

Harvesting Indices of Strawberries in Thailand^{1/}

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ABSTRACT

Tioga strawberries of 4 different-colored stages were harvested from Intanon area in the cooler month of December, 1982. Their quality criteria were determined right after sorting at the Intanon Station. The remaining berries were air-shipped to lab in Bangkok for study at daily interval. Another batch of different stages of berries similar to the December crop was studied in the warmer month of March, 1983.

It was found that after harvest all strawberries developed color rapidly, those of 21-40% red color when harvested developed color to an acceptable condition of over 90% color within 2 days. The March crop had a slightly faster rate of color development, it is faster than the December crop by approximately half a day. More advanced stage of strawberries, the 61-80% color in the December harvest had higher SS than others by only 1.0%. Those of March had slightly lower SS than the December by about 0.5%. The younger stage of 0-20% color strawberries tended to have higher acid content than other stages in the cooler month crop. Their difference in this respect between the two months was less than 0.03% in favor of the hotter month. The SS/TA ratios of the cooler month strawberries are higher than those of the warmer month by 1%. It is suggested along the support of organoleptic evaluation that strawberries of above 41% color of either months possessed acceptable eating quality right after harvest. The younger stage of 21-40% color needed 3 days after harvest to attain such quality.

Strawberries are firmer in the younger stages. They also had greater firmness in the cool month crop. Four days after harvest fruit firmness of the cool and hot month crops was different by 0.55 to 0.86 kg/cm².

Weight losses increased in relation with time. On the third day after harvest, the losses amounted to 6% for the December crop, while that for the warmer month was 9%. The apparent losses were fruit losses due to mechanical and biological injuries. The former factor played a bigger role due to human problems which could be alleviated with "Tender Loving Care" practices.

INTRODUCTION

Strawberries are considered as a new fruit for the Thais. The production is confined mainly in Chiang Rai and Chiang Mai provinces. The total area under cultivation is approximately 80 hectares at an average yield of 19 metric tons per hectare. Generally the crop is in the market between late December to late March. The produce is used both in the processing as well as in the fresh recipes.

Since the introduction of the 'Tioga' from California in the early 1970's, cultivation practices have been developed and improved. The crop has become an essential earning of many farmers

including both lowlands and highlands. It has been cited that the income of the crop is beating the opium. It is stated that hilltribes who grow the strawberry crop in Intanon area do not have time to do any other cropping activity, since it is highly intensive. However, one has to be cautious about socioeconomic factors.

Picking strawberries is really a combination of art and science that our farmers harvest the fruit with their common sense. Suggestions on harvesting index from our workers have come across certain difficulties in convincing many groups of people. Strawberries are harvested and packed

1 The research fund was supported by ARS, USDA Contract No. 53-32-R6-9-19.

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in mixed maturity and there are always complaints about the fruit quality. Momison (1959), Mitchell *et al* (1964) and Holland *et al* (1967) recommend that strawberries are harvested at different stages of maturity, depending on how and where the fruit is marketed. Fruit for fresh market should be pink or three-fourths colored. Those for local market should be fully ripe and firm. However, more mature fruit will bruise easily and deteriorate or decay in transit. For processing they should be fully ripe and firm, but with the calyx and stem removed.

All strawberries are hand-picked. It is essential that all stems have to be removed otherwise they may puncture each other, resulting in wounds and decay. Long stemmed fruit may be harvested for special occasion. Berries must be picked at the right stage of maturity and ripeness. Overripe ones are soft and easily injured from the time of harvest and every step leading to marketing. Immature berries have poor flavor and appearance. Weather conditions usually determine the frequency of picking. Berries ripen fast in warm weather and slowly in cool weather. They should be picked early in the day, since berries are firmer and easier to handle when they are cool than when picked in the heat of the day (Seelig, 1975).

Ryall and Pentzer (1974) have reviewed that there is a continuous or periodic succession of blossoms, green fruits, and ripe fruits throughout the harvest period. Picking must be made every few days to avoid harvest of overripe fruit. Selection by the pickers is almost entirely on the basis of berry color. The ideal is full bright red which indicates optimum quality. However, fruits harvested with less than full color will color after harvest, and those which are $\frac{1}{2}$ to $\frac{3}{4}$ red when harvested will attain satisfactory color when ripened. Under standards for strawberries, Agricultural Code of California states that "any strawberry which has two-thirds of the surface showing a pink or red color, shall be considered mature".

