1564	37	37	3.85	10.5	37	0.00491	0.00782	0.133708	709.2354
19	0.2111	34	35	3.85	11	34.5	0.00491	0.00782	0.125841	667.5063
20	0.1905	33	35	3.45	11	34	0.00491	0.00782	0.124239	659.0055
Avg	0.18944	35	35.2	3.61	10.6	35.11	0.00491	0.00782	0.127736	677.5579
Std	0.02326	1.78	1.90	0.28	0.59	1.681	0	********	0.005322	28.23032

Note :
A1 = First angle measurement for fruit.
A2 = Second angle measurement for fruit.
Pr = Penetrometer reading.
SSC = Soluble solids content.
Av = Average angle measurement (average between A1 and A2).
a = Radius of blade.
b = Width of blade.
M = Moment (calculated from Equation 9).
Cs = σ = Crushing strength (calculated from Equation 10).

Testing date : 14/5/1990.

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.203	35.5	32.5	3.7	11	34	0.00491	0.00782	0.124239	659.0055
2	0.22	34	33	3.3	12	33.5	0.00491	0.00782	0.122627	650.4544
3	0.21	33	33	3.2	12	33	0.00491	0.00782	0.121005	641.8538
4	0.2023	33	33	4.35	11	33	0.00491	0.00782	0.121005	641.8538
5	0.1955	31	32	3.95	10	31.5	0.00491	0.00782	0.116086	615.7614
6	0.2066	34	32	3.55	11	33	0.00491	0.00782	0.121005	641.8538
7	0.1638	36	37.5	3.65	11.5	36.75	0.00491	0.00782	0.132933	705.1220
8	0.2113	36	36	3.8	11	36	0.00491	0.00782	0.130591	692.7014
9	0.1772	31.5	32.5	3.5	11	32	0.00491	0.00782	0.117735	624.5067
10	0.2027	37.5	38	3.8	11	37.75	0.00491	0.00782	0.136019	721.4944
11	0.2022	32	33	3.65	13	32.5	0.00491	0.00782	0.119375	633.2044
12	0.1991	36	37	3.6	11.5	36.5	0.00491	0.00782	0.132155	700.9951
13	0.2072	31	35	3.45	11	33	0.00491	0.00782	0.121005	641.8538
14	0.2214	32	32.5	3.3	12	32.25	0.00491	0.00782	0.118556	628.8615
15	0.2307	32	32	4.1	11.5	32	0.00491	0.00782	0.117735	624.5067
16	0.1519	34	33	4.2	11	33.5	0.00491	0.00782	0.122627	650.4544
17	0.2173	31	33	3.5	11	32	0.00491	0.00782	0.117735	624.5067
18	0.1497	32	33	3.85	13	32.5	0.00491	0.00782	0.119375	633.2044
19	0.1942	34	34	3.35	11	34	0.00491	0.00782	0.124239	659.0055
20	0.2037	33.5	34	3.45	11.5	33.75	0.00491	0.00782	0.123434	654.7362
Avg	0.19849	33.4	33.8	3.66	11.4	33.62	0.00491	0.00782	0.122974	652.2968
Std	0.02138	1.89	1.83	0.30	0.7	1.723	0	********	0.005504	29.19914

Testing date : 18/6/1990.

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.2167	31	32	3.2	11	31.5	0.00491	0.00782	0.116086	615.7614
2	0.2359	31	31	3.15	12	31	0.00491	0.00782	0.114429	606.9693
3	0.1758	35	38	3.75	11	36.5	0.00491	0.00782	0.132155	700.9951
4	0.2506	31	28	3.3	13	29.5	0.00491	0.00782	0.109404	580.3182
5	0.2824	27.5	30	3	12	28.75	0.00491	0.00782	0.106864	566.8424
6	0.2278	32	36	3.6	12	34	0.00491	0.00782	0.124239	659.0055
7	0.2233	29	29.5	3	13	29.25	0.00491	0.00782	0.108559	575.8372
8	0.2522	31	31	3.7	14.5	31	0.00491	0.00782	0.114429	606.9693
9	0.2124	34.5	35	3	10.5	34.75	0.00491	0.00782	0.126639	671.7378
10	0.2372	35	37	3.3	12	36	0.00491	0.00782	0.130591	692.7014
11	0.1635	35	38	3.85	11	36.5	0.00491	0.00782	0.132155	700.9951
12	0.2705	32.5	35	3.15	11	33.75	0.00491	0.00782	0.123434	654.7362
13	0.1714	31	32	3.75	12	31.5	0.00491	0.00782	0.116086	615.7614
14	0.2358	30	33	3.1	10.5	31.5	0.00491	0.00782	0.116086	615.7614
15	0.1865	32	33	3.75	13	32.5	0.00491	0.00782	0.119375	633.2044
16	0.2214	33	37	3.45	12	35	0.00491	0.00782	0.127434	675.9564
17	0.1601	33	33	3.65	11	33	0.00491	0.00782	0.121005	641.8538
18	0.233	30	30	3.15	12.5	30	0.00491	0.00782	0.111088	589.2470
19	0.229	30	31	3.6	13	30.5	0.00491	0.00782	0.112762	598.1309
20	0.1932	33	35	3.5	11	34	0.00491	0.00782	0.124239	659.0055
Avg	0.21893	31.8	33.2	3.39	11.9	32.52	0.00491	0.00782	0.119353	633.0895
Std	0.03355	2.02	2.92	0.28	1.01	2.379	0	********	0.007756	41.14411

Testing date : 18/7/1990.

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.20592	30	31	3.3	11.5	30.5	0.00491	0.00782	0.112762	598.1309
2	0.22292	30	31.5	3.1	11.5	30.75	0.00491	0.00782	0.113597	602.5558
3	0.18782	32	32	3.05	11	32	0.00491	0.00782	0.117735	624.5067
4	0.17412	32	33.5	3.9	12	32.75	0.00491	0.00782	0.120191	637.5352
5	0.19312	32	33	3	11.5	32.5	0.00491	0.00782	0.119375	633.2044
6	0.18422	31	32	3.35	11	31.5	0.00491	0.00782	0.116086	615.7614
7	0.18282	32	33	3.25	11	32.5	0.00491	0.00782	0.119375	633.2044
8	0.20142	30	31	3	11	30.5	0.00491	0.00782	0.112762	598.1309
9	0.1926	27.5	27.5	2.9	14	27.5	0.00491	0.00782	0.102589	544.1680
10	0.1881	30	30	3.25	12	30	0.00491	0.00782	0.111088	589.2470
11	0.1788	26	27	2.75	13	26.5	0.00491	0.00782	0.099134	525.8414
12	0.1895	30	31	3.6	11.5	30.5	0.00491	0.00782	0.112762	598.1309
13	0.2136	29	30	2.95	12	29.5	0.00491	0.00782	0.109404	580.3182
14	0.1651	29	31.5	2.9	10.5	30.25	0.00491	0.00782	0.111926	593.6946
15	0.2435	28	30	2.75	13	29	0.00491	0.00782	0.107713	571.3452
16	0.2353	30	30	3.1	13	30	0.00491	0.00782	0.111088	589.2470
17	0.1977	29	28.5	3	12	28.75	0.00491	0.00782	0.106864	566.8424
18	0.2339	30	30	2.75	12	30	0.00491	0.00782	0.111088	589.2470
19	0.2039	30	31	3.15	11	30.5	0.00491	0.00782	0.112762	598.1309
20	0.2106	27	28	3.2	12.5	27.5	0.00491	0.00782	0.102589	544.1680
Avg	0.20024	29.7	30.5	3.11	11.8	30.15	0.00491	0.00782	0.111544	591.6705
Std	0.02067	1.63	1.75	0.27	0.86	1.659	0	********	0.005580	29.60093

Testing date :16/8/1990.

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.2039	29	28	2.6	11	28.5	0.00491	0.00782	0.106013	562.3287
2	0.1753	27	29	3.1	11.5	28	0.00491	0.00782	0.104305	553.2694
3	0.2039	27	27.5	2.6	12	27.25	0.00491	0.00782	0.101728	539.6016
4	0.2279	23	24	2.55	12	23.5	0.00491	0.00782	0.088592	469.9234
5	0.2091	26	26	2.8	12	26	0.00491	0.00782	0.097395	516.6178
6	0.1894	24.5	25.5	2.65	12	25	0.00491	0.00782	0.093895	498.0531
7	0.2177	26	25	2.6	12.5	25.5	0.00491	0.00782	0.095649	507.3547
8	0.2289	26	25	2.65	12	25.5	0.00491	0.00782	0.095649	507.3547
9	0.1849	25	26	2.95	12	25.5	0.00491	0.00782	0.095649	507.3547
10	0.1895	28	30	3	13	29	0.00491	0.00782	0.107713	571.3452
11	0.1855	26	26	2.65	12.5	26	0.00491	0.00782	0.097395	516.6178
12	0.2215	25	23	2.4	12	24	0.00491	0.00782	0.090367	479.3367
13	0.2389	24	25.5	2.65	12	24.75	0.00491	0.00782	0.093016	493.3880
14	0.1876	29	27.5	2.75	11.5	28.25	0.00491	0.00782	0.105160	557.8044
15	0.1859	28	28	2.9	11	28	0.00491	0.00782	0.104305	553.2694
16	0.2003	27.5	27.5	3.05	11	27.5	0.00491	0.00782	0.102589	544.1680
17	0.1729	26	26	2.65	11	26	0.00491	0.00782	0.097395	516.6178
18	0.2268	24	24	2.5	13	24	0.00491	0.00782	0.090367	479.3367
19	0.17	28	28	3	12	28	0.00491	0.00782	0.104305	553.2694
20	0.1781	27.5	28	2.9	12	27.75	0.00491	0.00782	0.103448	548.7239
Avg	0.1999	26.3	26.4	2.74	11.9	26.4	0.00491	0.00782	0.098747	523.7868
Std	0.02058	1.66	1.77	0.19	0.58	1.636	0	********	0.005687	30.16864

Testing date : 10/9/1990.

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1884	30	32	2.9	11	31	0.00491	0.00782	0.113520	602.1501
2	0.1678	23	23	2.8	12	23	0.00491	0.00782	0.086121	456.8183
3	0.2671	23	24	2.5	12	23.5	0.00491	0.00782	0.087889	466.1923
4	0.168	28	29	2.85	11	28.5	0.00491	0.00782	0.105171	557.8640
5	0.1949	26	26.5	3.1	12	26.25	0.00491	0.00782	0.097485	517.0961
6	0.1889	25	26.5	2.55	13	25.75	0.00491	0.00782	0.095756	507.9261
7	0.2145	25	23	2.7	13	24	0.00491	0.00782	0.089649	475.5309
8	0.1542	27.5	28	2.6	12	27.75	0.00491	0.00782	0.102627	544.3672
9	0.1652	28	29	2.6	11	28.5	0.00491	0.00782	0.105171	557.8640
10	0.1639	27	29	2.5	11	28	0.00491	0.00782	0.103477	548.8766
11	0.2489	23	24	2.65	11	23.5	0.00491	0.00782	0.087889	466.1923
12	0.1441	27.5	27	2.8	10	27.25	0.00491	0.00782	0.100920	535.3174
13	0.1621	27.5	26	2.6	10	26.75	0.00491	0.00782	0.099207	526.2268
14	0.1707	24	24	2.75	12	24	0.00491	0.00782	0.089649	475.5309
15	0.19	26	27	2.5	11	26.5	0.00491	0.00782	0.098347	521.6664
16	0.2025	23	24	2.5	15	23.5	0.00491	0.00782	0.087889	466.1923
17	0.2167	24	24	2.3	13	24	0.00491	0.00782	0.089649	475.5309
18	0.2577	24	23	2.6	12.5	23.5	0.00491	0.00782	0.087889	466.1923
19	0.2166	26.5	25.5	2.5	10.5	26	0.00491	0.00782	0.096622	512.5160
20	0.165	26	27.5	2.9	11	26.75	0.00491	0.00782	0.099207	526.2268
Avg	0.19236	25.7	26.1	2.66	11.7	25.9	0.00491	0.00782	0.096207	510.3139
Std	0.03429	2.00	2.43	0.18	1.17	2.161	0	********	0.007445	39.49549

APPENDIX 2 : Data For The Second Series Of Experiment For Apples.

Royal Gala, harvest date : 15/3/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.2013	17.5	16.5	1.75	9	17	0.00491	0.00782	0.064442	341.8226
2	0.2001	18	17.5	1.5	12	17.75	0.00491	0.00782	0.067195	356.4282
3	0.1997	22	21	2.4	11	21.5	0.00491	0.00782	0.080781	428.4902
4	0.1831	16	17	1.75	11	16.5	0.00491	0.00782	0.062600	332.0529
5	0.2143	16	17.5	1.8	11	16.75	0.00491	0.00782	0.063521	336.9409
6	0.1921	16.5	17.5	1.85	11.5	17	0.00491	0.00782	0.064442	341.8226
7	0.1924	17	18	2.1	11.5	17.5	0.00491	0.00782	0.066279	351.5663
8	0.2126	16	17.5	1.75	12	16.75	0.00491	0.00782	0.063521	336.9409
9	0.1874	21	21	2.3	13	21	0.00491	0.00782	0.078988	418.9813
10	0.2038	16	17	1.8	11.5	16.5	0.00491	0.00782	0.062600	332.0529
11	0.2211	16	16.5	1.7	11.5	16.25	0.00491	0.00782	0.061677	327.1585
12	0.2081	17	18.6	1.9	11.5	17.8	0.00491	0.00782	0.067378	357.3997
13	0.194	19	18.6	1.8	12	18.8	0.00491	0.00782	0.071031	376.7728
14	0.2115	17.5	18	2.1	12	17.75	0.00491	0.00782	0.067195	356.4282
15	0.217	17	18	2.2	13	17.5	0.00491	0.00782	0.066279	351.5663
16	0.222	15	15	1.65	13	15	0.00491	0.00782	0.057046	302.5949
17	0.1982	17.5	17.5	1.85	9	17.5	0.00491	0.00782	0.066279	351.5663
18	0.184	16	16.5	1.75	11	16.25	0.00491	0.00782	0.061677	327.1585
19	0.2041	16	16	1.7	11	16	0.00491	0.00782	0.060753	322.2579
20	0.1792	16	15	1.4	12	15.5	0.00491	0.00782	0.058902	312.4383
Avg	0.2013	17.1	17.5	1.85	11.4	17.33	0.00491	0.00782	0.065629	348.1220
Std	0.01239	1.71	1.51	0.24	1.04	1.562	0	********	0.005702	30.24926

Royal Gala, harvest date : 26/2/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1715	22	25	1.9	11	23.5	0.00491	0.00782	0.087889	466.1923
2	0.2028	22.5	23.5	2.25	12	23	0.00491	0.00782	0.086121	456.8183
3	0.1697	30	35	3.9	14	32.5	0.00491	0.00782	0.118427	628.1769
4	0.1602	21	21	2.4	13	21	0.00491	0.00782	0.078988	418.9813
5	0.1412	22.5	23	2.7	13	22.75	0.00491	0.00782	0.085235	452.1181
6	0.1995	16	17	2	11	16.5	0.00491	0.00782	0.062600	332.0529
7	0.2045	20	22	2.5	13	21	0.00491	0.00782	0.078988	418.9813
8	0.192	16	17	2.5	11	16.5	0.00491	0.00782	0.062600	332.0529
9	0.1929	20	19.5	2.1	11	19.75	0.00491	0.00782	0.074480	395.0710
10	0.1203	21	22	2.25	12	21.5	0.00491	0.00782	0.080781	428.4902
11	0.1597	24	25	2.7	13	24.5	0.00491	0.00782	0.091403	484.8333
12	0.1679	19	17.5	1.7	9	18.25	0.00491	0.00782	0.069025	366.1314
13	0.1844	21	23	2.9	13	22	0.00491	0.00782	0.082567	437.9665
14	0.193	22.5	21.5	2.5	11	22	0.00491	0.00782	0.082567	437.9665
15	0.191	21	21	2	11	21	0.00491	0.00782	0.078988	418.9813
16	0.1546	27.5	28.5	2.85	12	28	0.00491	0.00782	0.103477	548.8766
17	0.2076	22.5	22.5	2.3	12	22.5	0.00491	0.00782	0.084348	447.4094
18	0.1629	23	22.5	2.15	11	22.75	0.00491	0.00782	0.085235	452.1181
19	0.1858	22.5	22.5	2.25	11.5	22.5	0.00491	0.00782	0.084348	447.4094
20	0.1611	23	22.5	2.25	11.5	22.75	0.00491	0.00782	0.085235	452.1181
Avg	0.17613	21.8	22.5	2.40	11.8	22.21	0.00491	0.00782	0.083165	441.1373
Std	0.02248	3.11	3.91	0.45	1.11	3.463	0	********	0.012145	64.42613

Gala, harvest date : 15/2/ 1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1366	21	23	2.05	12	22	0.00491	0.00782	0.082567	437.9665
2	0.2667	21	24	2.1	13	22.5	0.00491	0.00782	0.084348	447.4094
3	0.1767	23	25	2.35	13	24	0.00491	0.00782	0.089649	475.5309
4	0.18	23	25	2.1	11.5	24	0.00491	0.00782	0.089649	475.5309
5	0.1338	25	25	2.55	12	25	0.00491	0.00782	0.093150	494.0987
6	0.1393	25.5	25	2.65	12	25.25	0.00491	0.00782	0.094020	498.7174
7	0.2162	22.5	22.5	2.25	12	22.5	0.00491	0.00782	0.084348	447.4094
8	0.1681	26	27.5	2.7	12	26.75	0.00491	0.00782	0.099207	526.2268
9	0.1491	26	27.5	2.9	13.5	26.75	0.00491	0.00782	0.099207	526.2268
10	0.1661	22.5	22.5	2.4	13	22.5	0.00491	0.00782	0.084348	447.4094
11	0.1553	24	25	2.6	12.5	24.5	0.00491	0.00782	0.091403	484.8333
12	0.1868	23	25	2.3	11.5	24	0.00491	0.00782	0.089649	475.5309
13	0.1989	27	25	2.3	12	26	0.00491	0.00782	0.096622	512.5160
14	0.1751	23.5	25	2.35	11.5	24.25	0.00491	0.00782	0.090527	480.1867
15	0.1814	21	21	2.2	11	21	0.00491	0.00782	0.078988	418.9813
16	0.2051	16	14	1.2	12	15	0.00491	0.00782	0.057046	302.5949
17	0.2194	20	22.5	2.05	11	21.25	0.00491	0.00782	0.079885	423.7398
18	0.1976	22.5	24	2.3	11	23.25	0.00491	0.00782	0.087006	461.5097
19	0.1632	25	29	2.7	11	27	0.00491	0.00782	0.100064	530.7772
20	0.1867	23	21	2.25	12	22	0.00491	0.00782	0.082567	437.9665
Avg	0.18010	23.0	23.9	2.31	11.9	23.47	0.00491	0.00782	0.087712	465.2581
Std	0.03135	2.45	3.02	0.34	0.71	2.630	0	********	0.009390	49.80884

Gala, harvest date : 26/2/1990.

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1302	23	26	2.35	11	24.5	0.00491	0.00782	0.091403	484.8333
2	0.1433	25.5	28.5	2.8	13	27	0.00491	0.00782	0.100064	530.7772
3	0.1443	24	26.5	2.45	12.5	25.25	0.00491	0.00782	0.094020	498.7174
4	0.1567	22	22	1.75	11	22	0.00491	0.00782	0.082567	437.9665
5	0.1723	26	28.5	2.6	13	27.25	0.00491	0.00782	0.100920	535.3174
6	0.1056	21	22	1.9	12	21.5	0.00491	0.00782	0.080781	428.4902
7	0.1599	25	26	2.5	12	25.5	0.00491	0.00782	0.094889	503.3265
8	0.2586	23	23	2.2	11	23	0.00491	0.00782	0.086121	456.8183
9	0.1513	25.5	25	2.25	12	25.25	0.00491	0.00782	0.094020	498.7174
10	0.1987	27.5	27	2.15	12	27.25	0.00491	0.00782	0.100920	535.3174
11	0.1399	21	22.5	2	11	21.75	0.00491	0.00782	0.081675	433.2325
12	0.1259	24	23	2.15	12	23.5	0.00491	0.00782	0.087889	466.1923
13	0.1357	25	26	2.55	11	25.5	0.00491	0.00782	0.094889	503.3265
14	0.1709	30	30	3.1	13	30	0.00491	0.00782	0.110206	584.5686
15	0.1611	23	25	2.25	12	24	0.00491	0.00782	0.089649	475.5309
16	0.1189	31	29	3.05	13	30	0.00491	0.00782	0.110206	584.5686
17	0.1304	29	31	2.8	13.5	30	0.00491	0.00782	0.110206	584.5686
18	0.1764	27	28	2.9	13	27.5	0.00491	0.00782	0.101774	539.8475
19	0.2324	25	25	2.75	13.5	25	0.00491	0.00782	0.093150	494.0987
20	0.1854	26	25	2.6	13	25.5	0.00491	0.00782	0.094889	503.3265
Avg	0.15989	25.1	25.9	2.45	12.2	25.56	0.00491	0.00782	0.095012	503.9771
Std	0.03662	2.68	2.58	0.36	0.85	2.541	0	********	0.008791	46.63490

APPENDIX 3 : Data For The Third Series Of Experiment For Apples.

