Discussion

Growth observation

Bollard (1970) cited to the ceveral reports that the growth of apple and pear fruits for increase of fruit fresh weight show a smooth sigmoid form. Bain and Robertson (1951) stated that combined growth resulting from cell division, cell enlargement and air space formation results in a general sigmoidal curve where fruit volume and weight was plot against time.

For this observation of fruit growth for increase of fruit weight, volume, lenght and width trend to be a single sigmoidal form. The curve for increase of fruit fresh weight and volume show the same pattern and trend to continue to increase as fruit maturation. Childers (1976) has suggested that the determination of proper time for apple picking was important to note that the fruit continue to increase in size as long as it remain upon the tree. For these studies, although the late harvest of Anna apple fruits are better size than the early harvest but fruits harvested late are losen as a result of diseases, insects and birds.

The measuring of the lenght and width of fruit showed that the average value of lenght is more higher than the width slightly through the observation period. The fruit shape measuring by the lenght and width was irregular form. It may be because the most fruit samples had no seed and some had a few. Childers (1976) has suggested that the apples have more uniform shape and better size and color because of additional seed and the cross polinated fruits

are often of better shape, size and color than those obtain from self pollination. These showed that the uniform shape of Anna apple need cross pollination. Ruck (1975) state that Anna apple required cross pollination usually Ein Shemer 28 is used, but there are only 3-4 plants of Ein Shamer and almost 400 Anna trees that was the result of cross pollination limited.

The specific gravity of Anna apple measuring by water displacement method was less than 1.000 throughout the observation period. The curve of specific gravity slightly declined as fruit maturation but it was not clear (Fig.13) enough to be used as the parameter of harvesting index. It showed that during maturation the air space in fruit increased gradually. Bollard (1970) stated that both cell shape and relative volume of intercellular space are factors which change during fruit development. Bain and Robertson (1951) has shown that in small apples the proportion of intercellular space is about 26 % but that in large apples this increase to 27 % and the specific gravity of apple fruit decrease during development (Westwood, 1962 ; quoted by Bollard, 1970).

2. Qualities change during growth

2.1 Physical changes

Flesh firmness

The average flesh firmness decrease from 19.52 lbs at 7 WAFB to 7.50 lbs at 16 WAFB, (measuring by Effe-gi pressure

tester with a 0.8 cm (5/16 inch). Olsen (1980) suggested that the desirable levels of firmness at harvest in Red Delicious and Golden Delicious was 19.0 and 18.0 lbs respectively. For these studies the flesh firmness during 12 to 14 WAFB showed none significant difference (p.01) and at the last two weeks the decrease of firmness different from 12 to 14 WAFB significantly (Table 8). When relate with repening behavior after harvest, fruits harvested at 13 WAFB showed the abnormal ripening (too early) but at 14, 15 and 16 WAFB showed a normal ripening, so the early harvest of Anna apple (an begin at 14 WAFB and the value of flesh firmness is about 10.00-11.00 lbs. The flesh firmness has been used as a general guide for harvesting index of apple. The measurement of firmness is easily done with sufficient accuracy to permit the begining of harvest and relating the other parameters to firmness in important.

Red color development

Anna apple has a red color. For these studies the red color appeared slightly in some fruits at 12th WAFB and increased as fruit maturation. The red color development of Anna apple shows very poor and the skin area that occured the red color may be found a spot of insect damage. Childers (1976) concluded that factors affecting anthocyanin

(red pigment) development in apples are temperature, nutrition, moisture, sunlight, mite damage, chemicals and their genetic ability to become red. Weather conditions, a few days or week before harvest, is the predominating factor. Clear days with relatively cool nights are ideal for good fruit color. A period of warm muggy and rainy weather one to three weeks before harvest can result in poor fruit color and condition. Pruning should be adequate to admit light through the tree so apple fruits will be red on all sides. For these studies, the factors that cause the poor red color may be the warm muggy and rainy weather because Anna apple fruits are harvested at early rainy season, in June. For a good marketing quality, it is necessary to develope a red color after harvest. The chemical treatments might stimulate color formation, Smock (1968) has shown that calcium carbonate can enhance red color of apples. Childer (1976) stated that ultraviolet and blue light are more effective in producing anthocyanin pigments in fruit with a light requirement than are the longer wavelenghts, and cited to Magness (1928) that low-intensity ultraviolet light for one hour per day increased the red color of Jonathan apples.