Determination on optimal harvesting indices of strawberries grown in northern Thailand shall be necessary as a harvesting guideline for the industry. The studies were conducted particularly

on crops produced by Intanon strawberry farms where the Royal Northern Agricultural Project is in operation in order to overcome shifting farming and opium cultivation problems.

MATERIALS AND METHODS

Intanon-produced Tioga strawberries were picked on December 26, 1982 and sorted into 4 groups based on percentage of red color appearing on each berry as follows: 0-20, 21-40, 41-60 and 61-80%. A sample of 12 fruits from each group was selected for determination of flesh firmness and soluble solids (SS) at the Intanon Strawberry Project Site, and titratable acids (TA) were determined with 0.1 N NaOH solution on a modified mobile titration stand. Organoleptic tests were also carried out by a panel of 3-8 members using a 3-point scale (1, 3 and 5) where 1 = dislike and 5 = like very much.

The remaining berries were packed in the improved consumer packages, each box consisting of 2 trays containing approximately 450-500 g and then shipped to Bangkok on December 26 evening by air for further studies on their postharvest changes at ambient temperature in Postharvest Horticulture Lab., Horticulture Department, Kasetsart University. At daily interval, fruits were sampled for aforementioned determination including average fruit weight losses at all stages of ripeness and for color changes. All observations were terminated when the strawberries became unacceptable in terms of external appearance coupled with sensory evaluation.

The study procedure of strawberries harvested on March 20, 1983 was similar to that of the December crop, except the 0-20% color group was excluded.

RESULTS AND DISCUSSION

Color changes: It has been observed that red color development of strawberries particularly during the postharvest period is very fast. Yet no research data of such matter have been reported in Thailand.

Strawberries harvested on December 26, 1982: The 0-20% red color group had the fastest rate of color development and the others were

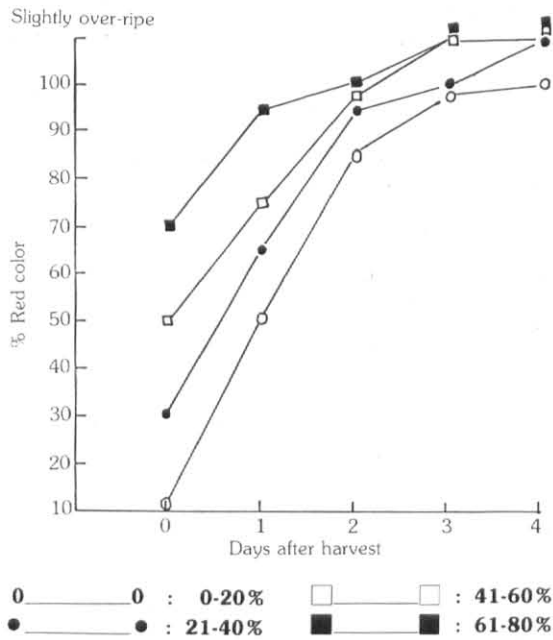


Figure 1. Color development at room temperature (25.3°C) of strawberries harvested at different color stages.

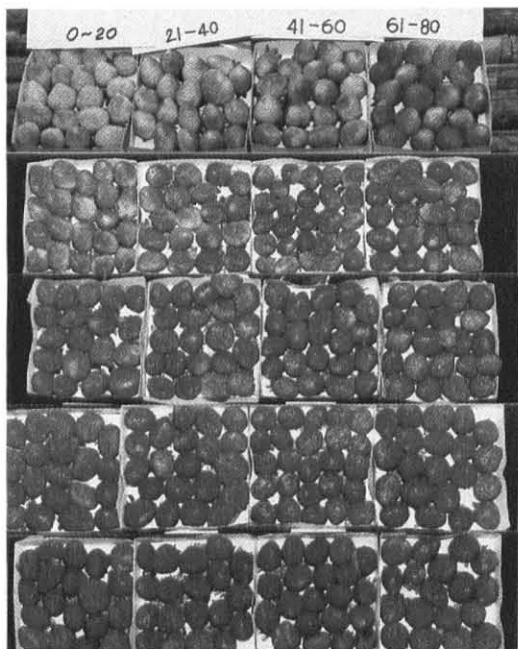


Figure 2. Color development of 4 color ranges: 0-20, 21-40, 41-60 and 61-80% red color of Tioga strawberries produced in Intanon area from December 26-30, 1983. a:Dec. 26, 5 hrs after harvest; b:29 hrs. c:53 hrs, d:77 hrs, and e:101 hrs after harvest at room temperature (25.3°C).

slightly slower (Fig. 1 and 2). It took about 2 days (Fig. 1) or 53 hrs (Fig. 2, c) from harvest for the 0-20% color to attain 85% color at room temperature (25.3°C and 45% RH), while others had almost 100% red color. The first group needed one more day to attain fully ripe condition as compared with other color groups. I may be one day younger at harvest.