Royal Gala :

Picking and testing date : 21/12/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.033	29	30	10.2	9	29.5	0.00335	0.0041	0.083465	1813.990
2	0.0304	29	30	9.6	9	29.5	0.00335	0.0041	0.083465	1813.990
3	0.046	25	25.5	8	9	25.25	0.00335	0.0041	0.072303	1571.394
4	0.0432	26.5	25	8	8.5	25.75	0.00335	0.0041	0.073638	1600.410
5	0.0432	28.5	26.5	9.5	8.5	27.5	0.00335	0.0041	0.078266	1700.990
6	0.0401	26	28	9.5	8	27	0.00335	0.0041	0.076951	1672.410
7	0.0376	27	25	9	9	26	0.00335	0.0041	0.074303	1614.872
8	0.0455	26	24	9.1	9	25	0.00335	0.0041	0.071633	1556.841
9	0.0366	26	31	9	9	28.5	0.00335	0.0041	0.080878	1757.758
10	0.0268	25	30	9.1	9	27.5	0.00335	0.0041	0.078266	1700.990
11	0.0375	24	24	8.4	8.5	24	0.00335	0.0041	0.068941	1498.337
12	0.0562	22	24	8.5	9	23	0.00335	0.0041	0.066228	1439.375
13	0.0407	31	31	10.4	9	31	0.00335	0.0041	0.087298	1897.298
14	0.0376	29	32	11	9	30.5	0.00335	0.0041	0.086027	1869.670
15	0.0321	27.5	27	9.1	8.5	27.25	0.00335	0.0041	0.077609	1686.716
16	0.0339	30	30	9.9	8.5	30	0.00335	0.0041	0.08475	1841.900
17	0.036	29	27.5	10.5	8.5	28.25	0.00335	0.0041	0.080227	1743.615
18	0.0369	31	30	10	8	30.5	0.00335	0.0041	0.086027	1869.670
19	0.0363	28	28	9.5	8.5	28	0.00335	0.0041	0.079575	1729.440
20	0.0414	26	24	9.5	9	25	0.00335	0.0041	0.071633	1556.841
21	0.0377	24	26	8.8	8.5	25	0.00335	0.0041	0.071633	1556.841
22	0.0405	26	26	10.4	8.5	26	0.00335	0.0041	0.074303	1614.872
23	0.0342	28	25	9	9	26.5	0.00335	0.0041	0.075630	1643.704
24	0.034	27.5	27	9.1	8	27.25	0.00335	0.0041	0.077609	1686.716
25	0.035	31	28.5	10.2	8.5	29.75	0.00335	0.0041	0.084108	1827.963
26	0.0302	32	28	11.5	8.5	30	0.00335	0.0041	0.08475	1841.900
27	0.0397	26	26	9	8.5	26	0.00335	0.0041	0.074303	1614.872
28	0.0444	25	23	8	9	24	0.00335	0.0041	0.068941	1498.337
29	0.0392	28.5	25	9.8	8	26.75	0.00335	0.0041	0.076291	1658.073
30	0.0535	26	24	8.1	8	25	0.00335	0.0041	0.071633	1556.841
31	0.0467	25	25.5	9.5	9	25.25	0.00335	0.0041	0.072303	1571.394
32	0.047	25.5	22	9.4	8.5	23.75	0.00335	0.0041	0.068265	1483.638
33	0.044	27	25	11	9	26	0.00335	0.0041	0.074303	1614.872
34	0.0387	29	27	9.4	9	28	0.00335	0.0041	0.079575	1729.440
35	0.0424	27	27	10.5	9	27	0.00335	0.0041	0.076951	1672.410
36	0.038	27	25	9.5	9	26	0.00335	0.0041	0.074303	1614.872
37	0.0391	28	30	11.7	8.5	29	0.00335	0.0041	0.082175	1785.942
38	0.0376	27	25	9.8	8	26	0.00335	0.0041	0.074303	1614.872
39	0.0343	27	25.5	8.2	9	26.25	0.00335	0.0041	0.074967	1629.303
40	0.0409	28	27	9.2	8.5	27.5	0.00335	0.0041	0.078266	1700.990
Avg	0.03920	27.2	26.7	9.49	8.66	27	0.00335	0.0041	0.076903	1671.359
Std	0.00585	2.10	2.43	0.91	0.36	2.027	********	********	0.005331	115.8677

Picking and testing date : 4/1/1991

No:	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.0507	22.5	24	8.5	9	23.25	0.00335	0.0041	0.066909	1454.158
2	0.0462	22	23.5	8.3	10	22.75	0.00335	0.0041	0.065547	1424.566
3	0.0677	24	22.5	9	10	23.25	0.00335	0.0041	0.066909	1454.158
4	0.0641	23	24	8.5	10	23.5	0.00335	0.0041	0.067587	1468.912
5	0.0593	25	22.5	9.4	9.5	23.75	0.00335	0.0041	0.068265	1483.638
6	0.0587	22	22	9.8	9.5	22	0.00335	0.0041	0.063495	1379.976
7	0.0521	23	23	8	9.5	23	0.00335	0.0041	0.066228	1439.375
8	0.0588	23.5	24.5	7.8	9.5	24	0.00335	0.0041	0.068941	1498.337
9	0.0501	24.5	25	9.2	9.5	24.75	0.00335	0.0041	0.070962	1542.259
10	0.0668	20	21	8.5	9	20.5	0.00335	0.0041	0.059360	1290.094
11	0.0563	20	24	9.1	10	22	0.00335	0.0041	0.063495	1379.976
12	0.0556	21	21	8	10	21	0.00335	0.0041	0.060743	1320.156
13	0.0552	22.5	21	8.6	9	21.75	0.00335	0.0041	0.062809	1365.060
14	0.0469	23.5	23.5	9.4	10	23.5	0.00335	0.0041	0.067587	1468.912
15	0.049	22.5	21	9.4	9.5	21.75	0.00335	0.0041	0.062809	1365.060
16	0.0483	22.5	22	9.2	9.5	22.25	0.00335	0.0041	0.064180	1394.866
17	0.0677	21	23	9	9	22	0.00335	0.0041	0.063495	1379.976
18	0.0677	21	21	8.3	9.5	21	0.00335	0.0041	0.060743	1320.156
19	0.0591	21	22.5	9.2	9.5	21.75	0.00335	0.0041	0.062809	1365.060
20	0.0491	23	24	8.6	9	23.5	0.00335	0.0041	0.067587	1468.912
21	0.0434	21	24	8.2	9	22.5	0.00335	0.0041	0.064864	1409.729
22	0.0608	20	22.5	9	9	21.25	0.00335	0.0041	0.061433	1335.149
23	0.06	23	21	9.4	9	22	0.00335	0.0041	0.063495	1379.976
24	0.0704	20.5	23	8.8	9.5	21.75	0.00335	0.0041	0.062809	1365.060
25	0.0616	20	21	8.4	9	20.5	0.00335	0.0041	0.059360	1290.094
26	0.0519	23	21	8.1	9	22	0.00335	0.0041	0.063495	1379.976
27	0.0723	21.5	21	9.1	9.5	21.25	0.00335	0.0041	0.061433	1335.149
28	0.0548	22.5	24.5	8.1	9.5	23.5	0.00335	0.0041	0.067587	1468.912
29	0.0673	23	20	8.8	9	21.5	0.00335	0.0041	0.062121	1350.117
30	0.061	20	23	7.5	10	21.5	0.00335	0.0041	0.062121	1350.117
31	0.0585	21	25	8.6	9.5	23	0.00335	0.0041	0.066228	1439.375
32	0.0712	25	26	9.6	9	25.5	0.00335	0.0041	0.072971	1585.917
33	0.055	21.5	22.5	8.3	9.5	22	0.00335	0.0041	0.063495	1379.976
34	0.0655	20	21	8.1	9	20.5	0.00335	0.0041	0.059360	1290.094
35	0.0622	22	21	7.8	9	21.5	0.00335	0.0041	0.062121	1350.117
36	0.0571	25	22	8.7	10	23.5	0.00335	0.0041	0.067587	1468.912
37	0.0624	22	23	8.3	9	22.5	0.00335	0.0041	0.064864	1409.729
38	0.0644	23	21	8.5	10	22	0.00335	0.0041	0.063495	1379.976
39	0.0585	20	20	7.8	9	20	0.00335	0.0041	0.057972	1259.934
40	0.0619	20	21	8.9	9.5	20.5	0.00335	0.0041	0.059360	1290.094
Avg	0.05874	22.0	22.4	8.64	9.41	22.25	0.00335	0.0041	0.064166	1394.550
Std	0.00730	1.50	1.49	0.55	0.38	1.214	****************		0.003318	72.12189

Picking and testing date : 11/1/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0758	22.5	18.5	7.8	11	20.5	0.00335	0.0041	0.059360	1290.094
2	0.0844	16.5	18.5	9	10.5	17.5	0.00335	0.0041	0.050969	1107.740
3	0.0792	21.5	20.5	7.1	11	21	0.00335	0.0041	0.060743	1320.156
4	0.0784	23	18.5	6.4	10	20.75	0.00335	0.0041	0.060052	1305.137
5	0.0756	24	23	8.2	9	23.5	0.00335	0.0041	0.067587	1468.912
6	0.062	19	21	8.3	9	20	0.00335	0.0041	0.057972	1259.934
7	0.076	20.5	20.5	7.2	10.5	20.5	0.00335	0.0041	0.059360	1290.094
8	0.0839	21	24	7.9	10	22.5	0.00335	0.0041	0.064864	1409.729
9	0.0728	19	17.5	6.9	9	18.25	0.00335	0.0041	0.053081	1153.633
10	0.0809	21	24	9	10	22.5	0.00335	0.0041	0.064864	1409.729
11	0.0693	19	21	7.4	9.5	20	0.00335	0.0041	0.057972	1259.934
12	0.0807	21	18	7.9	10	19.5	0.00335	0.0041	0.056580	1229.678
13	0.0814	16	20.5	6.8	10	18.25	0.00335	0.0041	0.053081	1153.633
14	0.0714	19	17.5	7	10	18.25	0.00335	0.0041	0.053081	1153.633
15	0.0707	20	22.5	7.6	9.5	21.25	0.00335	0.0041	0.061433	1335.149
16	0.0765	21.5	23	7.6	10	22.25	0.00335	0.0041	0.064180	1394.866
17	0.0725	21	21	8.9	10	21	0.00335	0.0041	0.060743	1320.156
18	0.0765	18	22	7.7	10	20	0.00335	0.0041	0.057972	1259.934
19	0.0693	20	22	8.6	10	21	0.00335	0.0041	0.060743	1320.156
20	0.0798	17.5	21	7.6	10	19.25	0.00335	0.0041	0.055882	1214.514
21	0.0664	17.5	21	7	10	19.25	0.00335	0.0041	0.055882	1214.514
22	0.0683	20	21.5	7.4	10	20.75	0.00335	0.0041	0.060052	1305.137
23	0.065	18.5	16	7.6	9.5	17.25	0.00335	0.0041	0.050263	1092.400
24	0.0568	22.5	22.5	9.2	10	22.5	0.00335	0.0041	0.064864	1409.729
25	0.074	21	17.5	7.3	10	19.25	0.00335	0.0041	0.055882	1214.514
26	0.0676	20.5	22.5	7.5	9.5	21.5	0.00335	0.0041	0.062121	1350.117
27	0.0933	20	19.5	6.7	10	19.75	0.00335	0.0041	0.057276	1244.818
28	0.0526	23	23	7.5	10	23	0.00335	0.0041	0.066228	1439.375
29	0.0597	19	22	7.5	9.5	20.5	0.00335	0.0041	0.059360	1290.094
30	0.0664	19	17.5	7.6	10.5	18.25	0.00335	0.0041	0.053081	1153.633
31	0.0764	23.5	24	9.7	9	23.75	0.00335	0.0041	0.068265	1483.638
32	0.0859	22.5	19	6.8	10	20.75	0.00335	0.0041	0.060052	1305.137
33	0.052	21	22	9.1	10	21.5	0.00335	0.0041	0.062121	1350.117
34	0.0789	19.5	21	7.6	9.5	20.25	0.00335	0.0041	0.058666	1275.026
35	0.0749	21	21	8.4	10	21	0.00335	0.0041	0.060743	1320.156
36	0.0521	23	23	8.5	10	23	0.00335	0.0041	0.066228	1439.375
37	0.0631	23	24	8.1	10	23.5	0.00335	0.0041	0.067587	1468.912
38	0.0789	20	23	8.6	10	21.5	0.00335	0.0041	0.062121	1350.117
39	0.0639	20	21	7.7	9.5	20.5	0.00335	0.0041	0.059360	1290.094
40	0.0535	22	20	8.1	9.5	21	0.00335	0.0041	0.060743	1320.156
Avg	0.07167	20.4	20.8	7.81	9.88	20.66	0.00335	0.0041	0.059785	1299.347
Std	0.00981	1.90	2.09	0.76	0.45	1.635	********	********	0.004526	98.37717

Picking and testing date : 18/1/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.112	23	25	8.6	9	24	0.00335	0.0041	0.068941	1498.337
2	0.072	18.5	18.5	7.6	10.5	18.5	0.00335	0.0041	0.053783	1168.887
3	0.0774	19.5	22	7.9	10	20.75	0.00335	0.0041	0.060052	1305.137
4	0.0827	16.5	20	7.5	10	18.25	0.00335	0.0041	0.053081	1153.633
5	0.0786	18.5	22.5	7.3	10	20.5	0.00335	0.0041	0.059360	1290.094
6	0.1014	19	21	7.6	10	20	0.00335	0.0041	0.057972	1259.934
7	0.069	19	15	7.4	10.5	17	0.00335	0.0041	0.049557	1077.039
8	0.0648	18.5	20.5	8	10	19.5	0.00335	0.0041	0.056580	1229.678
9	0.0719	17.5	20.5	8.1	10	19	0.00335	0.0041	0.055183	1199.328
10	0.0663	18.5	17.5	7.8	10	18	0.00335	0.0041	0.052378	1138.357
11	0.1017	17	17.5	8	10	17.25	0.00335	0.0041	0.050263	1092.400
12	0.1165	22	23	8.4	9	22.5	0.00335	0.0041	0.064864	1409.729
13	0.0743	18	17.5	6.5	10	17.75	0.00335	0.0041	0.051674	1123.059
14	0.0752	18	15.5	7	10	16.75	0.00335	0.0041	0.048849	1061.657
15	0.0858	23	18.5	7	10	20.75	0.00335	0.0041	0.060052	1305.137
16	0.0691	16.5	16.5	8.5	10	16.5	0.00335	0.0041	0.048140	1046.256
17	0.0671	17.5	18.5	6.9	10	18	0.00335	0.0041	0.052378	1138.357
18	0.0609	20.5	20.5	8.6	10	20.5	0.00335	0.0041	0.059360	1290.094
19	0.1003	18.5	18.5	6	10	18.5	0.00335	0.0041	0.053783	1168.887
20	0.0794	18.5	17	6.8	10	17.75	0.00335	0.0041	0.051674	1123.059
21	0.0794	17.5	17.5	7.9	9	17.5	0.00335	0.0041	0.050969	1107.740
22	0.0848	18.5	20	7.8	10	19.25	0.00335	0.0041	0.055882	1214.514
23	0.0799	22	19.5	7.1	10	20.75	0.00335	0.0041	0.060052	1305.137
24	0.0951	18	20	7.9	9.5	19	0.00335	0.0041	0.055183	1199.328
25	0.0781	18.5	20.5	7.6	10	19.5	0.00335	0.0041	0.056580	1229.678
26	0.0869	17.5	20	7.3	10	18.75	0.00335	0.0041	0.054483	1184.119
27	0.1	16	23	6.8	10	19.5	0.00335	0.0041	0.056580	1229.678
28	0.088	17.5	21	7	9.5	19.25	0.00335	0.0041	0.055882	1214.514
29	0.0833	16.5	17.5	6.8	10.5	17	0.00335	0.0041	0.049557	1077.039
30	0.0822	18	19	8.3	10	18.5	0.00335	0.0041	0.053783	1168.887
31	0.0952	14	16	6.1	10	15	0.00335	0.0041	0.043869	953.4380
32	0.0808	16	17.5	7	9.5	16.75	0.00335	0.0041	0.048849	1061.657
33	0.0878	20	23	7.9	10	21.5	0.00335	0.0041	0.062121	1350.117
34	0.0799	21	22	8.6	10.5	21.5	0.00335	0.0041	0.062121	1350.117
35	0.086	17.5	18	6.6	11	17.75	0.00335	0.0041	0.051674	1123.059
36	0.0873	18	16	7	11.5	17	0.00335	0.0041	0.049557	1077.039
37	0.0844	20	18.5	7.6	10	19.25	0.00335	0.0041	0.055882	1214.514
38	0.0739	16	18	7.4	11	17	0.00335	0.0041	0.049557	1077.039
39	0.0863	17.5	18	7.3	11	17.75	0.00335	0.0041	0.051674	1123.059
40	0.089	17	17	6.7	10	17	0.00335	0.0041	0.049557	1077.039
Avg	0.08336	18.3	19.1	7.45	10.0	18.78	0.00335	0.0041	0.054543	1185.419
Std	0.01225	1.89	2.30	0.66	0.49	1.808	********	********	0.005044	109.6358

Picking and testing date : 25/1/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1066	21	20	6.9	10	20.5	0.00335	0.0041	0.059360	1290.094
2	0.1093	17.5	17.5	5.5	9.5	17.5	0.00335	0.0041	0.050969	1107.740
3	0.0991	15	17.5	6.5	10	16.25	0.00335	0.0041	0.047431	1030.834
4	0.1174	19	17	7.2	10	18	0.00335	0.0041	0.052378	1138.357
5	0.1215	18	15	5.6	10	16.5	0.00335	0.0041	0.048140	1046.256
6	0.1076	17.5	21	7.5	10	19.25	0.00335	0.0041	0.055882	1214.514
7	0.1087	17.5	17.5	6.2	10.5	17.5	0.00335	0.0041	0.050969	1107.740
8	0.1017	15	16	6.2	10	15.5	0.00335	0.0041	0.045296	984.4531
9	0.0989	20.5	18	6.4	10	19.25	0.00335	0.0041	0.055882	1214.514
10	0.096	16	17.5	6.7	9.5	16.75	0.00335	0.0041	0.048849	1061.657
11	0.1004	17	15.5	6.1	10	16.25	0.00335	0.0041	0.047431	1030.834
12	0.0995	17.5	15.5	6.3	10	16.5	0.00335	0.0041	0.048140	1046.256
13	0.0909	17.5	18.5	7.6	10	18	0.00335	0.0041	0.052378	1138.357
14	0.1277	16	16.5	6.2	10.5	16.25	0.00335	0.0041	0.047431	1030.834
15	0.0895	19	19.5	6.8	10	19.25	0.00335	0.0041	0.055882	1214.514
16	0.0919	17.5	16	6.3	9.5	16.75	0.00335	0.0041	0.048849	1061.657
17	0.0888	16.5	20	6.5	10	18.25	0.00335	0.0041	0.053081	1153.633
18	0.1044	18	15	6	10.5	16.5	0.00335	0.0041	0.048140	1046.256
19	0.0911	14	15	6.2	10	14.5	0.00335	0.0041	0.042439	922.3502
20	0.085	17	16.5	6	9.5	16.75	0.00335	0.0041	0.048849	1061.657
21	0.0846	18	18	6.6	10	18	0.00335	0.0041	0.052378	1138.357
22	0.0923	17.5	17.5	6.8	10.5	17.5	0.00335	0.0041	0.050969	1107.740
23	0.085	16.5	17	7.8	10.5	16.75	0.00335	0.0041	0.048849	1061.657
24	0.1024	16	18	6.3	10	17	0.00335	0.0041	0.049557	1077.039
25	0.1037	18	18	6.4	10.5	18	0.00335	0.0041	0.052378	1138.357
26	0.1066	17.5	16	7	10	16.75	0.00335	0.0041	0.048849	1061.657
27	0.0797	16	15	6.4	9.5	15.5	0.00335	0.0041	0.045296	984.4531
28	0.0702	21	16	7.6	10	18.5	0.00335	0.0041	0.053783	1168.887
29	0.0831	13	16	6	10	14.5	0.00335	0.0041	0.042439	922.3502
30	0.1179	15	18	6.3	10	16.5	0.00335	0.0041	0.048140	1046.256
31	0.0854	17.5	16.5	6.3	9.5	17	0.00335	0.0041	0.049557	1077.039
32	0.0758	16	20	7.3	11	18	0.00335	0.0041	0.052378	1138.357
33	0.0747	20	20	6	10	20	0.00335	0.0041	0.057972	1259.934
34	0.0957	18.5	18.5	6.8	10	18.5	0.00335	0.0041	0.053783	1168.887
35	0.0693	17	20	8.7	11	18.5	0.00335	0.0041	0.053783	1168.887
36	0.0925	17.5	20	6.6	9.5	18.75	0.00335	0.0041	0.054483	1184.119
37	0.1002	17.5	17	6.3	10.5	17.25	0.00335	0.0041	0.050263	1092.400
38	0.078	15	15	6.3	10.5	15	0.00335	0.0041	0.043869	953.4380
39	0.1132	21	21	8.5	10	21	0.00335	0.0041	0.060743	1320.156
40	0.1129	17	18	5.9	10.5	17.5	0.00335	0.0041	0.050969	1107.740
Avg	0.09648	17.3	17.5	6.61	10.0	17.41	0.00335	0.0041	0.050705	1102.005
Std	0.01396	1.79	1.75	0.69	0.37	1.475	********	********	0.004159	90.39057