2.2 Chemical changes during growth

Total soluble solids (TSS) gradualy increased as fruit growth and maturation. Olsen (1980) stated that at approxi-

mately the same time that the rate of fruit softening on tree declines, the rate of accumulation of soluble solids increases. Douglas (1983) was found that soluble solids of McIntosh apple in two orchard increase during maturation. TSS increase to a high constant level during the last 4 weeks, so it trend to be used as harvesting index of Anna apple when fruits contain greatert than 10.0 %. Ingle (1972) quoted by Hammett et.al (1977) concluded that soluble solids was the most reliable index for maturity and storage quality of West Virginia grown Delicious strains where as Hammett et.al. (1977) was found that soluble solids content of the red strains of Delicious and Law Rome apple grown at North Carolina could not be predicted consistenly. Haller and Magness (1944) quoted by Hammett et.al. (1977) suggested that unreliability of chemical test appears to be due to variation in chemical composition due to environmental and cultural factors. For these studies, TSS at the last 4 weeks. (from 13 to 16 WAFB) showed none significant difference (p.01), so it trend to be used as harvesting index of Anna apple wher fruits contain greater than 10.0 %.

Titratable acidity (TA.)

Ulrish (1970) quoted the work of Krotkov, in Wolf (1969) that there is a peak of malic acid at the middle of June and

gradually fall off until the harvest time in October. From these studies, the determination of TA began at the 5 WAFB and the TA was steady decreased until the harvesting time (Fig.16, Table 10). It's possible that the Anna apple may not increase its acid at the early state or it may increase before the assesment was being done. However at the 14 WAFB, malic acid showed a small peak at harvesting time which may be the begining of acid utilization when the fruits started to the climacteric rise according to the evidences stated by Flood et al., 1970 (quoted by Hulme and Rhodes, 1971) that there are an increase of TA prior to the climacteric rise of apple fruit after harvest. However the change of TA of Anna apple at the harvesting time need to be comfirm for its consistancy.

Vitamin C

The naturally occuring ascorbic acid in fruits is L-ascorbic acid (Mapson, 1970). The result showed that vitamin C content of Anna apple devide into three stage during growth. First stage, from 5 to 8 WAFB is low and increased to the second level, from 9 to 14 WAFB and then increased again to the third level in the last two weeks. The concentration of vitamin may vary widely in diferent tissue of the fruits, in

apples it is two to three times as great in peel as in pulp (Zilva et.al., 1935 ; quoted by Mapson, 1970). The concentration of ascorbic acid varies with the degree to which the friut is exposed to sunlight (Kessler, 1939, McCollum, 1944 ; quoted by Mapson, 1970). The environmental conditions of growth all affect the vitamin content to a greater or lesser extent (Hulme, 1958 ; quoted by Mapson, 1970).

Starch-iodine test

The result showed that the pattern of disappearance of starch of Anna apple is not similar to the Grany Smith apple (Fig.27-32). The starch-iodine blue complex of Anna apple could not distinguish into 6 scores during fruit maturation. This showed that the starch in fruit of Anna apple decrease very slowly as fruit matures. The starch-iodine blue complex rapidly changed to disappear during fruit ripening. So the pattern of disappearance of starch of Anna apple could not used as a harvesting index.

Chlorophyll content

The peel of apples contains chloroplasts and, although these chloroplasts are smaller than those found in leaves, they

have a similar structure and contain chlorophyll which gives the green ground color to the fruit (Hulme and Rhodes, 1970). Workman (1963) was found that the chlorophyll content of Grimes Golden and Delicious apple decrease in peel and pulp during maturation. For these studies the colorophyll content of the peel increased reaching a maximum at a 9 WAFB and rapidly decreased as fruits maturation, and at 14 and 15 WAFB the average value was nearly constance. These pattern of the change of chlorophyll trend to be used as harvesting index but the measuring method is complicate. It is to be note that the decrease of chlorophyll content occors after fruits were wrapped and corresponds with the decrease of green ground color measuring by comparison with the Munsell color charts. The ground color changed from a leaf green to a lighter green and eventually to a yellowish color.

Qualities change after harvest and Sensory evaluation

The red color development was very poor. The red color of skin at harvest date and after harvest seem to be a similar percentage. The green ground color of skin gradually decrease. To compare with the Munsell color chart (1977) the color changed from lighter green to yellowish color. The flesh firmness slightly change between the

fruits at harvest date and 7 days after harvest but rapidly decrease at 14 days after harvest. The sensory evaluation for flesh texture showed a range from very crispy (4.9) to moderate crispy (4.2) respectively from 13 to 16 WAFB at harvest date and a range decreased to be a moderate (3.9) and less crispy (3.1) at 7 days after harvest. At 14 days after harvest fruits harvested at 13 and 14 WAFB ranged between a less crispy (3.4) to a slightly soft (2.8) but fruit harvested at 15 and 16 WAFB were lost the qualities (Table 15). Fruits harvested at 14, 15 and 16th WAFB developed good qualities and have a normal ripening when held for 7 days on shelf at 25 $\pm$ 2^{o}C.