The color range within each group is rather broad. It is more difficult to handle the first group of 0-20% since 0% color which is white color berry could be picked too green! The 41-60 and 61-80% color fruits became slightly overripe after 2 days of harvest, while the 21-40 color strawberries were 3 days after harvest. The slightly overripe condition of the fruit was the shrivelled and senescent calyx.

Strawberries harvested on March 20, 1983:
Due to the possible picking error of the 0-20%

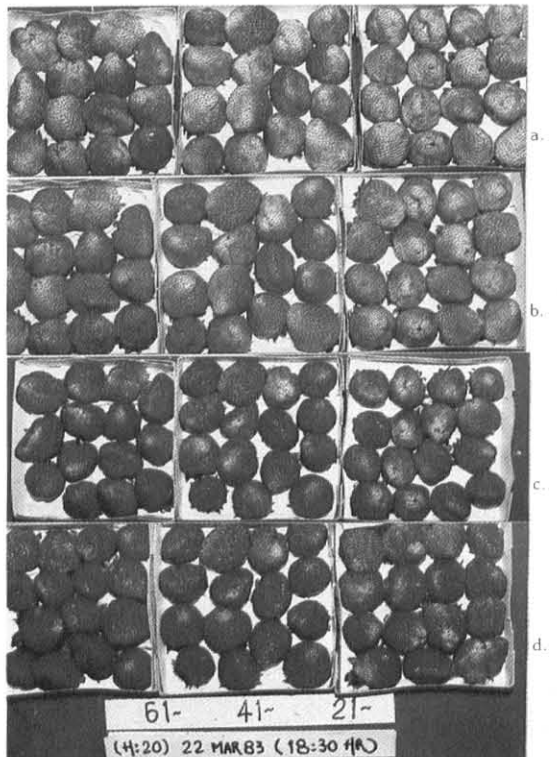


Figure 3. Color development of 3 color ranges: 61-80, 41-60 and 21-40% red color of Tioga strawberries produced in Intanon area from March 20-22, 1983. a:March 20, 8 hrs after harvest; b:24 hrs; c:40 hrs, and d:58 hrs after harvest at room temperature (33°C).

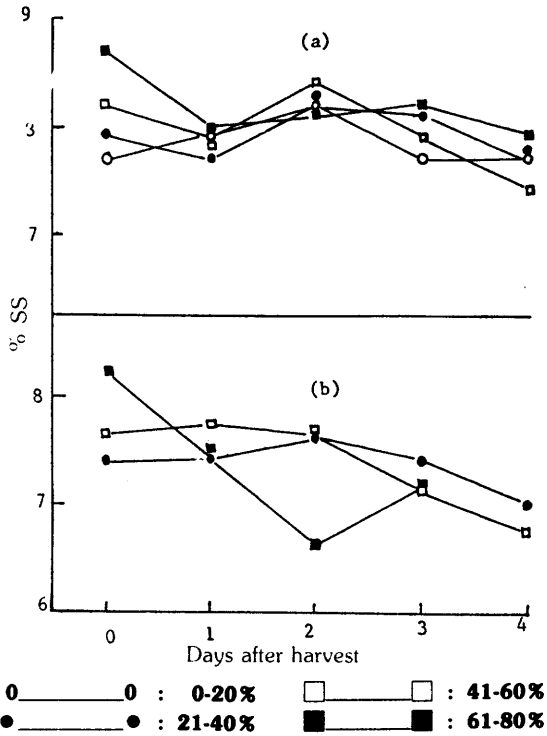


Figure 4. Changes in soluble solids (SS) at room temperature of strawberries harvested at different color stages on December 26, 1982 (a) and March 20, 1983 (b).

color fruit, this study included only 3 color groups: 21-40, 41-60 and 61-80% red color strawberries (Fig. 3). Color development at room temperature (33°C) and 55% RH was rapid at 40 hrs after harvest (Fig. 3, c), the 3 groups had red color ranging between 90 to 98% When they were 58 hrs after harvest (Fig. 3, d), they were considered almost fully ripe. The 21-40% color group at harvest seemed to have better storage quality. The following days, all of these fruits attained 100% red color, but the 61-80% color fruits became senescent and vulnerable to decay.