Picking and testing date : 1/2/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1185	17.5	16	6.3	10	16.75	0.00335	0.0041	0.048849	1061.657
2	0.0909	15.5	18	5.7	10	16.75	0.00335	0.0041	0.048849	1061.657
3	0.1209	17.5	15	6.7	11	16.25	0.00335	0.0041	0.047431	1030.834
4	0.1224	17.5	15	6.5	10	16.25	0.00335	0.0041	0.047431	1030.834
5	0.1172	16	16	6.1	10	16	0.00335	0.0041	0.046720	1015.393
6	0.1016	16	17.5	7.2	10	16.75	0.00335	0.0041	0.048849	1061.657
7	0.1274	16	20	7.4	10.5	18	0.00335	0.0041	0.052378	1138.357
8	0.1001	14	17.5	6.4	11	15.75	0.00335	0.0041	0.046009	999.9327
9	0.1136	14.5	15	6.4	11	14.75	0.00335	0.0041	0.043155	937.9030
10	0.1072	15.5	18	5.9	9.5	16.75	0.00335	0.0041	0.048849	1061.657
11	0.1058	18	17.5	6.5	10.5	17.75	0.00335	0.0041	0.051674	1123.059
12	0.1013	17	19	6.5	10	18	0.00335	0.0041	0.052378	1138.357
13	0.1049	15.5	19	6.8	11	17.25	0.00335	0.0041	0.050263	1092.400
14	0.1208	14.5	14.5	5.8	10	14.5	0.00335	0.0041	0.042439	922.3502
15	0.1142	14.5	15	6.3	11	14.75	0.00335	0.0041	0.043155	937.9030
16	0.11	17	16	7.4	9	16.5	0.00335	0.0041	0.048140	1046.256
17	0.116	18	14	5.9	9.5	16	0.00335	0.0041	0.046720	1015.393
18	0.1208	16	16	5.9	10	16	0.00335	0.0041	0.046720	1015.393
19	0.1195	16.5	16	6.5	9.5	16.25	0.00335	0.0041	0.047431	1030.834
20	0.1052	15.5	14	5.9	10	14.75	0.00335	0.0041	0.043155	937.9030
21	0.1283	18.5	14	6.5	10	16.25	0.00335	0.0041	0.047431	1030.834
22	0.1263	16.5	18.5	6.4	10	17.5	0.00335	0.0041	0.050969	1107.740
23	0.1095	14.5	16.5	6.3	10.5	15.5	0.00335	0.0041	0.045296	984.4531
24	0.0991	17.5	16	6.8	10	16.75	0.00335	0.0041	0.048849	1061.657
25	0.1005	16.5	14	6.7	10.5	15.25	0.00335	0.0041	0.044583	968.9548
26	0.0947	16	14.5	6	10	15.25	0.00335	0.0041	0.044583	968.9548
27	0.1468	15	18	6.2	10.5	16.5	0.00335	0.0041	0.048140	1046.256
28	0.122	14.5	15.5	6.5	12	15	0.00335	0.0041	0.043869	953.4380
29	0.0994	16	16	7	10.5	16	0.00335	0.0041	0.046720	1015.393
30	0.0962	17.5	15	6.7	9	16.25	0.00335	0.0041	0.047431	1030.834
31	0.0995	17.5	15	6.1	11	16.25	0.00335	0.0041	0.047431	1030.834
32	0.0961	14.5	17.5	5.7	10	16	0.00335	0.0041	0.046720	1015.393
33	0.0958	14	15.5	6	10	14.75	0.00335	0.0041	0.043155	937.9030
34	0.0877	15.5	14.5	6	9	15	0.00335	0.0041	0.043869	953.4380
35	0.0868	16.5	18	7.5	11	17.25	0.00335	0.0041	0.050263	1092.400
36	0.131	15	16.5	5.9	11	15.75	0.00335	0.0041	0.046009	999.9327
37	0.0947	15	16	6	10	15.5	0.00335	0.0041	0.045296	984.4531
38	0.1017	16.5	16	7.4	10.5	16.25	0.00335	0.0041	0.047431	1030.834
39	0.1033	14.5	15.5	5.8	9.5	15	0.00335	0.0041	0.043869	953.4380
40	0.1202	14	16.5	6	10.5	15.25	0.00335	0.0041	0.044583	968.9548
Avg	0.10944	15.9	16.2	6.38	10.2	16.07	0.00335	0.0041	0.046927	1019.895
Std	0.01326	1.25	1.53	0.49	0.63	0.918	********	********	0.002610	56.73165

Picking and testing date : 8/2/1991

No:	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.0954	13.5	14	6	10	13.75	0.00335	0.0041	0.040287	875.5876
2	0.1223	15	15	6.7	10.5	15	0.00335	0.0041	0.043869	953.4380
3	0.1113	15.5	15	6	10	15.25	0.00335	0.0041	0.044583	968.9548
4	0.1069	14	14	6.6	10	14	0.00335	0.0041	0.041005	891.1922
5	0.0883	14	15	6	9	14.5	0.00335	0.0041	0.042439	922.3502
6	0.0991	14	16.5	6	10	15.25	0.00335	0.0041	0.044583	968.9548
7	0.1108	14	15	6	10	14.5	0.00335	0.0041	0.042439	922.3502
8	0.1064	17	16	6.5	10.5	16.5	0.00335	0.0041	0.048140	1046.256
9	0.1175	14.5	14.5	5.9	10.5	14.5	0.00335	0.0041	0.042439	922.3502
10	0.0875	15	15	6.3	9.5	15	0.00335	0.0041	0.043869	953.4380
11	0.0964	13.5	14	6.6	10	13.75	0.00335	0.0041	0.040287	875.5876
12	0.0974	15.5	15.5	6.3	10	15.5	0.00335	0.0041	0.045296	984.4531
13	0.0987	16	14	6	10	15	0.00335	0.0041	0.043869	953.4380
14	0.1234	13.5	14	6	10	13.75	0.00335	0.0041	0.040287	875.5876
15	0.1177	14.5	15.5	6.4	10	15	0.00335	0.0041	0.043869	953.4380
16	0.086	17.5	16.5	5.9	9.5	17	0.00335	0.0041	0.049557	1077.039
17	0.0929	15	15.5	6.5	10.5	15.25	0.00335	0.0041	0.044583	968.9548
18	0.116	13.5	14	5.8	11	13.75	0.00335	0.0041	0.040287	875.5876
19	0.1289	15.5	13	6	10	14.25	0.00335	0.0041	0.041722	906.7798
20	0.104	16	15	5.8	11	15.5	0.00335	0.0041	0.045296	984.4531
21	0.0834	17.5	17.5	7.6	11	17.5	0.00335	0.0041	0.050969	1107.740
22	0.1142	14	15.5	6.1	10	14.75	0.00335	0.0041	0.043155	937.9030
23	0.0911	15	16.5	6.3	10	15.75	0.00335	0.0041	0.046009	999.9327
24	0.127	15	16	5.9	10	15.5	0.00335	0.0041	0.045296	984.4531
25	0.1192	15	15	5.7	10	15	0.00335	0.0041	0.043869	953.4380
26	0.1473	15	17	6.7	13	16	0.00335	0.0041	0.046720	1015.393
27	0.0992	16	16	6.5	11	16	0.00335	0.0041	0.046720	1015.393
28	0.1418	15	15	5.9	10.5	15	0.00335	0.0041	0.043869	953.4380
29	0.1224	16	16	6.4	10	16	0.00335	0.0041	0.046720	1015.393
30	0.112	15.5	15	5.9	10	15.25	0.00335	0.0041	0.044583	968.9548
31	0.1149	16.5	15.5	6.8	10.5	16	0.00335	0.0041	0.046720	1015.393
32	0.1303	15	14.5	5.5	9	14.75	0.00335	0.0041	0.043155	937.9030
33	0.1154	15	15	5.9	10	15	0.00335	0.0041	0.043869	953.4380
34	0.1163	14	14.5	5.5	9	14.25	0.00335	0.0041	0.041722	906.7798
35	0.1072	17.5	15	6.2	11	16.25	0.00335	0.0041	0.047431	1030.834
36	0.1018	15	15	6	9.5	15	0.00335	0.0041	0.043869	953.4380
37	0.1127	15.5	14	6.5	10.5	14.75	0.00335	0.0041	0.043155	937.9030
38	0.1242	14.5	15	6.4	11	14.75	0.00335	0.0041	0.043155	937.9030
39	0.1317	15	13	6.5	10.5	14	0.00335	0.0041	0.041005	891.1922
40	0.1366	12.5	14.5	6	11	13.5	0.00335	0.0041	0.039568	859.9664
Avg	0.11139	15.0	15.0	6.19	10.2	15.05	0.00335	0.0041	0.044007	956.4245
Std	0.01546	1.14	0.97	0.39	0.69	0.896	********	********	0.002558	55.59835

Picking and testing date : 15/2/1991

No:	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1419	14	13	5.2	11	13.5	0.00335	0.0041	0.039568	859.9664
2	0.1411	14.5	16	6	10.5	15.25	0.00335	0.0041	0.044583	968.9548
3	0.1231	14	15	6.5	11	14.5	0.00335	0.0041	0.042439	922.3502
4	0.1259	12	15	6.3	11	13.5	0.00335	0.0041	0.039568	859.9664
5	0.1401	13	14	5.7	10.5	13.5	0.00335	0.0041	0.039568	859.9664
6	0.1376	16	14	5.8	10.5	15	0.00335	0.0041	0.043869	953.4380
7	0.1302	12	14	6	10	13	0.00335	0.0041	0.038129	828.6750
8	0.1357	13	14	5.3	9	13.5	0.00335	0.0041	0.039568	859.9664
9	0.1214	15	16	5.8	9.5	15.5	0.00335	0.0041	0.045296	984.4531
10	0.1338	12	12.5	5.2	10	12.25	0.00335	0.0041	0.035964	781.6204
11	0.135	14	14.5	5.9	11.5	14.25	0.00335	0.0041	0.041722	906.7798
12	0.1343	16	13	5.5	11.5	14.5	0.00335	0.0041	0.042439	922.3502
13	0.1143	13	13.5	6.3	9.5	13.25	0.00335	0.0041	0.038849	844.3287
14	0.1377	13.5	13	5.2	10.5	13.25	0.00335	0.0041	0.038849	844.3287
15	0.1118	13	14.5	6.2	10.5	13.75	0.00335	0.0041	0.040287	875.5876
16	0.1227	12	11	5	10.5	11.5	0.00335	0.0041	0.033792	734.4319
17	0.1373	12.5	16	5.9	10.5	14.25	0.00335	0.0041	0.041722	906.7798
18	0.1527	15	13	5.9	10	14	0.00335	0.0041	0.041005	891.1922
19	0.1585	11	15	5.7	11	13	0.00335	0.0041	0.038129	828.6750
20	0.1326	12.5	14	5.7	10.5	13.25	0.00335	0.0041	0.038849	844.3287
21	0.1294	15	13	6.2	11	14	0.00335	0.0041	0.041005	891.1922
22	0.1272	14	15	5.4	10.5	14.5	0.00335	0.0041	0.042439	922.3502
23	0.1327	12.5	13	5.2	9.5	12.75	0.00335	0.0041	0.037408	813.0055
24	0.1103	13	11.5	4.4	11	12.25	0.00335	0.0041	0.035964	781.6204
25	0.1329	15	13	4.9	10	14	0.00335	0.0041	0.041005	891.1922
26	0.1187	11.5	15	5.3	10	13.25	0.00335	0.0041	0.038849	844.3287
27	0.1171	14.5	13.5	6.3	9	14	0.00335	0.0041	0.041005	891.1922
28	0.1091	13.5	13.5	4.9	9.5	13.5	0.00335	0.0041	0.039568	859.9664
29	0.1032	13	15	4.9	10	14	0.00335	0.0041	0.041005	891.1922
30	0.1075	15	15	6.5	10	15	0.00335	0.0041	0.043869	953.4380
31	0.1095	15	12.5	5.7	10.5	13.75	0.00335	0.0041	0.040287	875.5876
32	0.1271	14	14.5	5.6	9.5	14.25	0.00335	0.0041	0.041722	906.7798
33	0.135	12.5	15	6	10	13.75	0.00335	0.0041	0.040287	875.5876
34	0.1292	13	16	5.2	11	14.5	0.00335	0.0041	0.042439	922.3502
35	0.1225	12	13	5.4	11	12.5	0.00335	0.0041	0.036686	797.3205
36	0.1339	13	13.5	5.2	10	13.25	0.00335	0.0041	0.038849	844.3287
37	0.1255	13	13	5.5	11	13	0.00335	0.0041	0.038129	828.6750
38	0.1038	15	15	5.8	9.5	15	0.00335	0.0041	0.043869	953.4380
39	0.1196	14	14	4.7	9.5	14	0.00335	0.0041	0.041005	891.1922
40	0.0985	13.5	15	5	10	14.25	0.00335	0.0041	0.041722	906.7798
Avg	0.12651	13.5	14	5.57	10.2	13.75	0.00335	0.0041	0.040283	875.4914
Std	0.01317	1.21	1.18	0.50	0.64	0.851	********	********	0.002447	53.19434

Picking and testing date : 24/2/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1355	11	12.5	4.8	9.5	11.75	0.00335	0.0041	0.034517	750.1758
2	0.112	12.5	14	5.5	11	13.25	0.00335	0.0041	0.038849	844.3287
3	0.1456	12.5	12.5	5.4	12	12.5	0.00335	0.0041	0.036686	797.3205
4	0.1158	13	14	5.4	11	13.5	0.00335	0.0041	0.039568	859.9664
5	0.1034	14	15	6	10.5	14.5	0.00335	0.0041	0.042439	922.3502
6	0.1141	12	13	4.8	11	12.5	0.00335	0.0041	0.036686	797.3205
7	0.1204	14	14	5.5	11	14	0.00335	0.0041	0.041005	891.1922
8	0.1242	14	15	5.9	9.5	14.5	0.00335	0.0041	0.042439	922.3502
9	0.1142	13	13	4.7	11	13	0.00335	0.0041	0.038129	828.6750
10	0.1232	12.5	12.5	4.6	11	12.5	0.00335	0.0041	0.036686	797.3205
11	0.1192	13.5	13.5	6	10.5	13.5	0.00335	0.0041	0.039568	859.9664
12	0.1382	12.5	12.5	5.6	10	12.5	0.00335	0.0041	0.036686	797.3205
13	0.1007	13.5	13.5	5.5	11	13.5	0.00335	0.0041	0.039568	859.9664
14	0.1236	13	12	5.7	11	12.5	0.00335	0.0041	0.036686	797.3205
15	0.1581	13	12.5	5.5	12	12.75	0.00335	0.0041	0.037408	813.0055
16	0.12	13	13	5.7	10.5	13	0.00335	0.0041	0.038129	828.6750
17	0.1486	11.5	12.5	5.9	12.5	12	0.00335	0.0041	0.035241	765.9054
18	0.1446	12.5	12.5	6	10.5	12.5	0.00335	0.0041	0.036686	797.3205
19	0.1324	14	14	5.6	11.5	14	0.00335	0.0041	0.041005	891.1922
20	0.1271	12.5	12.5	5.5	10	12.5	0.00335	0.0041	0.036686	797.3205
21	0.1452	12.5	12.5	5.9	11	12.5	0.00335	0.0041	0.036686	797.3205
22	0.1535	12.5	13	6	12	12.75	0.00335	0.0041	0.037408	813.0055
23	0.1603	10	12.5	4.9	11	11.25	0.00335	0.0041	0.033067	718.6740
24	0.1681	11	12	5.5	11.5	11.5	0.00335	0.0041	0.033792	734.4319
25	0.1701	14	14	6.6	11	14	0.00335	0.0041	0.041005	891.1922
26	0.1316	11.5	12	5.1	11	11.75	0.00335	0.0041	0.034517	750.1758
27	0.1307	11.5	11.5	6.5	11	11.5	0.00335	0.0041	0.033792	734.4319
28	0.1379	11.5	13.5	5.5	10	12.5	0.00335	0.0041	0.036686	797.3205
29	0.1368	11.5	12.5	5.2	11.5	12	0.00335	0.0041	0.035241	765.9054
30	0.139	10.5	13	5.4	11	11.75	0.00335	0.0041	0.034517	750.1758
31	0.1598	15	15	6.1	10.5	15	0.00335	0.0041	0.043869	953.4380
32	0.1341	12	13	4.9	11	12.5	0.00335	0.0041	0.036686	797.3205
33	0.1315	12.5	12.5	5.7	11.5	12.5	0.00335	0.0041	0.036686	797.3205
34	0.1218	13	14	6.3	12.5	13.5	0.00335	0.0041	0.039568	859.9664
35	0.147	11.5	13	6	11	12.25	0.00335	0.0041	0.035964	781.6204
36	0.1408	14	13	5.9	11	13.5	0.00335	0.0041	0.039568	859.9664
37	0.1301	13.5	13.5	4.9	11	13.5	0.00335	0.0041	0.039568	859.9664
38	0.1566	12	13	5.1	11	12.5	0.00335	0.0041	0.036686	797.3205
39	0.1672	12.5	13	5.2	11	12.75	0.00335	0.0041	0.037408	813.0055
40	0.1326	13	12.5	5.6	11.5	12.75	0.00335	0.0041	0.037408	813.0055
Avg	0.13539	12.5	13.0	5.54	11	12.82	0.00335	0.0041	0.037620	817.6139
Std	0.01731	1.06	0.82	0.47	0.66	0.864	********	********	0.002491	54.15044