Fruits harvested at 13 and 14 WAFB showed a fresh aroma (unripe fruit 1.0) and those harvested at 15 and 16 WAFB showed a range between fresh aroma (1.1) to slightly ripe (1.4). At 7 days after harvest, fruits harvested at 13 WAFB showed a fresh aroma (1.1) the other showed a range between a slightly ripe (2.2) to a moderate ripe (2.7). At 14 days after harvest, fruits harvested at 13 WAFB showed a range between a fresh aroma to a slightly ripe (1.3) and fruits harvested a 14 WAFB showed a range between moderate ripe and very ripe (3.4) and those harvested at 15 and 16 WAFB showed a range between a very ripe to over ripe (almost fermenting 4.5-4.6). The results of aroma (degree of ripeness) showed that fruit harvested at 14, 15 and 16 WAFB have

a normal ripening at 7 days after harvest. It was interesting to note that fruits harvested at 13 WAFB showed the abnormal ripening because of the poor development of aroma and shriveling of fruits (Table 15).

Flood et al., 1970 (quoted by Hulme and Rhodes, 1971) studies the malic acid changes of Cox's Orange Pippin apples after harvest at various stages of maturity, they found that there are marked increase in malic acid utilization in peel and pulp as the respiration rose, and in the fruits picked when the climacteric had already begun on tree, the fall in malate had already commenced. From these studies, the 15 and 16 WAFB fruits showed the peak of malic acid at 7 days after harvest and fall off at the 14 days after harvest (Table 14). It was to be note that the younger fruit of 14 WAFB, the failing of malic acid has already begun at the first week after harvest (Table 14). It was possible that the climacteric rise has already begun at the harvesting time and the limitation of fruit sample may course the error between the fruit age and physiological maturity. However, the (3 WAFB did not show a peak of malic acid which may because they were harvested too early.

The acidity is a predominant taste of Anna apple. The sensory score showed a high sour taste when harvest either in

younger fruits of 14, 15 and 16 WAFB. The high sour taste of Anna apple when harvest caused the average value of acceptability to be low. (about 5 from 10 scores, Table 15). But it was interesting to note that after lefting the fruits to ripen on sheif for one week, all of the 3 apple maturity (14, 15 and 16 WAFB) developed better sweetness and had better aroma (Table 15). The better sweet taste may correlated with the rise of TSS after 7 and 14 days when lie to ripe on shelf. This result could be made to suggest that Anna apple should be kept to ripe off tree for developing better dessert quality. Normally, fruit left to ripen on tree will give the best dessert quality but they were lost by both deseases and pets (insects and bird) on field and may sensitive to handling and short shelf life after harvest. However in this experiment there are no fruits ripe on tree for quality assesment because the tagged apples were mistaken by the orchard owner.

CONCLUSION

The growth pattern of Anna apple, grown at Doi Mae-Hae during February to June 1986, trend to be a single sigmoid curved. It increase slowly in the initial stage, about 4 weeks

after full bloom then increase rapidly until harvest. The weight of fruit at the early harvest is about 151.6 gm.

Fruits harvested at 14, 15 and 16 WAFB can develop to the satisfactory qualities and have a normal repening when held for 7 days on shelf at 25 ± 2°C.

The value of flesh firmness at 12, 13 and 14 WAFB showed none siqnificant difference and also with the TSS value at 12 to 16 WAFB (p.01), the changes of flesh firmness begin on 15 WAFB. This two parameters seem not to related with the ripening behavior and sensory evaluation, which was found that the 13 WAFB fruits are too early and the 16 WAFB fruits, although, have better size and dessert quality but they are subject to higher loss during and after harvest. From the above data, it was possible to conclude that a number of days from full bloom should be the sensitive harvesting index for Anna apple. The data of the present 1986 seasons, the harvested time of Anna apple can begin at 14 WAFB and the value of flesh firmness is between 10.0-11.0 lbs, TSS is above 10.0 %.

However, due to the limitation of number of fruits, the harvesting indices mention above should be repeated several seasons with a larger number of fruits to confirm their sensitivity, consistency and reliability.