In order to be practical and to have time allowance for the operation from harvest to the distant market, it is proposed that the 21-40% color strawberries should be the first choice for harvest. At harvest the color appearance is not impressive, the berries attain their natural color of consumers' preference within a reasonable period of time. However, this is subject to the evaluation of other quality criteria.

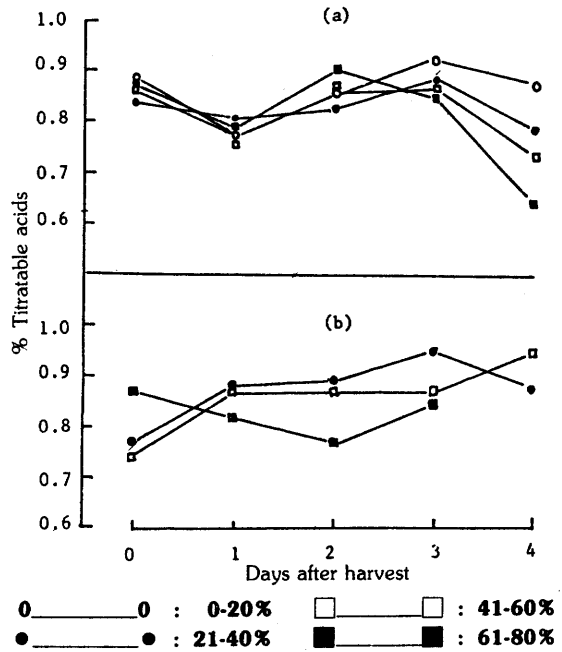


Figure 5. Changes in titratable acids at room temperature of strawberries harvested at different color stages on December 26, 1982 (a) and March 20, 1983 (b).

Soluble solids (SS): Right after harvest on December 26, 1982, the 61-80% color berries had higher SS than other subsequent younger stages. The biggest difference was only 1.0% ($8.7 \pm 0.26\%$ VS $7.7 \pm 0.26\%$) (Fig. 4 a). Along the 4 days after harvest, there were slight decreases and fluctuations of SS among the 4 color stages. On day 2, the difference was only 0.3%. Everyday after harvest, the variation among them was within 0.5%. Though the higher percentage color strawberries had slightly higher SS, it is difficult for one to be able to taste the difference of their SS concentrations.

During the higher temperature period of March 20-24, 1983, all samples had slightly lower SS than those harvested in the cooler month by approximately 0.5%. Changes of SS in the first few days were very small in groups of 21-40 and 41-60% color (Fig. 4 b). In the last few days, their SS declined as in those of the cooler month.

Titratable acids (TA): Titratable acids of the

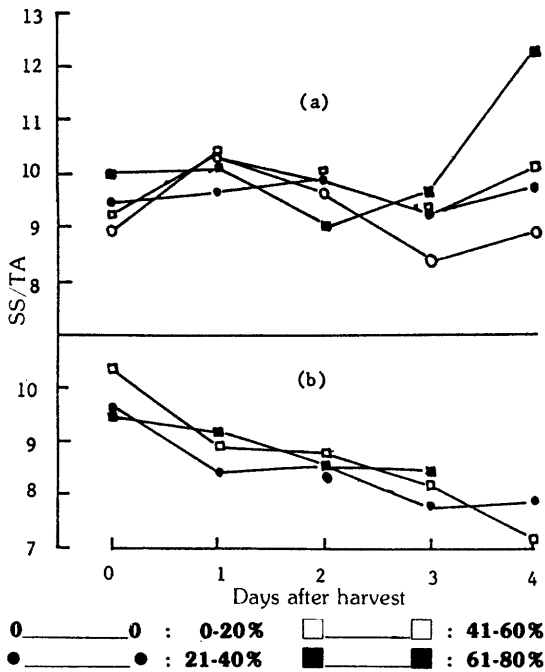


Figure 6. Changes in SS/TA at room temperature of strawberries harvested at different color stages on December 26, 1982 (a) and March 20, 1983 (b).

December crop of the 4 different color stages were almost equal after 5 hours of harvest (Fig. 5 a). Their percentages ranged between 0.84-0.87. Trends of acid changes for all stages of strawberries was similar to those of SS. There were decreases of TA in day 4 and the 0-20 % color group had higher TA than the 61-80% color one by 0.23%, while the latter group was slightly overripe. On day 3, the differences were small and would not be significant. Generally the younger stages had slightly higher acidity during the marketable period. It tends to believe that the 21-40, 41-60 and 61-80% color groups had slightly lower acidity than the 0-20% group.