Picking and testing date : 1/3/1991

No:	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1314	12.5	13	4.9	11	12.75	0.00335	0.0041	0.037408	813.0055
2	0.1557	13	12.5	4.9	11.5	12.75	0.00335	0.0041	0.037408	813.0055
3	0.1265	12.5	12.5	4.9	11	12.5	0.00335	0.0041	0.036686	797.3205
4	0.1362	13.5	11.5	5.6	10.5	12.5	0.00335	0.0041	0.036686	797.3205
5	0.145	11.5	12	5	10.5	11.75	0.00335	0.0041	0.034517	750.1758
6	0.1122	13	12	4.5	10.5	12.5	0.00335	0.0041	0.036686	797.3205
7	0.13	12.5	12	4.2	10	12.25	0.00335	0.0041	0.035964	781.6204
8	0.1575	12.5	13	5.4	9.5	12.75	0.00335	0.0041	0.037408	813.0055
9	0.1313	14	14	5.6	9.5	14	0.00335	0.0041	0.041005	891.1922
10	0.1374	11	13	5	11.5	12	0.00335	0.0041	0.035241	765.9054
11	0.1297	12.5	13	4.8	9	12.75	0.00335	0.0041	0.037408	813.0055
12	0.132	12.5	12	4.7	10.5	12.25	0.00335	0.0041	0.035964	781.6204
13	0.1424	11	11.5	5	11.5	11.25	0.00335	0.0041	0.033067	718.6740
14	0.1175	12.5	12.5	5.6	11	12.5	0.00335	0.0041	0.036686	797.3205
15	0.1925	11.5	11.5	5.2	12.5	11.5	0.00335	0.0041	0.033792	734.4319
16	0.1652	10.5	11.5	5.5	11.5	11	0.00335	0.0041	0.032342	702.9024
17	0.1482	12	10.5	4.9	11	11.25	0.00335	0.0041	0.033067	718.6740
18	0.1404	11.5	12.5	4.8	10.5	12	0.00335	0.0041	0.035241	765.9054
19	0.1552	10.5	12	4.6	12.5	11.25	0.00335	0.0041	0.033067	718.6740
20	0.1479	11.5	10.5	5.3	11.5	11	0.00335	0.0041	0.032342	702.9024
21	0.1481	11.5	10.5	5.4	12	11	0.00335	0.0041	0.032342	702.9024
22	0.1619	11.5	12.5	4.5	12	12	0.00335	0.0041	0.035241	765.9054
23	0.1371	11.5	11.5	4.4	10	11.5	0.00335	0.0041	0.033792	734.4319
24	0.148	12.5	10	5.4	12	11.25	0.00335	0.0041	0.033067	718.6740
25	0.1453	11	10.5	4.3	11.5	10.75	0.00335	0.0041	0.031615	687.1175
26	0.1482	12.5	12.5	5.2	11.5	12.5	0.00335	0.0041	0.036686	797.3205
27	0.1447	11.5	12.5	5.4	10.5	12	0.00335	0.0041	0.035241	765.9054
28	0.1828	10.5	11	5.3	12	10.75	0.00335	0.0041	0.031615	687.1175
29	0.1514	10.5	11	4.4	12	10.75	0.00335	0.0041	0.031615	687.1175
30	0.1573	11	11	6.4	13.5	11	0.00335	0.0041	0.032342	702.9024
31	0.1189	11	11	4.8	12.5	11	0.00335	0.0041	0.032342	702.9024
32	0.1414	12	12	5.5	13	12	0.00335	0.0041	0.035241	765.9054
33	0.1425	12.5	12.5	4.9	12	12.5	0.00335	0.0041	0.036686	797.3205
34	0.148	11	11	4.4	12.5	11	0.00335	0.0041	0.032342	702.9024
35	0.1457	12.5	12.5	5.3	11	12.5	0.00335	0.0041	0.036686	797.3205
36	0.1609	11.5	12.5	4.9	11.5	12	0.00335	0.0041	0.035241	765.9054
37	0.1559	12	12	5.4	11	12	0.00335	0.0041	0.035241	765.9054
38	0.1539	11	11	4.8	13	11	0.00335	0.0041	0.032342	702.9024
39	0.1807	9	11	4.5	14	10	0.00335	0.0041	0.029433	639.6854
40	0.1908	10.5	12	4.5	13	11.25	0.00335	0.0041	0.033067	718.6740
Avg	0.14744	11.7	11.8	5.00	11.4	11.78	0.00335	0.0041	0.034604	752.0700
Std	0.01781	0.96	0.87	0.45	1.10	0.794	********	********	0.002301	50.00959

Picking and testing date : 8/3/1991

No:	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.146	14	11	5.6	12	12.5	0.00335	0.0041	0.036686	797.3205
2	0.121	12	12.5	4.6	11	12.25	0.00335	0.0041	0.035964	781.6204
3	0.12	11	12.5	5.2	12	11.75	0.00335	0.0041	0.034517	750.1758
4	0.119	10.5	10.5	4.6	11	10.5	0.00335	0.0041	0.030888	671.3195
5	0.11	14	12.5	4.7	12	13.25	0.00335	0.0041	0.038849	844.3287
6	0.172	11	13	5	12	12	0.00335	0.0041	0.035241	765.9054
7	0.129	12	11	6	13	11.5	0.00335	0.0041	0.033792	734.4319
8	0.163	8.5	10	4.5	12	9.25	0.00335	0.0041	0.027245	592.1437
9	0.13	12	12	5.4	12	12	0.00335	0.0041	0.035241	765.9054
10	0.135	11	11	4.6	12	11	0.00335	0.0041	0.032342	702.9024
11	0.129	10	11	4.9	11	10.5	0.00335	0.0041	0.030888	671.3195
12	0.125	13	10.5	5.2	12.5	11.75	0.00335	0.0041	0.034517	750.1758
13	0.111	11	10.5	4.9	10.5	10.75	0.00335	0.0041	0.031615	687.1175
14	0.138	10.5	11	4.9	11.5	10.75	0.00335	0.0041	0.031615	687.1175
15	0.143	10.5	11	5.4	12	10.75	0.00335	0.0041	0.031615	687.1175
16	0.135	11	11	4.7	14	11	0.00335	0.0041	0.032342	702.9024
17	0.168	10	10	4.9	12	10	0.00335	0.0041	0.029433	639.6854
18	0.2	11.5	11.5	5	12	11.5	0.00335	0.0041	0.033792	734.4319
19	0.15	11.5	11.5	4.9	12	11.5	0.00335	0.0041	0.033792	734.4319
20	0.171	10	10	5.2	11	10	0.00335	0.0041	0.029433	639.6854
21	0.142	10.5	11	5.4	12.5	10.75	0.00335	0.0041	0.031615	687.1175
22	0.123	11	12	5.2	11	11.5	0.00335	0.0041	0.033792	734.4319
23	0.14	12.5	12.5	4.9	11	12.5	0.00335	0.0041	0.036686	797.3205
24	0.1625	10.5	13.5	4.5	11.5	12	0.00335	0.0041	0.035241	765.9054
25	0.1425	11	11.5	4.9	12	11.25	0.00335	0.0041	0.033067	718.6740
26	0.135	10.5	10	4.6	12	10.25	0.00335	0.0041	0.030161	655.5087
27	0.161	11.5	12.5	4.9	11.5	12	0.00335	0.0041	0.035241	765.9054
28	0.162	9	9	5.2	11.5	9	0.00335	0.0041	0.026515	576.2735
29	0.127	11	11	6.1	13	11	0.00335	0.0041	0.032342	702.9024
30	0.157	12	12	4.8	11.5	12	0.00335	0.0041	0.035241	765.9054
31	0.136	11	11	5.7	12.5	11	0.00335	0.0041	0.032342	702.9024
32	0.137	11	11	4.8	12	11	0.00335	0.0041	0.032342	702.9024
33	0.149	13	13	4.7	11	13	0.00335	0.0041	0.038129	828.6750
34	0.1275	10.5	10.5	5.8	12.5	10.5	0.00335	0.0041	0.030888	671.3195
35	0.126	10	11	4.8	12	10.5	0.00335	0.0041	0.030888	671.3195
36	0.138	10.5	10.5	5.3	14	10.5	0.00335	0.0041	0.030888	671.3195
37	0.153	11.5	12	5.4	12	11.75	0.00335	0.0041	0.034517	750.1758
38	0.134	11.5	11.5	5.5	12	11.5	0.00335	0.0041	0.033792	734.4319
39	0.117	10	11	4.9	11	10.5	0.00335	0.0041	0.030888	671.3195
40	0.138	11.5	11.5	4.9	11.5	11.5	0.00335	0.0041	0.033792	734.4319
Avg	0.14056	11.1	11.3	5.06	11.8	11.21	0.00335	0.0041	0.032954	716.2195
Std	0.01871	1.12	0.95	0.39	0.74	0.907	********	********	0.002633	57.23632

Picking and testing date : 14/3/1991

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1587	11	11	5.2	11.5	11	0.00335	0.0041	0.032342	702.9024
2	0.1527	10.5	11	5.1	12	10.75	0.00335	0.0041	0.031615	687.1175
3	0.1544	10	10	4.8	11	10	0.00335	0.0041	0.029433	639.6854
4	0.1753	10	10	4.5	11	10	0.00335	0.0041	0.029433	639.6854
5	0.1584	10	12	4.5	10.5	11	0.00335	0.0041	0.032342	702.9024
6	0.1223	11	11	5.2	10.5	11	0.00335	0.0041	0.032342	702.9024
7	0.198	9	10	4.7	13	9.5	0.00335	0.0041	0.027975	608.0026
8	0.1593	11	11	5.5	11.5	11	0.00335	0.0041	0.032342	702.9024
9	0.1469	10	12	5.7	11	11	0.00335	0.0041	0.032342	702.9024
10	0.1583	11.5	11.5	4.7	11.5	11.5	0.00335	0.0041	0.033792	734.4319
11	0.1629	10.5	10.5	4.7	12.5	10.5	0.00335	0.0041	0.030888	671.3195
12	0.1683	10.5	9	5.4	12	9.75	0.00335	0.0041	0.028704	623.8499
13	0.1439	10	12	5.6	12	11	0.00335	0.0041	0.032342	702.9024
14	0.144	10.5	10	5.3	11	10.25	0.00335	0.0041	0.030161	655.5087
15	0.1467	9	10	4.6	13	9.5	0.00335	0.0041	0.027975	608.0026
16	0.1486	10	9.5	4.8	11	9.75	0.00335	0.0041	0.028704	623.8499
17	0.1731	8.5	10.5	5	12	9.5	0.00335	0.0041	0.027975	608.0026
18	0.1365	9	10	5.7	12.5	9.5	0.00335	0.0041	0.027975	608.0026
19	0.1463	11	12.5	5	11.5	11.75	0.00335	0.0041	0.034517	750.1758
20	0.1482	9.5	10.5	5.2	12	10	0.00335	0.0041	0.029433	639.6854
21	0.1713	11	11	5	12	11	0.00335	0.0041	0.032342	702.9024
22	0.1402	10.5	10	6.1	13	10.25	0.00335	0.0041	0.030161	655.5087
23	0.1581	9	10	5.2	13	9.5	0.00335	0.0041	0.027975	608.0026
24	0.1587	8.5	8.5	4.8	11.5	8.5	0.00335	0.0041	0.025053	544.5005
25	0.1247	10	10	5.9	12	10	0.00335	0.0041	0.029433	639.6854
26	0.1487	12	11	4.9	12.5	11.5	0.00335	0.0041	0.033792	734.4319
27	0.1818	12	11.5	5.3	11.5	11.75	0.00335	0.0041	0.034517	750.1758
28	0.1612	10.5	10.5	5.2	12	10.5	0.00335	0.0041	0.030888	671.3195
29	0.1283	10.5	10.5	4.9	11	10.5	0.00335	0.0041	0.030888	671.3195
30	0.1399	10.5	10.5	5.8	13	10.5	0.00335	0.0041	0.030888	671.3195
31	0.1732	10	10	5	11.5	10	0.00335	0.0041	0.029433	639.6854
32	0.1365	10	10.5	5	12	10.25	0.00335	0.0041	0.030161	655.5087
33	0.1545	9.5	8.5	4.8	11.5	9	0.00335	0.0041	0.026515	576.2735
34	0.1428	11	10	5.2	11.5	10.5	0.00335	0.0041	0.030888	671.3195
35	0.1266	10	10	4.9	11	10	0.00335	0.0041	0.029433	639.6854
36	0.1795	9	9	5	12	9	0.00335	0.0041	0.026515	576.2735
37	0.15	9	9	4.9	12	9	0.00335	0.0041	0.026515	576.2735
38	0.1477	10	10	5.5	11	10	0.00335	0.0041	0.029433	639.6854
39	0.1385	12	12	5.6	11.5	12	0.00335	0.0041	0.035241	765.9054
40	0.1743	10	9.5	4.8	12	9.75	0.00335	0.0041	0.028704	623.8499
Avg	0.15348	10.1	10.4	5.12	11.7	10.29	0.00335	0.0041	0.030285	658.2090
Std	0.01648	0.89	0.94	0.38	0.67	0.819	********	********	0.002384	51.82916

Picking and testing date : 26/3/1991

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.126	8.5	10.5	5.5	10	9.5	0.00335	0.0041	0.027975	608.0026
2	0.14	9.5	12	4.8	12.5	10.75	0.00335	0.0041	0.031615	687.1175
3	0.165	9	9	4.7	13	9	0.00335	0.0041	0.026515	576.2735
4	0.136	10.5	11	4.7	12	10.75	0.00335	0.0041	0.031615	687.1175
5	0.157	9.5	10.5	5	13	10	0.00335	0.0041	0.029433	639.6854
6	0.14	10	10	4.4	11.5	10	0.00335	0.0041	0.029433	639.6854
7	0.133	8	9	5.3	11.5	8.5	0.00335	0.0041	0.025053	544.5005
8	0.169	9	10	4.8	11.5	9.5	0.00335	0.0041	0.027975	608.0026
9	0.145	10	11	6.2	10	10.5	0.00335	0.0041	0.030888	671.3195
10	0.126	9	10.5	5.5	12	9.75	0.00335	0.0041	0.028704	623.8499
11	0.163	10	11	5.4	12.5	10.5	0.00335	0.0041	0.030888	671.3195
12	0.147	8.5	8.5	4.6	12	8.5	0.00335	0.0041	0.025053	544.5005
13	0.133	8.5	9	4.8	11	8.75	0.00335	0.0041	0.025784	560.3923
14	0.138	10.5	10.5	5.2	11	10.5	0.00335	0.0041	0.030888	671.3195
15	0.174	8.5	8.5	4.9	15	8.5	0.00335	0.0041	0.025053	544.5005
16	0.126	8.5	10.5	5	12.5	9.5	0.00335	0.0041	0.027975	608.0026
17	0.125	8.5	8.5	5.1	12	8.5	0.00335	0.0041	0.025053	544.5005
18	0.15	9	8.5	4.7	14	8.75	0.00335	0.0041	0.025784	560.3923
19	0.144	9	11	4.9	11	10	0.00335	0.0041	0.029433	639.6854
20	0.119	9	8.5	4.8	13	8.75	0.00335	0.0041	0.025784	560.3923
21	0.146	9	10	4.6	13.5	9.5	0.00335	0.0041	0.027975	608.0026
22	0.137	10	10.5	5.2	13	10.25	0.00335	0.0041	0.030161	655.5087
23	0.124	9.5	10.5	4.9	14	10	0.00335	0.0041	0.029433	639.6854
24	0.123	10	9.5	4.5	12	9.75	0.00335	0.0041	0.028704	623.8499
25	0.168	8	8	4.4	13	8	0.00335	0.0041	0.023589	512.6860
26	0.149	9	8.5	4.5	11.5	8.75	0.00335	0.0041	0.025784	560.3923
27	0.145	8	10	4.5	11.5	9	0.00335	0.0041	0.026515	576.2735
28	0.152	8.5	9	4.7	12.5	8.75	0.00335	0.0041	0.025784	560.3923
29	0.182	8	8.5	4.4	13.5	8.25	0.00335	0.0041	0.024321	528.5983
30	0.153	10	10.5	5	15	10.25	0.00335	0.0041	0.030161	655.5087
31	0.2	8	8	4.5	13	8	0.00335	0.0041	0.023589	512.6860
32	0.17	8	9.5	4.6	13	8.75	0.00335	0.0041	0.025784	560.3923
33	0.173	9	8	5	12.5	8.5	0.00335	0.0041	0.025053	544.5005
34	0.155	10.5	10.5	4.8	13	10.5	0.00335	0.0041	0.030888	671.3195
35	0.147	8.5	8.5	5.1	12	8.5	0.00335	0.0041	0.025053	544.5005
36	0.166	9	9	4.7	13	9	0.00335	0.0041	0.026515	576.2735
37	0.152	10	10	5.4	12	10	0.00335	0.0041	0.029433	639.6854
38	0.17	8	7.5	4.7	12.5	7.75	0.00335	0.0041	0.022857	496.7640
39	0.132	10.5	11	5.2	12	10.75	0.00335	0.0041	0.031615	687.1175
40	0.132	10.5	10.5	4.9	13	10.5	0.00335	0.0041	0.030888	671.3195
Avg	0.1483	9.12	9.63	4.89	12.4	9.381	0.00335	0.0041	0.027625	600.4004
Std	0.01838	0.82	1.09	0.36	1.08	0.878	********	********	0.002564	55.72502

Gravenstein :

Picking and testing date : 21/12/1990.

No:	Weight Kg.	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0546	21	19	6.3	9	20	0.00335	0.0041	0.057972	1259.934
2	0.0569	17.5	17	7	9	17.25	0.00335	0.0041	0.050263	1092.400
3	0.0726	16.5	17.5	6	8	17	0.00335	0.0041	0.049557	1077.039
4	0.0865	15.5	14.5	6.5	8	15	0.00335	0.0041	0.043869	953.4380
5	0.0744	16	16	6.4	9	16	0.00335	0.0041	0.046720	1015.393
6	0.0585	15	17	6.3	9	16	0.00335	0.0041	0.046720	1015.393
7	0.0878	15.5	15	6.3	8	15.25	0.00335	0.0041	0.044583	968.9548
8	0.0842	16	17	6	9.5	16.5	0.00335	0.0041	0.048140	1046.256
9	0.0549	17	16	6.6	9	16.5	0.00335	0.0041	0.048140	1046.256
10	0.0619	19	17	7.4	8	18	0.00335	0.0041	0.052378	1138.357
11	0.0826	16	14	5.5	7.5	15	0.00335	0.0041	0.043869	953.4380
12	0.0822	18.5	17.5	6	9	18	0.00335	0.0041	0.052378	1138.357
13	0.0697	17.5	17.5	6.9	9	17.5	0.00335	0.0041	0.050969	1107.740
14	0.0642	18	17	7	9	17.5	0.00335	0.0041	0.050969	1107.740
15	0.1182	16	15	5.9	8	15.5	0.00335	0.0041	0.045296	984.4531
16	0.0622	18.5	18	6.2	8	18.25	0.00335	0.0041	0.053081	1153.633
17	0.05	19	16.5	7.3	8	17.75	0.00335	0.0041	0.051674	1123.059
18	0.0802	16	16.5	6.7	9	16.25	0.00335	0.0041	0.047431	1030.834
19	0.0848	14	14.5	6	8	14.25	0.00335	0.0041	0.041722	906.7798
20	0.0707	19	15.5	7.3	9	17.25	0.00335	0.0041	0.050263	1092.400
21	0.0664	15	17.5	5.7	8.5	16.25	0.00335	0.0041	0.047431	1030.834
22	0.0659	15	14	5.9	8	14.5	0.00335	0.0041	0.042439	922.3502
23	0.0475	18	18.5	7.2	9	18.25	0.00335	0.0041	0.053081	1153.633
24	0.0609	16	16	6.3	8	16	0.00335	0.0041	0.046720	1015.393
25	0.0655	15	17.5	7.5	8.5	16.25	0.00335	0.0041	0.047431	1030.834
26	0.0595	16	16.5	6.3	9	16.25	0.00335	0.0041	0.047431	1030.834
27	0.051	16.5	15	6.2	8.5	15.75	0.00335	0.0041	0.046009	999.9327
28	0.066	17	16	6.4	8	16.5	0.00335	0.0041	0.048140	1046.256
29	0.0576	17.5	15	6.5	8	16.25	0.00335	0.0041	0.047431	1030.834
30	0.0618	14	14	6.4	8	14	0.00335	0.0041	0.041005	891.1922
31	0.0769	16.5	17	6	8.5	16.75	0.00335	0.0041	0.048849	1061.657
32	0.0783	14	14	6	9	14	0.00335	0.0041	0.041005	891.1922
33	0.0711	15	16	6.5	8	15.5	0.00335	0.0041	0.045296	984.4531
34	0.0726	16	17	6.6	8	16.5	0.00335	0.0041	0.048140	1046.256
35	0.0516	16	18	7.1	9	17	0.00335	0.0041	0.049557	1077.039
36	0.0567	16	16.5	7.8	8.5	16.25	0.00335	0.0041	0.047431	1030.834
37	0.0541	16	15	6.6	8	15.5	0.00335	0.0041	0.045296	984.4531
38	0.0611	15	17	7	8	16	0.00335	0.0041	0.046720	1015.393
39	0.0504	15.5	16.5	6.6	8	16	0.00335	0.0041	0.046720	1015.393
40	0.0445	15	17	6	8.5	16	0.00335	0.0041	0.046720	1015.393
Avg	0.06691	16.4	16.3	6.50	8.45	16.35	0.00335	0.0041	0.047721	1037.150
Std	0.01420	1.54	1.29	0.52	0.49	1.228	********	********	0.003481	75.67460

Picking and testing date : 4/1/1991

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1492	11.5	11.5	4.8	10	11.5	0.00335	0.0041	0.033792	734.4319
2	0.103	13	13	5.6	9	13	0.00335	0.0041	0.038129	828.6750
3	0.123	10.5	11.5	4.1	9.5	11	0.00335	0.0041	0.032342	702.9024
4	0.1	11.5	13	4.9	9	12.25	0.00335	0.0041	0.035964	781.6204
5	0.1185	14	13	5.9	11	13.5	0.00335	0.0041	0.039568	859.9664
6	0.0746	11.5	13	5.8	10	12.25	0.00335	0.0041	0.035964	781.6204
7	0.1097	12.5	13	4.8	9	12.75	0.00335	0.0041	0.037408	813.0055
8	0.0916	15.5	16	5.2	10.5	15.75	0.00335	0.0041	0.046009	999.9327
9	0.1147	13	13	4.8	9	13	0.00335	0.0041	0.038129	828.6750
10	0.0903	14	16	5.3	11	15	0.00335	0.0041	0.043869	953.4380
11	0.1083	14	14	5.5	10	14	0.00335	0.0041	0.041005	891.1922
12	0.113	14	14.5	4.9	9	14.25	0.00335	0.0041	0.041722	906.7798
13	0.102	13	14	5.1	10.5	13.5	0.00335	0.0041	0.039568	859.9664
14	0.1094	13	13	4.9	10	13	0.00335	0.0041	0.038129	828.6750
15	0.087	15	14	6.5	11	14.5	0.00335	0.0041	0.042439	922.3502
16	0.1014	13.5	14	5.5	9	13.75	0.00335	0.0041	0.040287	875.5876
17	0.0982	18	13.5	6.2	9.5	15.75	0.00335	0.0041	0.046009	999.9327
18	0.1082	11	13.5	4.5	10	12.25	0.00335	0.0041	0.035964	781.6204
19	0.0966	13.5	14.5	6.2	9.5	14	0.00335	0.0041	0.041005	891.1922
20	0.1072	15	14	5.2	11	14.5	0.00335	0.0041	0.042439	922.3502
21	0.096	11	12.5	4.8	9	11.75	0.00335	0.0041	0.034517	750.1758
22	0.0881	12	13	5.3	9	12.5	0.00335	0.0041	0.036686	797.3205
23	0.0943	14	13.5	5.3	10	13.75	0.00335	0.0041	0.040287	875.5876
24	0.1175	13	11	4.7	8.5	12	0.00335	0.0041	0.035241	765.9054
25	0.0953	14	13	6.7	9	13.5	0.00335	0.0041	0.039568	859.9664
26	0.1118	13	13	5.8	9.5	13	0.00335	0.0041	0.038129	828.6750
27	0.1001	12	13	5.5	9	12.5	0.00335	0.0041	0.036686	797.3205
28	0.0934	12.5	11.5	5.1	9.5	12	0.00335	0.0041	0.035241	765.9054
29	0.1242	11	11.5	4.9	9.5	11.25	0.00335	0.0041	0.033067	718.6740
30	0.1642	11.5	13	5.1	10	12.25	0.00335	0.0041	0.035964	781.6204
31	0.0914	12	13	5.9	10.5	12.5	0.00335	0.0041	0.036686	797.3205
32	0.0985	13	13	6.2	9.5	13	0.00335	0.0041	0.038129	828.6750
33	0.109	13	14	6.2	9.5	13.5	0.00335	0.0041	0.039568	859.9664
34	0.1023	14.5	14	5.3	9	14.25	0.00335	0.0041	0.041722	906.7798
35	0.1013	13.5	13.5	5.5	9	13.5	0.00335	0.0041	0.039568	859.9664
36	0.0981	10.5	10	4.9	10	10.25	0.00335	0.0041	0.030161	655.5087
37	0.0988	13.5	14	6.4	10	13.75	0.00335	0.0041	0.040287	875.5876
38	0.0981	15.5	12.5	5.9	9.5	14	0.00335	0.0041	0.041005	891.1922
39	0.0904	13	12	6	9	12.5	0.00335	0.0041	0.036686	797.3205
40	0.092	15	15	5.7	9	15	0.00335	0.0041	0.043869	953.4380
Avg	0.10426	13.1	13.2	5.42	9.63	13.15	0.00335	0.0041	0.038570	838.2705
Std	0.01586	1.54	1.19	0.59	0.67	1.219	********	********	0.003511	76.31270

Picking and testing date : 11/1/1991

No	Weght Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1374	12.5	14	5.1	10	13.25	0.00335	0.0041	0.038849	844.3287
2	0.1215	13.5	12.5	5.5	11	13	0.00335	0.0041	0.038129	828.6750
3	0.1001	13	13	5.4	10.5	13	0.00335	0.0041	0.038129	828.6750
4	0.1137	11	11	5.1	12	11	0.00335	0.0041	0.032342	702.9024
5	0.1207	12.5	11	5.1	10	11.75	0.00335	0.0041	0.034517	750.1758
6	0.1098	8.5	9.5	4.4	12	9	0.00335	0.0041	0.026515	576.2735
7	0.1183	12.5	12.5	4.5	10.5	12.5	0.00335	0.0041	0.036686	797.3205
8	0.0961	13	12.5	5.4	11	12.75	0.00335	0.0041	0.037408	813.0055
9	0.2008	9.5	10.5	5	9.5	10	0.00335	0.0041	0.029433	639.6854
10	0.1342	10	12.5	5.4	13	11.25	0.00335	0.0041	0.033067	718.6740
11	0.104	14	10.5	5.3	11	12.25	0.00335	0.0041	0.035964	781.6204
12	0.1335	10.5	10	5.4	11	10.25	0.00335	0.0041	0.030161	655.5087
13	0.112	9.5	11	5.4	10	10.25	0.00335	0.0041	0.030161	655.5087
14	0.1108	14	12.5	4.8	10	13.25	0.00335	0.0041	0.038849	844.3287
15	0.1138	11	12.5	5.2	9	11.75	0.00335	0.0041	0.034517	750.1758
16	0.1034	10.5	12.5	5	10.5	11.5	0.00335	0.0041	0.033792	734.4319
17	0.131	12.5	13	4.8	9.5	12.75	0.00335	0.0041	0.037408	813.0055
18	0.1241	12.5	13	5.5	9.5	12.75	0.00335	0.0041	0.037408	813.0055
19	0.1187	8.5	8.5	4.8	12.5	8.5	0.00335	0.0041	0.025053	544.5005
20	0.097	13	15	5.9	10.5	14	0.00335	0.0041	0.041005	891.1922
21	0.1179	11	12	5.4	11	11.5	0.00335	0.0041	0.033792	734.4319
22	0.1162	11.5	11.5	5.2	11	11.5	0.00335	0.0041	0.033792	734.4319
23	0.1123	12	12	6	10	12	0.00335	0.0041	0.035241	765.9054
24	0.1289	14	11.5	5.2	10	12.75	0.00335	0.0041	0.037408	813.0055
25	0.1156	12.5	13	5	9	12.75	0.00335	0.0041	0.037408	813.0055
26	0.1092	12	12	5	10	12	0.00335	0.0041	0.035241	765.9054
27	0.1044	12	12	5	10	12	0.00335	0.0041	0.035241	765.9054
28	0.0931	14	11	4.9	11	12.5	0.00335	0.0041	0.036686	797.3205
29	0.1204	11.5	12.5	4.4	10	12	0.00335	0.0041	0.035241	765.9054
30	0.1304	10	10.5	4.6	9.5	10.25	0.00335	0.0041	0.030161	655.5087
31	0.1241	12.5	12.5	4.3	9.5	12.5	0.00335	0.0041	0.036686	797.3205
32	0.1381	10.5	11	4.3	10	10.75	0.00335	0.0041	0.031615	687.1175
33	0.1785	12	12	5.2	9.5	12	0.00335	0.0041	0.035241	765.9054
34	0.1448	10.5	10	4.4	9	10.25	0.00335	0.0041	0.030161	655.5087
35	0.1093	12.5	13	5.3	10	12.75	0.00335	0.0041	0.037408	813.0055
36	0.1387	11	11	4.4	10	11	0.00335	0.0041	0.032342	702.9024
37	0.0931	11	11	5.8	9.5	11	0.00335	0.0041	0.032342	702.9024
38	0.1048	12.5	13.5	5.2	9.5	13	0.00335	0.0041	0.038129	828.6750
39	0.1303	13	13	5.2	10	13	0.00335	0.0041	0.038129	828.6750
40	0.1079	13.5	11	4.8	10	12.25	0.00335	0.0041	0.035964	781.6204
Avg	0.12047	11.7	11.8	5.06	10.2	11.81	0.00335	0.0041	0.034690	753.9488
Std	0.02069	1.45	1.26	0.42	0.90	1.198	********	********	0.003475	75.54448

Picking and testing date : 18/1/1991

No	Weght	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1239	9.5	12	4.8	10	10.75	0.00335	0.0041	0.031615	687.1175
2	0.1747	8.5	12.5	4.9	12	10.5	0.00335	0.0041	0.030888	671.3195
3	0.1818	13	12	4.8	12.5	12.5	0.00335	0.0041	0.036686	797.3205
4	0.1235	12	12	4.9	12	12	0.00335	0.0041	0.035241	765.9054
5	0.1456	10.5	9	4.3	11	9.75	0.00335	0.0041	0.028704	623.8499
6	0.1441	9.5	10	4.5	10.5	9.75	0.00335	0.0041	0.028704	623.8499
7	0.2289	10	12	3.8	10	11	0.00335	0.0041	0.032342	702.9024
8	0.1167	10	10.5	4.5	11	10.25	0.00335	0.0041	0.030161	655.5087
9	0.138	7.5	7.5	4.4	12	7.5	0.00335	0.0041	0.022124	480.8325
10	0.1256	9.5	12	4.5	11	10.75	0.00335	0.0041	0.031615	687.1175
11	0.1352	12.5	11.5	5	10.5	12	0.00335	0.0041	0.035241	765.9054
12	0.1051	10.5	12	5.8	12	11.25	0.00335	0.0041	0.033067	718.6740
13	0.144	11.5	10	4.5	10	10.75	0.00335	0.0041	0.031615	687.1175
14	0.1457	11	12.5	4.9	12	11.75	0.00335	0.0041	0.034517	750.1758
15	0.1338	11.5	11.5	5.2	10	11.5	0.00335	0.0041	0.033792	734.4319
16	0.1538	11.5	11.5	4.8	10.5	11.5	0.00335	0.0041	0.033792	734.4319
17	0.1309	11.5	11.5	5.2	10	11.5	0.00335	0.0041	0.033792	734.4319
18	0.1342	10.5	11	4.5	12.5	10.75	0.00335	0.0041	0.031615	687.1175
19	0.1242	10	9.5	4.4	11	9.75	0.00335	0.0041	0.028704	623.8499
20	0.1534	11	10	5.5	13	10.5	0.00335	0.0041	0.030888	671.3195
21	0.1237	11	11	4.3	11	11	0.00335	0.0041	0.032342	702.9024
22	0.1586	10	10	4.8	10.5	10	0.00335	0.0041	0.029433	639.6854
23	0.1725	8.5	10	4.2	10.5	9.25	0.00335	0.0041	0.027245	592.1437
24	0.1401	10	11	4.6	11	10.5	0.00335	0.0041	0.030888	671.3195
25	0.1132	12.5	12.5	5	11	12.5	0.00335	0.0041	0.036686	797.3205
26	0.1532	8.5	10	4.2	9	9.25	0.00335	0.0041	0.027245	592.1437
27	0.1292	13	12	4.8	11	12.5	0.00335	0.0041	0.036686	797.3205
28	0.1556	11	11	5	10	11	0.00335	0.0041	0.032342	702.9024
29	0.1628	8.5	10	4.6	11	9.25	0.00335	0.0041	0.027245	592.1437
30	0.128	11	12	5.4	10.5	11.5	0.00335	0.0041	0.033792	734.4319
31	0.1217	10	9.5	4.3	10	9.75	0.00335	0.0041	0.028704	623.8499
32	0.1145	10	10.5	4	10.5	10.25	0.00335	0.0041	0.030161	655.5087
33	0.1325	11	12	5.4	11.5	11.5	0.00335	0.0041	0.033792	734.4319
34	0.1225	12	12	5.1	10	12	0.00335	0.0041	0.035241	765.9054
35	0.1582	8.5	10	4.2	11.5	9.25	0.00335	0.0041	0.027245	592.1437
36	0.1278	10.5	10.5	4.7	9.5	10.5	0.00335	0.0041	0.030888	671.3195
37	0.1252	11	12	4.8	12.5	11.5	0.00335	0.0041	0.033792	734.4319
38	0.1129	10.5	11	4.9	11	10.75	0.00335	0.0041	0.031615	687.1175
39	0.1555	11	10	4.7	10.5	10.5	0.00335	0.0041	0.030888	671.3195
40	0.1525	11	10.5	4.9	11.5	10.75	0.00335	0.0041	0.031615	687.1175
Avg	0.14058	10.5	10.9	4.72	10.9	10.73	0.00335	0.0041	0.031574	686.2159
Std	0.02291	1.27	1.11	0.41	0.90	1.044	********	********	0.003037	66.01447

Picking and testing date : 25/1/1991

No	Weght	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1086	11	10	4.3	10	10.5	0.00335	0.0041	0.030888	671.3195
2	0.141	10	10	4.4	10	10	0.00335	0.0041	0.029433	639.6854
3	0.1455	8.5	8.5	4.2	10	8.5	0.00335	0.0041	0.025053	544.5005
4	0.1473	8.5	8	3.9	14	8.25	0.00335	0.0041	0.024321	528.5983
5	0.1408	12	10	4.7	10	11	0.00335	0.0041	0.032342	702.9024
6	0.1374	10.5	10	4.5	9.5	10.25	0.00335	0.0041	0.030161	655.5087
7	0.1329	10.5	11.5	5.3	11	11	0.00335	0.0041	0.032342	702.9024
8	0.135	10.5	10.5	4.3	11	10.5	0.00335	0.0041	0.030888	671.3195
9	0.1235	9.5	9	4.5	9.5	9.25	0.00335	0.0041	0.027245	592.1437
10	0.1285	10.5	10.5	5.1	12	10.5	0.00335	0.0041	0.030888	671.3195
11	0.123	10.5	10.5	4.4	10.5	10.5	0.00335	0.0041	0.030888	671.3195
12	0.153	9.5	10	4.2	10	9.75	0.00335	0.0041	0.028704	623.8499
13	0.1013	9.5	10.5	4.4	9	10	0.00335	0.0041	0.029433	639.6854
14	0.1283	9.5	8.5	3.5	11	9	0.00335	0.0041	0.026515	576.2735
15	0.125	10	10.5	4.7	12.5	10.25	0.00335	0.0041	0.030161	655.5087
16	0.1447	11.5	10.5	4.2	11	11	0.00335	0.0041	0.032342	702.9024
17	0.1625	9.5	10	3.7	10	9.75	0.00335	0.0041	0.028704	623.8499
18	0.1185	10.5	8.5	3.5	11	9.5	0.00335	0.0041	0.027975	608.0026
19	0.1517	9	10.5	5.3	11.5	9.75	0.00335	0.0041	0.028704	623.8499
20	0.1417	9.5	10.5	4.2	11	10	0.00335	0.0041	0.029433	639.6854
21	0.1259	7.5	10	3.5	11	8.75	0.00335	0.0041	0.025784	560.3923
22	0.1238	10	11	4.2	11	10.5	0.00335	0.0041	0.030888	671.3195
23	0.1533	8.5	8.5	4.7	12.5	8.5	0.00335	0.0041	0.025053	544.5005
24	0.1215	9	8.5	4	10.5	8.75	0.00335	0.0041	0.025784	560.3923
25	0.1494	10	7.5	4.2	12	8.75	0.00335	0.0041	0.025784	560.3923
26	0.1681	9	9	4.3	9.5	9	0.00335	0.0041	0.026515	576.2735
27	0.1739	8.5	9	4.4	12	8.75	0.00335	0.0041	0.025784	560.3923
28	0.1248	9.5	9.5	4.4	12	9.5	0.00335	0.0041	0.027975	608.0026
29	0.1064	10	9.5	4.1	10.5	9.75	0.00335	0.0041	0.028704	623.8499
30	0.1433	10	9	4	10	9.5	0.00335	0.0041	0.027975	608.0026
31	0.1216	9	10	4.6	10.5	9.5	0.00335	0.0041	0.027975	608.0026
32	0.1238	8.5	10.5	4.4	13	9.5	0.00335	0.0041	0.027975	608.0026
33	0.1333	9	10.5	4.9	12.5	9.75	0.00335	0.0041	0.028704	623.8499
34	0.1417	8.5	8.5	3.6	12	8.5	0.00335	0.0041	0.025053	544.5005
35	0.1738	8	8.5	4.3	10	8.25	0.00335	0.0041	0.024321	528.5983
36	0.1991	9	9	4.3	10	9	0.00335	0.0041	0.026515	576.2735
37	0.1425	10	10	4.4	12	10	0.00335	0.0041	0.029433	639.6854
38	0.1225	10	9	4	10	9.5	0.00335	0.0041	0.027975	608.0026
39	0.1277	10.5	10	4.4	11.5	10.25	0.00335	0.0041	0.030161	655.5087
40	0.1537	10.5	10.5	4.1	12	10.5	0.00335	0.0041	0.030888	671.3195
Avg	0.13800	9.63	9.65	4.30	10.9	9.643	0.00335	0.0041	0.028392	617.0597
Std	0.01946	0.94	0.91	0.42	1.10	0.776	***************		0.002264	49.21344

Picking and testing date : 28/1/1991

No	Weght	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.14	11.5	10.5	4.3	12	11	0.00335	0.0041	0.032342	702.9024
2	0.1367	10	10	4.1	9.5	10	0.00335	0.0041	0.029433	639.6854
3	0.1526	9	10	4.4	12.5	9.5	0.00335	0.0041	0.027975	608.0026
4	0.1516	10.5	10.5	4.3	10	10.5	0.00335	0.0041	0.030888	671.3195
5	0.1416	9.5	9.5	4.2	11.5	9.5	0.00335	0.0041	0.027975	608.0026
6	0.1587	10.5	10.5	4.4	9.5	10.5	0.00335	0.0041	0.030888	671.3195
7	0.2671	8.5	7.5	4	10.5	8	0.00335	0.0041	0.023589	512.6860
8	0.1402	8.5	8.5	4	12	8.5	0.00335	0.0041	0.025053	544.5005
9	0.1856	10.5	9	4.2	11	9.75	0.00335	0.0041	0.028704	623.8499
10	0.129	11.5	10.5	5.8	11.5	11	0.00335	0.0041	0.032342	702.9024
11	0.1641	8.5	10	4.3	10	9.25	0.00335	0.0041	0.027245	592.1437
12	0.1778	9.5	9.5	4.5	13	9.5	0.00335	0.0041	0.027975	608.0026
13	0.184	8.5	9	4.5	10	8.75	0.00335	0.0041	0.025784	560.3923
14	0.1916	8.5	10.5	4.2	10	9.5	0.00335	0.0041	0.027975	608.0026
15	0.1621	8.5	10	4.7	11.5	9.25	0.00335	0.0041	0.027245	592.1437
16	0.1629	8.5	8.5	4	9	8.5	0.00335	0.0041	0.025053	544.5005
17	0.1449	8	8	4.2	10	8	0.00335	0.0041	0.023589	512.6860
18	0.1397	7	10.5	4	11.5	8.75	0.00335	0.0041	0.025784	560.3923
19	0.1578	10	11.5	5.3	11.5	10.75	0.00335	0.0041	0.031615	687.1175
20	0.1512	7.5	10	4.2	11	8.75	0.00335	0.0041	0.025784	560.3923
21	0.1266	9.5	9.5	5.9	13.5	9.5	0.00335	0.0041	0.027975	608.0026
22	0.1742	9.5	9.5	4.1	11.5	9.5	0.00335	0.0041	0.027975	608.0026
23	0.1842	8.5	10	3.8	11	9.25	0.00335	0.0041	0.027245	592.1437
24	0.1637	8.5	10.5	3.6	11.5	9.5	0.00335	0.0041	0.027975	608.0026
25	0.1732	10	9	4.4	10.5	9.5	0.00335	0.0041	0.027975	608.0026
26	0.2236	9	9	4.4	10	9	0.00335	0.0041	0.026515	576.2735
27	0.2341	8.5	9	4.2	10	8.75	0.00335	0.0041	0.025784	560.3923
28	0.1578	9	9.5	4	13	9.25	0.00335	0.0041	0.027245	592.1437
29	0.1781	8.5	10	4.6	11.5	9.25	0.00335	0.0041	0.027245	592.1437
30	0.1094	10	11.5	4.5	12	10.75	0.00335	0.0041	0.031615	687.1175
31	0.1521	10.5	10.5	4.2	11	10.5	0.00335	0.0041	0.030888	671.3195
32	0.1672	9	9	4.9	12.5	9	0.00335	0.0041	0.026515	576.2735
33	0.1517	8.5	8.5	4.8	12	8.5	0.00335	0.0041	0.025053	544.5005
34	0.1737	7.5	8.5	4.3	12	8	0.00335	0.0041	0.023589	512.6860
35	0.2214	8	8	3.6	10.5	8	0.00335	0.0041	0.023589	512.6860
36	0.1574	9	9	4	11.5	9	0.00335	0.0041	0.026515	576.2735
37	0.1263	9	8.5	3.9	11	8.75	0.00335	0.0041	0.025784	560.3923
38	0.2409	9	9	4	9.5	9	0.00335	0.0041	0.026515	576.2735
39	0.1977	8.5	10	4.4	11.5	9.25	0.00335	0.0041	0.027245	592.1437
40	0.1486	10	11	4.5	11.5	10.5	0.00335	0.0041	0.030888	671.3195
Avg	0.16752	9.11	9.58	4.34	11.1	9.35	0.00335	0.0041	0.027534	598.4259
Std	0.03284	1.00	0.94	0.47	1.05	0.824	********	********	0.002406	52.31181