In the hotter month of March, their acidity was approximately in the range of 0.80 to 0.95% during the four days after harvest (Fig. 5 b). The average acidity of each of the three color groups was slightly higher than that of the cooler month by only 0.01 to 0.03%.

Soluble solids/titratable acids: There were slight decreases of SS/TA in the December crop during the first three days after harvest, but the

Table 1. Organoleptic test of strawberries harvested at different color stages on December 26, 1982 and March 20, 1983.

Days after harvest	Red Color (%)			
	0-20	21-40	41-60	61-80
December				
0	1.50 ^{a/}	2.00	2.90	3.30
1	2.13	2.25	3.38	3.50
2	1.54	2.00	3.00	3.16
3	2.80	3.10	3.20	3.60
4	3.00	3.00	3.23	2.75
March				
0	—	2.25	3.70	3.63
1	—	2.00	2.67	2.67
2	—	1.67	1.83	2.00
3	—	2.50	2.50	2.50

^{a/} 1-5 ranking score was used: 1 = dislike
 3 = like
 5 = like very much

ratios increased on day 4 (Fig. 6 a) due to the greater reduction of acid content. The ratios of the March strawberries (Fig. 6 b) slightly decreased constantly from day 0 to day 4 from the value of 9.5-10.4 to 7.1-8.5.

Since the acid content of strawberries is relatively high with relatively low SS, their ratios are between 7.1 to 12.34. It is observed from Fig. 6 that SS/TA ratios of the cooler month are higher than those of the summer month by 1%. Consumers' taste buds may be able to differentiate them, but it will be difficult.

Organoleptic evaluation: Strawberries of above 41% color harvested in December or March (Table 1) possessed acceptable eating quality or "like". The scores after harvest of the March crop did not represent well as the former harvest. This phenomenon was the outcome of having inexperienced members in strawberries on the taste panel. It is quite certain that the 0-20% color berries are inferior in taste to other groups, yet they had variation of maturity among themselves that some fruits may be 0% color.

It should be noted that organoleptic test of strawberries does not attain a score of 5 or close to 5, if they are eaten alone without any seasonings such as sugar and cream. Generally the fruits have sour taste, except they are harvested at full color

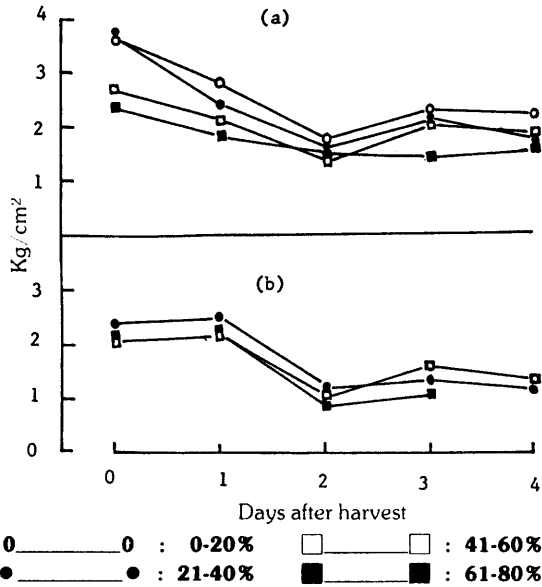


Figure 7. Changes in flesh firmness of strawberries harvested at different color stages on December 26, 1982 (a) and March 20, 1983 (b) (Each point is an average of 24 readings).

and specially low acid varieties. The 21-40% color fruits gained their flavor on the third day after harvest. On the other hand, the younger stage needed one day longer. This is agreeable with the review of Woodward (1972) that strawberry flavor development after harvest is positively related to the fruits' maturity.

Fruit firmness: The younger berries of 0-20% and 21-40% red color harvested on December 26, 1982 had flesh firmness of 3.63 kg/cm² at 5 hrs after harvest (Fig. 7) which was firmer than the other two groups by approximately 1.00. The firmness decreased gradually in all color stages from the picking time to the last day of study. Their firmness was in the range of 1.76 to 2.29 kg/cm². Fluctuation of curves is probably due to reading errors or higher surface tension of the fruits.