Picking and testing date : 5/2/1991

No	Weght Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1113	11	12.5	3.5	10.5	11.75	0.00335	0.0041	0.024058	522.8658
2	0.1306	12.5	14	4.1	10	13.25	0.00335	0.0041	0.027077	588.4896
3	0.1418	13	13.5	3.9	11	13.25	0.00335	0.0041	0.027077	588.4896
4	0.1646	13	14	3.9	11	13.5	0.00335	0.0041	0.027579	599.3889
5	0.1486	12	12.5	4.4	10.5	12.25	0.00335	0.0041	0.025066	544.7825
6	0.116	10	14	3.5	11	12	0.00335	0.0041	0.024562	533.8292
7	0.1948	14	16	4.5	10.5	15	0.00335	0.0041	0.030576	664.5378
8	0.1791	12	13	4.6	11	12.5	0.00335	0.0041	0.025570	555.7253
9	0.1812	13	15	4.1	11	14	0.00335	0.0041	0.028580	621.1531
10	0.1735	10.5	12	4	11.5	11.25	0.00335	0.0041	0.023047	500.9094
11	0.1531	12	13	3.6	10.5	12.5	0.00335	0.0041	0.025570	555.7253
12	0.1561	13	13	4.1	11	13	0.00335	0.0041	0.026575	577.5791
13	0.1927	12.5	14	4.6	10	13.25	0.00335	0.0041	0.027077	588.4896
14	0.1434	12.5	11	4.2	12.5	11.75	0.00335	0.0041	0.024058	522.8658
15	0.1485	12	12.5	4.4	12	12.25	0.00335	0.0041	0.025066	544.7825
16	0.1563	12	12.5	4.1	10.5	12.25	0.00335	0.0041	0.025066	544.7825
17	0.1118	14	13	4.3	11.5	13.5	0.00335	0.0041	0.027579	599.3889
18	0.1602	11.5	15	4	11	13.25	0.00335	0.0041	0.027077	588.4896
19	0.1564	11	10.5	3.8	11	10.75	0.00335	0.0041	0.022035	478.9148
20	0.2062	11.5	11.5	3.8	11	11.5	0.00335	0.0041	0.023553	511.8925
21	0.1284	12.5	12.5	4.4	11	12.5	0.00335	0.0041	0.025570	555.7253
22	0.1523	11.5	12.5	4	10	12	0.00335	0.0041	0.024562	533.8292
23	0.1295	13	11	3.8	10.5	12	0.00335	0.0041	0.024562	533.8292
24	0.1376	12.5	10	4	12	11.25	0.00335	0.0041	0.023047	500.9094
25	0.1508	13	13	4	12	13	0.00335	0.0041	0.026575	577.5791
26	0.167	13	10	4.9	11	11.5	0.00335	0.0041	0.023553	511.8925
27	0.1514	11.5	11.5	4	11	11.5	0.00335	0.0041	0.023553	511.8925
28	0.1413	11	12.5	4.3	10.5	11.75	0.00335	0.0041	0.024058	522.8658
29	0.1331	10.5	11.5	4.3	11	11	0.00335	0.0041	0.022542	489.9168
30	0.1384	13	13	4.1	10	13	0.00335	0.0041	0.026575	577.5791
31	0.12	12.5	12.5	4	12	12.5	0.00335	0.0041	0.025570	555.7253
32	0.1629	13.5	13.5	3.9	11	13.5	0.00335	0.0041	0.027579	599.3889
33	0.1463	13.5	11.5	4	11	12.5	0.00335	0.0041	0.025570	555.7253
34	0.1252	10.5	12.5	3.9	10	11.5	0.00335	0.0041	0.023553	511.8925
35	0.1144	11	12	4	10	11.5	0.00335	0.0041	0.023553	511.8925
36	0.1353	14	14	4.8	12.5	14	0.00335	0.0041	0.028580	621.1531
37	0.1535	10	11	3.6	10	10.5	0.00335	0.0041	0.021529	467.9037
38	0.1687	10	9.5	3.5	9.5	9.75	0.00335	0.0041	0.020006	434.8179
39	0.1511	11.5	11.5	5.2	11	11.5	0.00335	0.0041	0.023553	511.8925
40	0.1383	10.5	11	3.9	11	10.75	0.00335	0.0041	0.022035	478.9148
Avg	0.14929	12.0	12.4	4.1	10.9	12.25	0.00335	0.0041	0.025074	544.9602
Std	0.02230	1.14	1.40	0.37	0.69	1.073	********	********	0.002161	46.97033

Picking and testing date : 12/2/1991

No	Weght Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1118	12.5	13.5	3.9	12	13	0.00335	0.0041	0.026575	577.5791
2	0.1311	11.5	12	3.9	13	11.75	0.00335	0.0041	0.024058	522.8658
3	0.1699	11	12	3.9	10.5	11.5	0.00335	0.0041	0.023553	511.8925
4	0.1374	12.5	10	4.5	11	11.25	0.00335	0.0041	0.023047	500.9094
5	0.1094	13	13	4.8	12	13	0.00335	0.0041	0.026575	577.5791
6	0.1294	11.5	11.5	3.8	11.5	11.5	0.00335	0.0041	0.023553	511.8925
7	0.15	12.5	12.5	4.2	11.5	12.5	0.00335	0.0041	0.025570	555.7253
8	0.1298	12	13	5	11.5	12.5	0.00335	0.0041	0.025570	555.7253
9	0.1623	9	11	3.9	13	10	0.00335	0.0041	0.020514	445.8550
10	0.1697	12	12	3.8	11.5	12	0.00335	0.0041	0.024562	533.8292
11	0.1562	11	12	4.4	12	11.5	0.00335	0.0041	0.023553	511.8925
12	0.1392	12.5	13	4.2	13	12.75	0.00335	0.0041	0.026073	566.6576
13	0.1735	11	10	3.6	11	10.5	0.00335	0.0041	0.021529	467.9037
14	0.1295	12	12	4.5	12	12	0.00335	0.0041	0.024562	533.8292
15	0.1322	12.5	13	4.2	11.5	12.75	0.00335	0.0041	0.026073	566.6576
16	0.145	12.5	13	4.5	12	12.75	0.00335	0.0041	0.026073	566.6576
17	0.1139	13	13	4.2	12.5	13	0.00335	0.0041	0.026575	577.5791
18	0.1495	13	13	4	11	13	0.00335	0.0041	0.026575	577.5791
19	0.1229	10	10	4.5	11.5	10	0.00335	0.0041	0.020514	445.8550
20	0.1406	12	12	3.9	13	12	0.00335	0.0041	0.024562	533.8292
21	0.1364	11	11	4.2	11.5	11	0.00335	0.0041	0.022542	489.9168
22	0.1294	12	11	3.9	11	11.5	0.00335	0.0041	0.023553	511.8925
23	0.138	13	13	4.4	11.5	13	0.00335	0.0041	0.026575	577.5791
24	0.1767	11.5	11.5	4.3	12	11.5	0.00335	0.0041	0.023553	511.8925
25	0.1348	12.5	12.5	4	13	12.5	0.00335	0.0041	0.025570	555.7253
26	0.1296	14	14	4.3	12	14	0.00335	0.0041	0.028580	621.1531
27	0.1599	11	12	4	11.5	11.5	0.00335	0.0041	0.023553	511.8925
28	0.1308	12	12	4	13	12	0.00335	0.0041	0.024562	533.8292
29	0.1526	12	12	4	11	12	0.00335	0.0041	0.024562	533.8292
30	0.1048	13	13	4.8	13	13	0.00335	0.0041	0.026575	577.5791
31	0.1278	13	13	4.4	13.5	13	0.00335	0.0041	0.026575	577.5791
32	0.1517	12.5	12.5	4	10.5	12.5	0.00335	0.0041	0.025570	555.7253
33	0.1893	12.5	12.5	4	11.5	12.5	0.00335	0.0041	0.025570	555.7253
34	0.1144	12.5	12.5	4.6	9.5	12.5	0.00335	0.0041	0.025570	555.7253
35	0.1212	14	14	4.2	11	14	0.00335	0.0041	0.028580	621.1531
36	0.1376	11.5	11	3.8	9	11.25	0.00335	0.0041	0.023047	500.9094
37	0.1272	11.5	11.5	3.8	11	11.5	0.00335	0.0041	0.023553	511.8925
38	0.168	12.5	12.5	4.5	11	12.5	0.00335	0.0041	0.025570	555.7253
39	0.1057	13.5	13.5	4.3	11	13.5	0.00335	0.0041	0.027579	599.3889
40	0.147	12.5	12.5	4.5	12	12.5	0.00335	0.0041	0.025570	555.7253
Avg	0.13965	12.1	12.2	4.1	11.6	12.17	0.00335	0.0041	0.024912	541.4283
Std	0.02027	0.97	0.98	0.3	0.95	0.920	****************		0.001856	40.34714

APPENDIX 4 : Data For The Forth Series Of Experiment For Apples.

Royal Gala, picking and testing date : 4/3/1991

No	Weight Kg	SA1 Deg.	SA2 Deg.	BA1 Deg.	BA2 Deg.	AvSA Deg.	AvBA Deg.	Pr Kg	SSC %	MS Nm	MB Nm
1	0.1231	12.5	12.5	82	78	12.5	80	4.9	10	0.037783	0.171917
2	0.148	13	11	62	52	12	57	5.2	10.5	0.036295	0.146406
3	0.0981	12.5	12.5	67	54	12.5	60.5	5	11	0.037783	0.151937
4	0.1051	12	13	70	84	12.5	77	5.1	11	0.037783	0.170095
5	0.1139	12.5	12	85	70	12.25	77.5	6.2	12	0.037039	0.170431
6	0.0914	12.5	13	58	61	12.75	59.5	4.9	11	0.038527	0.150414
7	0.1061	13.5	15	62	87	14.25	74.5	5	11	0.042970	0.168220
8	0.1184	15.5	16	57	58	15.75	57.5	6.4	11.5	0.078962	0.245342
9	0.1261	10	10.5	61	65	10.25	63	4.5	11	0.031063	0.155543
10	0.1261	14	12	60	58	13	59	4.8	11	0.039269	0.149635
11	0.1016	13	13	65	63	13	64	5.5	11	0.039269	0.156902
12	0.1152	16.5	16	55	52	16.25	53.5	5.7	11.5	0.081402	0.233841
13	0.1163	11	12	62	66	11.5	64	5	10.5	0.034803	0.156902
14	0.1314	16	12.5	51	40	14.25	45.5	5.3	12	0.071605	0.207484
15	0.1413	13	12.5	71	65	12.75	68	4.7	12	0.038527	0.161858
16	0.1649	13.5	13	90	89	13.25	89.5	5.4	11	0.040011	0.174563
17	0.1444	12	11	71	57	11.5	64	4.9	10	0.034803	0.156902
18	0.1291	11	12	61	73	11.5	67	5.4	12	0.034803	0.160692
19	0.1438	12.5	11	65	57	11.75	61	4.8	11	0.035549	0.152682
20	0.131	11	13.5	55	80	12.25	67.5	4.7	11.5	0.037039	0.161281
21	0.16	11	11	56	53	11	54.5	4.5	13	0.033309	0.142120
22	0.1288	13	11	65	55	12	60	5.4	11	0.036295	0.151182
23	0.1576	13	11	70	59	12	64.5	4.5	11	0.036295	0.157564
24	0.1336	12	11	76	57	11.5	66.5	5.2	11	0.034803	0.160091
25	0.1461	11.5	11.5	65	66	11.5	65.5	4.4	11	0.034803	0.158851
26	0.1451	14	12.5	84	62	13.25	73	5.2	12.5	0.040011	0.166942
27	0.1687	12.5	10	70	61	11.25	65.5	4.8	10.5	0.034056	0.158851
28	0.1351	11	12.5	58	72	11.75	65	4.8	14	0.035549	0.158214
29	0.1677	10.5	11	50	56	10.75	53	4.3	13	0.032561	0.139417
30	0.1571	15	12.5	86	71	13.75	78.5	5.8	13	0.041492	0.171065
31	0.1562	12	10.5	75	50	11.25	62.5	5.5	13.5	0.034056	0.154845
32	0.1451	13.5	12.5	75	56	13	65.5	5	11.5	0.039269	0.158851
33	0.1735	12	10	71	51	11	61	4.9	13	0.033309	0.152682
34	0.1489	13	11	62	60	12	61	4.8	10	0.036295	0.152682
35	0.1413	12.5	13	62	60	12.75	61	5.4	12	0.038527	0.152682
36	0.1406	12.5	10	60	54	11.25	57	4.8	10.5	0.034056	0.146406
37	0.1484	12.5	13.5	72	75	13	73.5	5.6	11	0.039269	0.167381
38	0.1561	11.5	11	57	56	11.25	56.5	5.6	11.5	0.034056	0.145571
39	0.1259	11.5	11	70	68	11.25	69	4.7	11	0.034056	0.162975
40	0.139	12.5	11	76	63	11.75	69.5	5.2	12	0.035549	0.163514
Avg	0.1362	12.6	12.03	66.7	62.85	12.325	64.8	5.09	11.4	0.039573	0.163123
Std	0.0201	1.39	1.424	9.68	10.55	1.2414	8.3716	0.45	0.95	0.011097	0.020886

Note :
- SA1 = Angle reading 1 for small blade.
- SA2 = Angle reading 2 for small blade.
- BA1 = Angle reading 1 for big blade.
- BA2 = Angle reading 2 for big blade.
- AvSA = Average angle reading for small blade
- AvBa = Average angle reading for big blade.
- MS = Moment for small blade.
- MB = Moment for big blade.

Gravenstein, picking date : 5/2/1991, t sting date : 4/3 1991

No	Weight Kg	SA1 Deg.	SA2 Deg.	BA1 Deg.	BA2 Deg.	AvSA Deg.	AvBA Deg.	Pr Kg	SSC %	MS Nm	MB Nm
1	0.1377	13	11	55	55	12	55	4.5	14	0.036295	0.142999
2	0.1254	10	9	48	45	9.5	46.5	3.9	11.5	0.028812	0.126628
3	0.1033	9	9	48	46	9	47	4	11	0.027308	0.127672
4	0.0978	10.5	9	55	53	9.75	54	4.7	12	0.029563	0.141230
5	0.1165	10	11	45	75	10.5	60	4.4	13.5	0.031812	0.151182
6	0.1053	8	11	42	51	9.5	46.5	4	13	0.028812	0.126628
7	0.108	9	10	47	49	9.5	48	4.2	11.5	0.028812	0.129730
8	0.1024	10.5	11.5	46	55	11	50.5	4.3	11	0.033309	0.134702
9	0.1011	8.5	10	47	51	9.25	49	4.2	12	0.028060	0.131749
10	0.1151	10	8.5	53	47.5	9.25	50.25	4.4	11.5	0.028060	0.134216
11	0.1194	10.5	9.5	45	45	10	45	3.7	12	0.030313	0.123439
12	0.1004	9.5	9	50	44	9.25	47	4	11	0.028060	0.127672
13	0.1273	10	9.5	43	42	9.75	42.5	4.2	11.5	0.029563	0.117937
14	0.1216	10.5	9.5	49	42.5	10	45.75	4.5	11	0.030313	0.125044
15	0.1595	9	8	47	40	8.5	43.5	3.8	11	0.025803	0.120166
16	0.1029	10	11	43	52	10.5	47.5	4	11.5	0.031812	0.128706
17	0.115	10	11	45	58	10.5	51.5	4.4	11	0.031812	0.136619
18	0.106	9	9.5	43	47	9.25	45	4.6	11.5	0.028060	0.123439
19	0.1425	11	11	45	46	11	45.5	4.2	11	0.033309	0.124512
20	0.0921	8	8.5	36.5	38	8.25	37.25	3.9	11.5	0.025049	0.105666
21	0.1641	8	9	36	43	8.5	39.5	3.8	12.5	0.025803	0.111040
22	0.1699	8.5	9	41	41	8.75	41	4.1	12	0.026556	0.114528
23	0.1348	9.5	8.5	44	44	9	44	4.4	13	0.027308	0.121266
24	0.1704	8.5	9	42.5	45	8.75	43.75	4.2	11.5	0.026556	0.120717
25	0.1453	12.5	10	48.5	43.5	11.25	46	4.5	14	0.034056	0.125575
26	0.1187	10.5	11.5	43.5	48	11	45.75	4	13	0.033309	0.125044
27	0.116	9	9	45	45	9	45	4.3	11	0.027308	0.123439
28	0.1575	9	10	39	41	9.5	40	4.1	11	0.028812	0.112211
29	0.1286	8.5	9	36	38	8.75	37	3.5	11	0.026556	0.105058
30	0.1393	9	10.5	38	44	9.75	41	4	12	0.029563	0.114528
31	0.1231	10	10.5	41	43	10.25	42	3.6	10	0.031063	0.116810
32	0.156	9.5	10	41	43	9.75	42	3.9	11.5	0.029563	0.116810
33	0.0985	10	10	45	42.5	10	43.75	4.2	12.5	0.030313	0.120717
34	0.1018	10.5	12	50	51	11.25	50.5	4.5	13	0.034056	0.134702
35	0.1086	10	10.5	41	49	10.25	45	5.2	15	0.031063	0.123439
36	0.1326	10	10.5	45.5	45.5	10.25	45.5	4.2	11.5	0.031063	0.124512
37	0.1473	10	9.5	41.5	38.5	9.75	40	4.1	11.5	0.029563	0.112211
38	0.12	8.5	10	38	43.5	9.25	40.75	3.9	11	0.028060	0.113952
39	0.1355	10.5	10	50	47	10.25	48.5	4.7	13	0.031063	0.130745
40	0.0841	13.5	12.5	61.5	53.5	13	57.5	5.2	12.5	0.039269	0.147230
Avg	0.1237	9.78	9.937	45.0	46.77	9.8625	45.893	4.20	11.9	0.029896	0.124862
Std	0.0222	1.21	1.031	5.35	6.580	0.9841	5.0105	0.36	1.03	0.002949	0.010261

APPENDIX 5 : Data For The First Series Of Experiment For Kiwifruit.

Picking and testing date : 18/4/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.119	26	26.5	9.6	4.5	26.25	0.00335	0.0041	0.077988	1694.956555
2	0.1127	26	24.5	9.6	4.5	25.25	0.00335	0.0041	0.075216	1634.713927
3	0.0972	25	26	8.8	4.5	25.5	0.00335	0.0041	0.075912	1649.821986
4	0.0988	27	28	9.1	4	27.5	0.00335	0.0041	0.081420	1769.531656
5	0.0908	26	28	8.6	4	27	0.00335	0.0041	0.080052	1739.800701
6	0.088	25	26	8.6	4.5	25.5	0.00335	0.0041	0.075912	1649.821986
7	0.092	25	27	8.7	4	26	0.00335	0.0041	0.077297	1679.943587
8	0.1013	24	25	8.3	4	24.5	0.00335	0.0041	0.073122	1589.204168
9	0.097	25	24.5	8.5	4.5	24.75	0.00335	0.0041	0.073822	1604.404729
10	0.0839	22	24	8.3	5	23	0.00335	0.0041	0.068897	1497.375587
11	0.0879	21	23	7	5	22	0.00335	0.0041	0.066054	1435.582494
12	0.0812	23.5	22	8.5	5	22.75	0.00335	0.0041	0.068188	1481.969342
13	0.0886	22.5	23	8.5	4	22.75	0.00335	0.0041	0.068188	1481.969342
14	0.0816	23	24	8.9	4	23.5	0.00335	0.0041	0.070311	1528.102262
15	0.0877	23	24	7.9	5	23.5	0.00335	0.0041	0.070311	1528.102262
16	0.0804	26	27	8.4	4.5	26.5	0.00335	0.0041	0.078678	1709.937253
17	0.0802	23	24.5	8.2	4.5	23.75	0.00335	0.0041	0.071016	1543.422106
18	0.0911	24	25	9.4	5	24.5	0.00335	0.0041	0.073122	1589.204168
19	0.0888	23.5	23	8.1	4	23.25	0.00335	0.0041	0.069605	1512.753325
20	0.088	24.5	23	8.5	5	23.75	0.00335	0.0041	0.071016	1543.422106
Avg	0.09181	24.2	24.9	8.5	4.47	24.57	0.00335	0.0041	0.073306	1593.201977
Std	0.00999	1.52	1.71	0.5	0.40	1.522	********	0	0.004255	92.48159976

Picking and testing date : 2/5/1990

No	Weght Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0955	20	21	7.5	5	20.5	0.00335	0.0041	0.077809	1691.051
2	0.1027	17.5	18	8.4	6	17.75	0.00335	0.0041	0.067734	1472.102
3	0.0638	18	18	7.9	4.5	18	0.00335	0.0041	0.068657	1492.154
4	0.0698	16	18	7.5	5	17	0.00335	0.0041	0.064959	1411.779
5	0.0874	17.5	17.5	7.9	5	17.5	0.00335	0.0041	0.066810	1452.022
6	0.0834	16	16	8.5	5	16	0.00335	0.0041	0.061241	1330.973
7	0.0724	17.5	19	7.8	5	18.25	0.00335	0.0041	0.069578	1512.178
8	0.0908	17.5	20	7.3	5	18.75	0.00335	0.0041	0.071417	1552.139
9	0.0854	19	17.5	7.8	5	18.25	0.00335	0.0041	0.069578	1512.178
10	0.0894	15	17.5	7.7	6	16.25	0.00335	0.0041	0.062172	1351.214
11	0.0965	19	22	7.3	5	20.5	0.00335	0.0041	0.077809	1691.051
12	0.0856	20	18.5	7.7	5	19.25	0.00335	0.0041	0.073250	1591.981
13	0.0846	14.5	15	6.8	5	14.75	0.00335	0.0041	0.056567	1229.400
14	0.0812	16	18.5	7.7	5	17.25	0.00335	0.0041	0.065885	1431.914
15	0.1225	20	18	7.5	5.5	19	0.00335	0.0041	0.072334	1572.075
16	0.1132	18	19	7.8	5	18.5	0.00335	0.0041	0.070498	1532.173
17	0.0942	14.5	18	7.5	6	16.25	0.00335	0.0041	0.062172	1351.214
18	0.0923	18.5	20	8.4	6	19.25	0.00335	0.0041	0.073250	1591.981
19	0.0926	20	18	7.9	5.5	19	0.00335	0.0041	0.072334	1572.075
20	0.0641	17	19	7.5	5	18	0.00335	0.0041	0.068657	1492.154
Avg	0.08837	17.5	18.4	7.7	5.22	18	0.00335	0.0041	0.068636	1491.690
Std	0.01427	1.76	1.52	0.3	0.43	1.433	********	0	0.005293	115.0373

Picking and testing date : 16/5/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0935	17.5	17.5	8.3	8	17.5	0.00335	0.0041	0.066810	1452.022
2	0.0934	14.5	13.5	7.8	8	14	0.00335	0.0041	0.053750	1168.171
3	0.0881	14	12.5	7.6	8	13.25	0.00335	0.0041	0.050923	1106.743
4	0.1337	14	13	8.3	6	13.5	0.00335	0.0041	0.051866	1127.240
5	0.0884	13	12.5	7.2	7	12.75	0.00335	0.0041	0.049034	1065.684
6	0.1189	14	15.5	8	7	14.75	0.00335	0.0041	0.056567	1229.400
7	0.0928	14	15	6.8	7	14.5	0.00335	0.0041	0.055629	1209.013
8	0.0947	11.5	13	7.2	6.5	12.25	0.00335	0.0041	0.047141	1024.545
9	0.0907	14.5	13	7	7	13.75	0.00335	0.0041	0.052809	1147.717
10	0.1004	12	15	8.7	7	13.5	0.00335	0.0041	0.051866	1127.240
11	0.1047	17	18	7.3	8	17.5	0.00335	0.0041	0.066810	1452.022
12	0.1111	15	14	7.5	7	14.5	0.00335	0.0041	0.055629	1209.013
13	0.0944	11	14	8	9	12.5	0.00335	0.0041	0.048088	1045.125
14	0.1116	15	19	7.4	7	17	0.00335	0.0041	0.064959	1411.779
15	0.1248	17.5	18	8.2	6.5	17.75	0.00335	0.0041	0.067734	1472.102
16	0.1117	16	18	7.8	8	17	0.00335	0.0041	0.064959	1411.779
17	0.1081	15.5	13	8.2	7	14.25	0.00335	0.0041	0.054690	1188.603
18	0.1042	15	14	7.3	6	14.5	0.00335	0.0041	0.055629	1209.013
19	0.0799	14.5	13.5	7.5	7	14	0.00335	0.0041	0.053750	1168.171
20	0.0926	12	14	6.9	9	13	0.00335	0.0041	0.049979	1086.224
Avg	0.10188	14.3	14.8	7.6	7.3	14.58	0.00335	0.0041	0.055931	1215.580
Std	0.01333	1.80	2.07	0.5	0.82	1.732	********	0	0.006482	140.8819

Picking and testing date : 23/5/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1027	12.5	13	6.9	7	12.75	0.00335	0.0041	0.049034	1065.684
2	0.1209	13	13	7.3	9	13	0.00335	0.0041	0.049979	1086.224
3	0.0961	10	12	7	9	11	0.00335	0.0041	0.042393	921.3620
4	0.0911	12.5	12.5	6.8	9	12.5	0.00335	0.0041	0.048088	1045.125
5	0.0868	12	12.5	7.5	8	12.25	0.00335	0.0041	0.047141	1024.545
6	0.0774	14	13	7	7	13.5	0.00335	0.0041	0.051866	1127.240
7	0.0967	11	14	7	7	12.5	0.00335	0.0041	0.048088	1045.125
8	0.0872	10	11	6.4	9	10.5	0.00335	0.0041	0.040489	879.9632
9	0.103	13	13	7.1	9	13	0.00335	0.0041	0.049979	1086.224
10	0.0929	11	13.5	6.9	9	12.25	0.00335	0.0041	0.047141	1024.545
11	0.1158	13	13	6.4	7	13	0.00335	0.0041	0.049979	1086.224
12	0.0954	12	12.5	6.9	7	12.25	0.00335	0.0041	0.047141	1024.545
13	0.1019	11.5	14	6.8	8	12.75	0.00335	0.0041	0.049034	1065.684
14	0.0969	12.5	12.5	6.9	7	12.5	0.00335	0.0041	0.048088	1045.125
15	0.088	12.5	13.5	7.2	8	13	0.00335	0.0041	0.049979	1086.224
16	0.0787	12.5	13	6.8	9.5	12.75	0.00335	0.0041	0.049034	1065.684
17	0.1063	15.5	15.5	7.8	7	15.5	0.00335	0.0041	0.059375	1290.417
18	0.0857	10	10	6	9	10	0.00335	0.0041	0.038581	838.4974
19	0.0961	15	14	7	7	14.5	0.00335	0.0041	0.055629	1209.013
20	0.0938	11	10	6.7	8	10.5	0.00335	0.0041	0.040489	879.9632
Avg	0.09567	12.2	12.7	6.9	8.02	12.5	0.00335	0.0041	0.048076	1044.871
Std	0.01063	1.47	1.27	0.3	0.92	1.262	********	0	0.004777	103.8349

Picking and testing date : 30/5 1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.0857	11	11.5	7.2	11	11.25	0.00335	0.0041	0.043345	942.0353
2	0.0779	11	10	6.5	9	10.5	0.00335	0.0041	0.040489	879.9632
3	0.0835	10	8	6	8	9	0.00335	0.0041	0.034756	755.3773
4	0.0744	14	13	7.7	7	13.5	0.00335	0.0041	0.051866	1127.240
5	0.0975	13	11.5	7.1	8	12.25	0.00335	0.0041	0.047141	1024.545
6	0.0894	12.5	12.5	6.8	8	12.5	0.00335	0.0041	0.048088	1045.125
7	0.0981	11	10	6.5	9	10.5	0.00335	0.0041	0.040489	879.9632
8	0.0927	14	13	7	7	13.5	0.00335	0.0041	0.051866	1127.240
9	0.0863	14	14	7.1	7	14	0.00335	0.0041	0.053750	1168.171
10	0.0828	10.5	11	6.7	8.5	10.75	0.00335	0.0041	0.041441	900.6712
11	0.0882	7.5	10	6	10	8.75	0.00335	0.0041	0.033798	734.5603
12	0.0913	12	12.5	7.6	8.5	12.25	0.00335	0.0041	0.047141	1024.545
13	0.0857	11	12.5	7.1	9	11.75	0.00335	0.0041	0.045245	983.3277
14	0.0951	14	14	7.7	7	14	0.00335	0.0041	0.053750	1168.171
15	0.088	12	13	7.3	8.5	12.5	0.00335	0.0041	0.048088	1045.125
16	0.0869	12	12	8	8	12	0.00335	0.0041	0.046193	1003.946
17	0.0949	10	11	7.6	9	10.5	0.00335	0.0041	0.040489	879.9632
18	0.0904	12	12.5	7.3	7	12.25	0.00335	0.0041	0.047141	1024.545
19	0.1027	13	12.5	7.1	7	12.75	0.00335	0.0041	0.049034	1065.684
20	0.0961	8	9	6.3	10	8.5	0.00335	0.0041	0.032840	713.7293
Avg	0.08938	11.6	11.6	7.0	8.32	11.65	0.00335	0.0041	0.044847	974.6966
Std	0.00679	1.81	1.57	0.5	1.13	1.613	********	0	0.006133	133.2907

Picking and testing date : 6/6/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.1103	8.5	7.5	5.7	10.5	8	0.00335	0.0041	0.030921	672.0271
2	0.1105	11	9.5	6.5	9.5	10.25	0.00335	0.0041	0.039535	859.2385
3	0.0924	10	12.5	7.5	7	11.25	0.00335	0.0041	0.043345	942.0353
4	0.1022	10	8.5	6.5	9	9.25	0.00335	0.0041	0.035713	776.1798
5	0.098	9	7.5	5	11	8.25	0.00335	0.0041	0.031881	692.8848
6	0.1042	9	9	6.4	10	9	0.00335	0.0041	0.034756	755.3773
7	0.1128	9	10	5.8	8	9.5	0.00335	0.0041	0.036670	796.9677
8	0.0948	11	10	6.7	9.5	10.5	0.00335	0.0041	0.040489	879.9632
9	0.0878	9	9	6.9	9	9	0.00335	0.0041	0.034756	755.3773
10	0.0903	8	8	5	11	8	0.00335	0.0041	0.030921	672.0271
11	0.1193	13	12.5	7.5	8	12.75	0.00335	0.0041	0.049034	1065.684
12	0.0957	9	11	6.7	9	10	0.00335	0.0041	0.038581	838.4974
13	0.0922	10	13	6.5	7	11.5	0.00335	0.0041	0.044295	962.6907
14	0.1118	10	9.5	6.7	7.5	9.75	0.00335	0.0041	0.037626	817.7403
15	0.0915	6	8	6	12	7	0.00335	0.0041	0.027076	588.4722
16	0.0948	11	11	6.5	7	11	0.00335	0.0041	0.042393	921.3620
17	0.1196	13	12.5	7.2	7	12.75	0.00335	0.0041	0.049034	1065.684
18	0.108	12	10	7.2	8	11	0.00335	0.0041	0.042393	921.3620
19	0.0884	10	10	6	8	10	0.00335	0.0041	0.038581	838.4974
20	0.0876	11	11	6.5	8	11	0.00335	0.0041	0.042393	921.3620
Avg	0.10061	9.97	10	6.4	8.8	9.987	0.00335	0.0041	0.038520	837.1716
Std	0.01037	1.63	1.67	0.6	1.46	1.503	********	0	0.005738	124.7164

APPEDIX 6 : Data For The Second Series Of Experiment For Kiwifruit.

Testing date : 28/6/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0871	23.5	21	2.3	14	22.25	0.00491	0.00782	0.060090	318.7391
2	0.0827	29	28	2.9	11	28.5	0.00491	0.00782	0.075723	401.6630
3	0.0792	39	38	5.5	9	38.5	0.00491	0.00782	0.098791	524.0208
4	0.1182	19	21.5	2.3	11	20.25	0.00491	0.00782	0.054927	291.3546
5	0.0872	24	22.5	2.4	11	23.25	0.00491	0.00782	0.062644	332.2877
6	0.0841	23	21	3.3	11.5	22	0.00491	0.00782	0.059448	315.3366
7	0.09	22	18	1.6	11	20	0.00491	0.00782	0.054277	287.9059
8	0.0783	25	26	3.1	12	25.5	0.00491	0.00782	0.068320	362.3959
9	0.0921	31	28	5.3	9	29.5	0.00491	0.00782	0.078146	414.5126
10	0.1124	18	20	1.5	11.5	19	0.00491	0.00782	0.051666	274.0569
11	0.0781	21	21	2.8	11	21	0.00491	0.00782	0.056871	301.6672
12	0.0863	21	22	3.3	9	21.5	0.00491	0.00782	0.058162	308.5136
13	0.1094	19	20	2.2	11	19.5	0.00491	0.00782	0.052974	280.9921
14	0.1158	25	24	5	8	24.5	0.00491	0.00782	0.065810	349.0807
15	0.1032	20	20	2.4	11.5	20	0.00491	0.00782	0.054277	287.9059
16	0.1068	23.5	25.5	3.7	10.5	24.5	0.00491	0.00782	0.065810	349.0807
17	0.0875	17.5	16	2.1	11	16.75	0.00491	0.00782	0.045735	242.5980
18	0.0907	17	17.5	2.1	11	17.25	0.00491	0.00782	0.047060	249.6229
19	0.1028	17	17.5	2.3	11	17.25	0.00491	0.00782	0.047060	249.6229
20	0.0987	19	20	3	13	19.5	0.00491	0.00782	0.052974	280.9921
Avg	0.09453	22.6	22.3	2.9	10.9	22.52	0.00491	0.00782	0.060538	321.1175
Std	0.01254	5.27	4.84	1.1	1.33	4.990	0	********	0.012309	65.29305

Testing date : 5/7/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1065	16	16.5	2.5	10	16.25	0.00491	0.00782	0.044408	235.5546
2	0.111	18	17	2.1	10	17.5	0.00491	0.00782	0.047721	253.1283
3	0.1052	15.5	17.5	2.5	11	16.5	0.00491	0.00782	0.045072	239.0786
4	0.0883	16	18	2.6	10	17	0.00491	0.00782	0.046398	246.1128
5	0.0978	13	14	1.5	11	13.5	0.00491	0.00782	0.037047	196.5098
6	0.0971	12	13	1.4	12	12.5	0.00491	0.00782	0.034348	182.1946
7	0.0953	19	21.5	2.7	9	20.25	0.00491	0.00782	0.054927	291.3546
8	0.0963	13.5	14.5	2	10.5	14	0.00491	0.00782	0.038392	203.6451
9	0.0936	17	17.5	2.5	11	17.25	0.00491	0.00782	0.047060	249.6229
10	0.0919	18	17.5	2.9	10	17.75	0.00491	0.00782	0.048381	256.6288
11	0.0915	16	17	2.1	11	16.5	0.00491	0.00782	0.045072	239.0786
12	0.0907	19.5	18	3.6	10	18.75	0.00491	0.00782	0.051011	270.5815
13	0.0946	21	20	2.9	9	20.5	0.00491	0.00782	0.055576	294.7978
14	0.1025	20	19	2	12	19.5	0.00491	0.00782	0.052974	280.9921
15	0.1141	15	16	1.9	12	15.5	0.00491	0.00782	0.042409	224.9561
16	0.0947	14	15	1.5	10	14.5	0.00491	0.00782	0.039734	210.7650
17	0.0967	15	14	1.5	10.5	14.5	0.00491	0.00782	0.039734	210.7650
18	0.0914	14	15	1.4	11	14.5	0.00491	0.00782	0.039734	210.7650
19	0.0952	20	18	3.2	10	19	0.00491	0.00782	0.051666	274.0569
20	0.0889	16	15	2.2	10	15.5	0.00491	0.00782	0.042409	224.9561
Avg	0.09716	16.4	16.7	2.2	10.5	16.56	0.00491	0.00782	0.045204	239.7772
Std	0.00697	2.50	2.10	0.6	0.85	2.224	0	********	0.005899	31.29383

Testing date : 12/7/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1153	12.5	12.5	1.2	13	12.5	0.00491	0.00782	0.034348	182.1946
2	0.1121	9.5	10.5	1	12	10	0.00491	0.00782	0.027557	146.1736
3	0.1187	11.5	12.5	1.1	11.5	12	0.00491	0.00782	0.032994	175.0160
4	0.096	12	13	1.1	13	12.5	0.00491	0.00782	0.034348	182.1946
5	0.1149	9	9.5	1	13	9.25	0.00491	0.00782	0.025509	135.3099
6	0.1058	11	12.5	0.9	12	11.75	0.00491	0.00782	0.032317	171.4217
7	0.0901	12	11	0.9	11.5	11.5	0.00491	0.00782	0.031639	167.8240
8	0.0952	11.5	11.5	1	13	11.5	0.00491	0.00782	0.031639	167.8240
9	0.0967	11.5	12.5	1	11	12	0.00491	0.00782	0.032994	175.0160
10	0.0943	10	12	1.1	12.5	11	0.00491	0.00782	0.030280	160.6193
11	0.112	13	11	1.3	11	12	0.00491	0.00782	0.032994	175.0160
12	0.0969	11	12	1	12	11.5	0.00491	0.00782	0.031639	167.8240
13	0.0969	12.5	14	1.1	12	13.25	0.00491	0.00782	0.036373	192.9364
14	0.12	10	12	1	12	11	0.00491	0.00782	0.030280	160.6193
15	0.1071	11.5	14	1	12	12.75	0.00491	0.00782	0.035024	185.7788
16	0.1099	11.5	13	1	11	12.25	0.00491	0.00782	0.033671	178.6070
17	0.1172	12	14	1	12	13	0.00491	0.00782	0.035699	189.3594
18	0.1076	11.5	11.5	0.9	12	11.5	0.00491	0.00782	0.031639	167.8240
19	0.1078	10.5	10.5	1	13	10.5	0.00491	0.00782	0.028920	153.4023
20	0.1018	12.5	13.5	1.1	11	13	0.00491	0.00782	0.035699	189.3594
Avg	0.10581	11.3	12.1	1.0	12.0	11.73	0.00491	0.00782	0.032278	171.2160
Std	0.00899	1.04	1.22	0.0	0.69	1.004	0	********	0.002727	14.46645

Testing date : 19/7/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.1056	12.5	13	0.9	12	12.75	0.00491	0.00782	0.019457	103.2104
2	0.1135	11	13	0.8	12.5	12	0.00491	0.00782	0.018330	97.23114
3	0.0824	11	11	0.8	15.5	11	0.00491	0.00782	0.016822	89.23296
4	0.0986	14	15	1	11.5	14.5	0.00491	0.00782	0.022074	117.0917
5	0.0944	16	16	0.9	10	16	0.00491	0.00782	0.024301	128.9034
6	0.118	13.5	15	0.8	11	14.25	0.00491	0.00782	0.021702	115.1150
7	0.1158	13	13	0.7	11	13	0.00491	0.00782	0.019832	105.1997
8	0.1105	13.5	13	0.9	11.5	13.25	0.00491	0.00782	0.020207	107.1869
9	0.0934	12	13	0.8	11.5	12.5	0.00491	0.00782	0.019082	101.2192
10	0.0972	15	17	1	12.5	16	0.00491	0.00782	0.024301	128.9034
11	0.0922	14	16	1	12	15	0.00491	0.00782	0.022818	121.0382
12	0.1161	13	13	0.7	11	13	0.00491	0.00782	0.019832	105.1997
13	0.0964	15	16.5	1	10.5	15.75	0.00491	0.00782	0.023931	126.9407
14	0.0879	13.5	13.5	0.7	11	13.5	0.00491	0.00782	0.020581	109.1721
15	0.095	20	21	1	9.5	20.5	0.00491	0.00782	0.030876	163.7765
16	0.0934	15	15	0.8	12	15	0.00491	0.00782	0.022818	121.0382
17	0.0915	16.5	17	1	10.5	16.75	0.00491	0.00782	0.025408	134.7767
18	0.0837	18	19	0.8	10	18.5	0.00491	0.00782	0.027975	148.3894
19	0.1063	20	19	1.1	10	19.5	0.00491	0.00782	0.029430	156.1067
20	0.0982	14	15	0.7	11	14.5	0.00491	0.00782	0.022074	117.0917
Avg	0.09950	14.5	15.2	0.8	11.3	14.86	0.00491	0.00782	0.022593	119.8412
Std	0.01052	2.47	2.46	0.1	1.26	2.436	0	********	0.003604	19.12157

Testing date : 26/7/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.0937	12.5	13	0.9	12.5	12.75	0.00491	0.00782	0.019457	103.2104
2	0.0988	13	14	0.9	11	13.5	0.00491	0.00782	0.020581	109.1721
3	0.1008	13	15	1.1	12	14	0.00491	0.00782	0.021329	113.1362
4	0.1045	12	13	0.8	11	12.5	0.00491	0.00782	0.019082	101.2192
5	0.0977	13	12	1	12.5	12.5	0.00491	0.00782	0.019082	101.2192
6	0.1042	12	12.5	0.7	11	12.25	0.00491	0.00782	0.018706	99.22615
7	0.1271	11.5	12	1	13	11.75	0.00491	0.00782	0.017954	95.23427
8	0.1042	11	11	0.6	12	11	0.00491	0.00782	0.016822	89.23296
9	0.0905	14	13	0.7	11	13.5	0.00491	0.00782	0.020581	109.1721
10	0.113	11.5	12	0.7	12.5	11.75	0.00491	0.00782	0.017954	95.23427
11	0.097	11	13	0.7	11.5	12	0.00491	0.00782	0.018330	97.23114
12	0.1174	14	14	0.8	12.5	14	0.00491	0.00782	0.021329	113.1362
13	0.1096	11.5	11.5	0.7	12.5	11.5	0.00491	0.00782	0.017577	93.23560
14	0.1237	13.5	14	0.8	12.5	13.75	0.00491	0.00782	0.020955	111.1552
15	0.1212	12	13	1	12.5	12.5	0.00491	0.00782	0.019082	101.2192
16	0.11	14	14	0.8	11	14	0.00491	0.00782	0.021329	113.1362
17	0.0939	12	13	0.6	11	12.5	0.00491	0.00782	0.019082	101.2192
18	0.0862	14	13.5	0.8	11.5	13.75	0.00491	0.00782	0.020955	111.1552
19	0.1186	14.5	14.5	0.9	12.5	14.5	0.00491	0.00782	0.022074	117.0917
20	0.1031	13	13	0.6	11.5	13	0.00491	0.00782	0.019832	105.1997
Avg	0.10576	12.6	13.0	0.8	11.8	12.85	0.00491	0.00782	0.019605	103.9918
Std	0.01124	1.07	0.99	0.1	0.68	0.959	0	********	0.001440	7.638427

Testing date : 2/8/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.097	12.5	13.5	0.8	10.5	13	0.00491	0.00782	0.019832	105.1997
2	0.0875	14.5	16	1	9.5	15.25	0.00491	0.00782	0.023190	123.0081
3	0.0976	13.5	13	0.7	11	13.25	0.00491	0.00782	0.020207	107.1869
4	0.1023	12	14	0.6	11	13	0.00491	0.00782	0.019832	105.1997
5	0.096	15	14.5	0.8	11	14.75	0.00491	0.00782	0.022446	119.0661
6	0.0913	9.5	9	0.6	14	9.25	0.00491	0.00782	0.014171	75.17221
7	0.1026	13	15	0.7	10.5	14	0.00491	0.00782	0.021329	113.1362
8	0.1131	15	14.5	0.7	10	14.75	0.00491	0.00782	0.022446	119.0661
9	0.0886	13	13	0.8	12	13	0.00491	0.00782	0.019832	105.1997
10	0.1132	14	13.5	0.7	10	13.75	0.00491	0.00782	0.020955	111.1552
11	0.0998	13	12.5	0.7	12	12.75	0.00491	0.00782	0.019457	103.2104
12	0.0989	12.5	13.5	0.9	11	13	0.00491	0.00782	0.019832	105.1997
13	0.1028	14	14	0.6	10	14	0.00491	0.00782	0.021329	113.1362
14	0.1023	15	13.5	0.6	11	14.25	0.00491	0.00782	0.021702	115.1150
15	0.1146	12	14	0.7	11	13	0.00491	0.00782	0.019832	105.1997
16	0.0982	14.5	13	0.6	11	13.75	0.00491	0.00782	0.020955	111.1552
17	0.0958	10.5	11	0.7	12.5	10.75	0.00491	0.00782	0.016444	87.22907
18	0.0873	10	11	0.5	11	10.5	0.00491	0.00782	0.016066	85.22352
19	0.0912	12.5	13	0.5	12	12.75	0.00491	0.00782	0.019457	103.2104
20	0.1053	14	13	0.8	11	13.5	0.00491	0.00782	0.020581	109.1721
Avg	0.09927	13	13.2	0.7	11.1	13.11	0.00491	0.00782	0.019995	106.0620
Std	0.00792	1.58	1.49	0.1	0.99	1.439	0	********	0.002163	11.47460

Testing date : 9/8/1990

No	Weight Kg	A1 Deg.	A2 Deg.	Pr Kg	SSC %	Av Deg.	a m	b m	M Nm	Cs k Pa
1	0.0676	13	14	0.9	11	13.5	0.00491	0.00782	0.020581	109.1721
2	0.0857	12.5	13	0.7	12.5	12.75	0.00491	0.00782	0.019457	103.2104
3	0.0804	11	13	0.7	12	12	0.00491	0.00782	0.018330	97.23114
4	0.074	12.5	12.5	0.6	11	12.5	0.00491	0.00782	0.019082	101.2192
5	0.0744	13	15	0.6	11	14	0.00491	0.00782	0.021329	113.1362
6	0.0718	11	12.5	0.7	12	11.75	0.00491	0.00782	0.017954	95.23427
7	0.094	12	12.5	0.7	12	12.25	0.00491	0.00782	0.018706	99.22615
8	0.0957	12.5	12.5	0.7	11	12.5	0.00491	0.00782	0.019082	101.2192
9	0.0894	12	12	0.6	12	12	0.00491	0.00782	0.018330	97.23114
10	0.0729	11	12	0.7	12	11.5	0.00491	0.00782	0.017577	93.23560
11	0.0877	9	10	0.5	15	9.5	0.00491	0.00782	0.014551	77.18549
12	0.1098	10	11	0.7	12	10.5	0.00491	0.00782	0.016066	85.22352
13	0.0903	9.5	10	0.7	14	9.75	0.00491	0.00782	0.014930	79.19730
14	0.0964	10	11	0.6	14	10.5	0.00491	0.00782	0.016066	85.22352
15	0.0837	12	12	0.6	11	12	0.00491	0.00782	0.018330	97.23114
16	0.0772	12	14	0.7	12	13	0.00491	0.00782	0.019832	105.1997
17	0.0847	12	12	0.6	14	12	0.00491	0.00782	0.018330	97.23114
18	0.0727	14	14.5	0.6	11	14.25	0.00491	0.00782	0.021702	115.1150
19	0.0802	11	11	0.7	12	11	0.00491	0.00782	0.016822	89.23296
20	0.0803	11	11	0.5	12	11	0.00491	0.00782	0.016822	89.23296
Avg	0.08344	11.5	12.2	0.6	12.1	11.91	0.00491	0.00782	0.018194	96.50942
Std	0.01020	1.24	1.35	0.0	1.15	1.253	0	********	0.001886	10.00830

Testing date : 16/8/1990

No	Weight	A1	A2	Pr	SSC	Av	a	b	M	Cs
	Kg	Deg.	Deg.	Kg	%	Deg.	m	m	Nm	k Pa
1	0.0949	11	11.5	0.7	12.5	11.25	0.00491	0.00782	0.017200	91.23515
2	0.1044	9	9	0.7	15	9	0.00491	0.00782	0.013792	73.15751
3	0.0887	9	9	0.7	16	9	0.00491	0.00782	0.013792	73.15751
4	0.0773	11.5	12.5	0.8	11.5	12	0.00491	0.00782	0.018330	97.23114
5	0.0643	11	11	0.6	11	11	0.00491	0.00782	0.016822	89.23296
6	0.0667	12	13	0.6	11.5	12.5	0.00491	0.00782	0.019082	101.2192
7	0.0862	8.5	8.5	0.6	14	8.5	0.00491	0.00782	0.013031	69.12395
8	0.0713	12.5	14	0.7	12	13.25	0.00491	0.00782	0.020207	107.1869
9	0.0681	10	9	0.6	13	9.5	0.00491	0.00782	0.014551	77.18549
10	0.0817	13	14	0.8	12	13.5	0.00491	0.00782	0.020581	109.1721
11	0.0743	12.5	13.5	0.7	10.5	13	0.00491	0.00782	0.019832	105.1997
12	0.0693	11.5	12.5	0.5	11	12	0.00491	0.00782	0.018330	97.23114
13	0.0751	15	14	0.7	13	14.5	0.00491	0.00782	0.022074	117.0917
14	0.0681	12.5	13	0.6	13	12.75	0.00491	0.00782	0.019457	103.2104
15	0.0733	13	12	0.7	13	12.5	0.00491	0.00782	0.019082	101.2192
16	0.068	10	10	0.7	14.5	10	0.00491	0.00782	0.015309	81.20760
17	0.0689	12.5	14	0.8	13	13.25	0.00491	0.00782	0.020207	107.1869
18	0.0823	10	8.5	0.5	13	9.25	0.00491	0.00782	0.014171	75.17221
19	0.0793	12.5	13	0.7	12	12.75	0.00491	0.00782	0.019457	103.2104
20	0.0863	10	10	0.9	14	10	0.00491	0.00782	0.015309	81.20760
Avg	0.07742	11.3	11.6	0.6	12.7	11.47	0.00491	0.00782	0.017531	92.99195
Std	0.01029	1.62	1.99	0.0	1.38	1.765	0	********	0.002664	14.13083

APPENDIX 7 : Example Of Solution For Ks And Kc.

Moment, M = A Ks + B Kc

$$= 2a\ (\ a + b\ )\ Ks + a^2\ b\ Kc$$

Royal Gala :

Big blade :

163.123 Nmm = 2(4.91 mm (4.91 mm + 7.82 mm)) Ks +
4.91 mm * 4.91 mm * 7.82 mm Kc

= 125 Ks (mm2) + 188.525 Kc (mm3)

Small blade :

39.573 Nmm = 2(3.35 mm (3.35 mm + 4.10 mm)) Ks +
3.35 mm * 3.35 mm * 4.10 mm Kc

Ks = 0.7928 (N/mm) - 0.9218 Kc (mm)

163.123 Nmm = 125 (mm2) (0.7928 (N/mm) - 0.9218 Kc (mm)) +
188.525 Kc (mm3)

163.123 Nmm = 99.107 (Nmm) + 73.292 Kc (mm3)

Kc = 0.87344 N/mm2 = 0.87344 M Pa.

Ks = 1.5856 (N/mm) - 1.8436 (mm) (0.87344 (N/mm2))
= - 0.02467 N/mm = - 24.67 N/m.

APPENDIX 8 : Data For Testing Speed Simulation.

Royal Gala, picked 4/3/1991, tested 10/4/1991

No	LSA1	LSA2	HSA1	HSA2	a	b	ALSA	AHSA	Mls	Mhs	Cls	Chs
	Deg.	Deg.	Deg.	Deg.	m	m	Deg.	Deg.	Nm	Nm	k Pa	k Pa
1	37.5	40	49	51	0.0049	0.0078	38.75	50	0.1578	0.1931	837.1705	1024.581
2	37.5	41.5	51	56	0.0049	0.0078	39.5	53.5	0.1603	0.2026	850.7524	1075.155
3	38.5	44	51	57	0.0049	0.0078	41.25	54	0.1662	0.2039	881.8727	1082.057
4	40	37	55	46	0.0049	0.0078	38.5	50.5	0.1569	0.1945	832.6111	1032.045
5	35	42	54	56	0.0049	0.0078	38.5	55	0.1569	0.2065	832.6111	1095.613
6	42.5	44	55	60	0.0049	0.0078	43.25	57.5	0.1727	0.2126	916.4299	1128.033
7	42	42	65	72	0.0049	0.0078	42	68.5	0.1687	0.2346	894.9598	1244.430
8	39	42	58	61	0.0049	0.0078	40.5	59.5	0.1637	0.2172	868.6345	1152.426
9	40	38	55	50	0.0049	0.0078	39	52.5	0.1586	0.2000	841.7138	1061.107
10	44	45	55	60	0.0049	0.0078	44.5	57.5	0.1767	0.2126	937.4637	1128.033
11	45	40	61	56	0.0049	0.0078	42.5	58.5	0.1703	0.2149	903.5995	1140.403
12	43	40	65	54	0.0049	0.0078	41.5	59.5	0.1670	0.2172	886.2520	1152.426
13	45	43	74	66	0.0049	0.0078	44	70	0.1751	0.2369	929.1031	1256.835
14	44	40	62	55	0.0049	0.0078	42	58.5	0.1687	0.2149	894.9598	1140.403
15	36	40	55	56	0.0049	0.0078	38	55.5	0.1552	0.2078	823.4451	1102.265
16	36	40	51	55	0.0049	0.0078	38	53	0.1552	0.2013	823.4451	1068.172
17	45	43	55	52	0.0049	0.0078	44	53.5	0.1751	0.2026	929.1031	1075.155
18	45	46	55	65	0.0049	0.0078	45.5	60	0.1798	0.2183	953.9700	1158.306
19	43	39	60	55	0.0049	0.0078	41	57.5	0.1654	0.2126	877.4767	1128.033
20	42	40	62	55	0.0049	0.0078	41	58.5	0.1654	0.2149	877.4767	1140.403
21	42	41	64	61	0.0049	0.0078	41.5	62.5	0.1670	0.2236	886.2520	1186.373
22	38.5	36.5	58	57	0.0049	0.0078	37.5	57.5	0.1535	0.2126	814.2163	1128.033
23	42	40	65	60	0.0049	0.0078	41	62.5	0.1654	0.2236	877.4767	1186.373
24	36	45	51	65	0.0049	0.0078	40.5	58	0.1637	0.2138	868.6345	1134.261
25	42	40	63	60	0.0049	0.0078	41	61.5	0.1654	0.2215	877.4767	1175.414
26	38.5	38.5	55	54	0.0049	0.0078	38.5	54.5	0.1569	0.2052	832.6111	1088.876
27	44	36	65	56	0.0049	0.0078	40	60.5	0.1620	0.2194	859.7262	1164.097
28	42	46	60	73	0.0049	0.0078	44	66.5	0.1751	0.2312	929.1031	1226.564
29	36	42.5	52	65	0.0049	0.0078	39.25	58.5	0.1595	0.2149	846.2412	1140.403
30	40	42	59	63	0.0049	0.0078	41	61	0.1654	0.2205	877.4767	1169.800
31	41	37	62	61	0.0049	0.0078	39	61.5	0.1586	0.2215	841.7138	1175.414
32	39	38.5	55	55	0.0049	0.0078	38.75	55	0.1578	0.2065	837.1705	1095.613
33	46	39	62	53	0.0049	0.0078	42.5	57.5	0.1703	0.2126	903.5995	1128.033
34	42.5	42	65	60	0.0049	0.0078	42.25	62.5	0.1695	0.2236	899.2883	1186.373
35	41	45	50	62	0.0049	0.0078	43	56	0.1719	0.2090	912.1704	1108.834
36	42	40	61	53	0.0049	0.0078	41	57	0.1654	0.2114	877.4767	1121.719
37	41	42.5	61	63	0.0049	0.0078	41.75	62	0.1679	0.2226	890.6144	1180.939
38	41	39	61	58	0.0049	0.0078	40	59.5	0.1620	0.2172	859.7262	1152.426
39	39	40	52	54	0.0049	0.0078	39.5	53	0.1603	0.2013	850.7524	1068.172
40	41	41	65	65	0.0049	0.0078	41	65	0.1654	0.2285	877.4767	1212.183
Avg	40.8	40.9	58.3	58.4	0.0049	0.0078	40.90	58.3	0.1650	0.2140	875.3063	1135.394
Std	2.86	2.52	5.53	5.58	**************		1.965	4.46	0.0065	0.0100	34.51561	53.06435

Note :

LSA1 : Low speed angle1
LSA2 : Low speed angle2
HSA1 : High speed angle1
HSA2 : High speed angle2
ALSA : Average low speed angle
AHSA : Average high speed angle
Mls : Moment for low speed
Mhs : Moment for high speed
Cls : Crushing strength for low speed.
Chs : Crushing strength for high speed.

APPEDIX 9 : Data For Simulation The Effect Of The Skin Peeling.

Granny Smith Apples, harvested at 29/4/1991, tested on 2/5/1991

		Intact		Peeled			
No:	Weight Kg	A1 Deg.	A2 Deg.	A1 Deg.	A2 Deg.	a m	b m
1	0.2254	52	52.5	49	53	0.00491	0.00782
2	0.1974	50	55	50	52	0.00491	0.00782
3	0.2049	54	57	52	54	0.00491	0.00782
4	0.2478	58	52	58	53	0.00491	0.00782
5	0.2075	49	49	51	45	0.00491	0.00782
6	0.2151	54	54.5	49	55	0.00491	0.00782
7	0.2073	45	56	46	48	0.00491	0.00782
8	0.2197	65	46	62	48.5	0.00491	0.00782
9	0.2173	51.5	48	51	52	0.00491	0.00782
10	0.1865	50.5	50	49	47	0.00491	0.00782
11	0.2272	48.5	50	47.5	44	0.00491	0.00782
12	0.2001	52	59	49	57	0.00491	0.00782
13	0.2199	56.5	52.5	51.5	52.5	0.00491	0.00782
14	0.2105	56	50	51	56.5	0.00491	0.00782
15	0.2364	46	54	50	53	0.00491	0.00782
16	0.1835	63	56.5	54	52	0.00491	0.00782
17	0.2195	55	52	45	47	0.00491	0.00782
18	0.1922	53	55	47.5	50	0.00491	0.00782
19	0.2527	58	58	55	55.5	0.00491	0.00782
20	0.2036	56	61	52.5	58	0.00491	0.00782
Avg	0.213725	53.65	53.4	51	51.65	0.00491	0.00782
Std	0.017993	4.952524	3.806573	3.885871	3.889408	0	*********

Note :

AVIA = Average angle reading for skin intact.
AVPA = Average angle reading for skin peeled.
CsI = Crushing strength for skin intact.
CsP = Crushing strength for skin peeled.

AVIA Deg.	AVPA Deg.	MI Nm	MP Nm	CsI k Pa	CsP k Pa	Pr Kg	SSC %
52.25	51	0.135207	0.132891	717.1869	704.9023	4.2	13
52.5	51	0.135663	0.132891	719.6031	704.9023	4	12
55.5	53	0.140925	0.136566	747.5153	724.3942	4.2	13
55	55.5	0.140074	0.140925	743.0035	747.5153	3.8	12
49	48	0.129055	0.127077	684.5516	674.0619	3.9	13.5
54.25	52	0.138779	0.134749	736.1299	714.7571	4.1	13.5
50.5	47	0.131947	0.125061	699.8942	663.3669	4.4	15.5
55.5	55.25	0.140925	0.140501	747.5153	745.2665	3.9	12
49.75	51.5	0.130512	0.133825	692.2822	709.8567	3.9	12.5
50.25	48	0.131471	0.127077	697.3701	674.0619	3.9	11.5
49.25	45.75	0.129543	0.122487	687.1416	649.7144	3.5	13.5
55.5	53	0.140925	0.136566	747.5153	724.3942	4.4	13
54.5	52	0.139213	0.134749	738.4352	714.7571	4.4	12.5
53	53.75	0.136566	0.137902	724.3942	731.4774	3.5	11
50	51.5	0.130993	0.133825	694.8328	709.8567	4.4	14
59.75	53	0.147715	0.136566	783.5332	724.3942	3.6	11
53.5	46	0.137459	0.123007	729.1302	652.4698	3.6	13
54	48.75	0.138341	0.128564	733.8106	681.9486	4	12.5
58	55.25	0.145016	0.140501	769.2134	745.2665	3.6	11
58.5	55.25	0.145801	0.140501	773.3786	745.2665	4	14
53.525	51.325	0.137307	0.133312	728.3218	707.1315	3.965	12.7
3.060739	3.049692	0.005378	0.005755	28.52966	30.53098	0.297111	1.122497