Strawberries harvested on March 20, 1983 had slightly lower firmness than the December

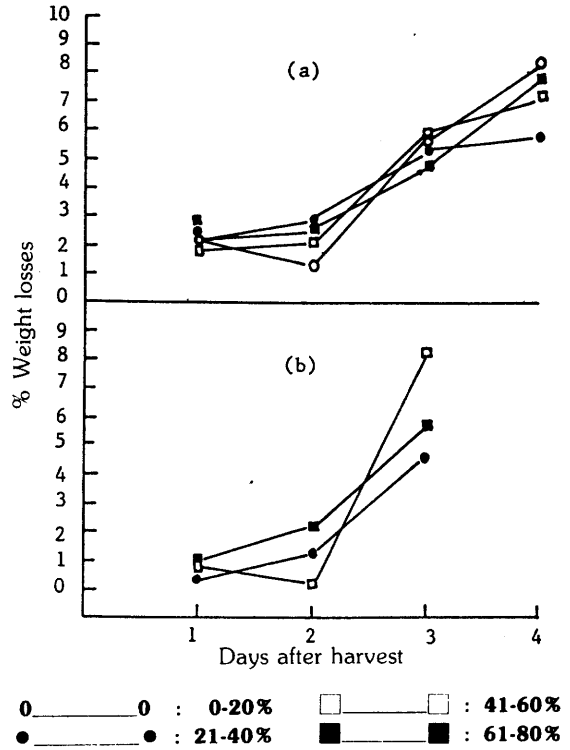


Figure 8. Weight losses of strawberries harvested at different color stages on December 26, 1982 (a) and March 20, 1983 (b) (Each point is an average of 2 trays of strawberries).

crop. All berries attained their lowest firmness on the 2nd day after harvest. On day 4, their flesh firmness was between 1.21 to 1.43 kg/cm². The loss of firmness was not only due to an enzymatic degradation of the pectic material of the fruit cell wall. The wall separation at the middle lamella could be brought about by methylation of polyuronides in this region which may destroy the Ca²⁺ cross-links (Barnes and Patchett, 1976). As fruits had darker color and became softer, they became more susceptible to disease; and therefore, higher deterioration rate of the fruit would be found (Woodward, 1971).

Weight losses: The December crop lost weight by approximately 2% on day 1 (Fig. 8 a). There was slight increase in weight losses on the next day, except the 0-20% color group. On days 3 and 4 all strawberries lost their weight of 5-6 and 6-7% or the Weight losses increased by over 2 and 3 fold of those of days 1 and 2. Weight losses of

the March crop (Fig. 8 b) were severe on days 2 and 3. The increase of the 3 groups was averaged over 3 times in one day from about 1-3% to 5-9%.

There is no doubt about the greater weight losses in the March crop. It is certainly due to higher temperature of the period and high vapor pressure deficit.

The berries become ripe and overripe very rapidly that they are susceptible to desiccation at a faster rate.

Fruit losses: During the two studies, damaged fruits were observed. Postharvest losses included decay, skin bruising, fruit bruising and insect damage. There were only 5 berries (less than 0.8%) with insect damaged scars. These are the result of cultural practice during preharvest period and the sorting mistake.

Bruising is divided into two degrees. The severe symptom is the bruised fruit that parts or the whole berry are affected. For the slightly bruised one, it exhibited on the skin symptom a few days after harvest. Skin bruising is observed by the skin dryness due to excessive skin water evaporation. Fruit and skin bruising berries were amounted to less than 0.2% and 2.5 to 3.9% respectively. Fruit and skin bruising must be originated at the farms during harvesting and packaging operation. There are 0-5 berries in a box and if there were 5 berries, they were not adjacent to each other or in one group.

Decay of strawberries was generally caused by *Rhizopus* and *Botrytis* fungi. The incidence was noticed on the second day of harvest with less than 0.5% of moldy fruits. The percentage increased to 1.2 on the fourth day. It is no doubt that only contaminated strawberries exhibited decay symptom. There is no need of any postharvest fungicidal treatment, if the fruits are healthy and clean. Emphasis of such nature needs strictly good cultural practices as well as "Tender Loving Care" during harvest and packaging at the farms.

CONCLUSION

It is essential to note from our finding that Intanon 'Tioga' strawberries should be harvested

at different stages according to the market demand. Local consumers should be supplied with 61-80% color fruits. Domestic tourists who want to buy strawberries as a gift or for their own use, should select the 41-60% color group. This has better carrying quality than the advanced stage. The distant markets, Bangkok or export markets, the 21-40% color strawberries are far better than any other groups.

The eating quality as affected by maturity has now been verified. Naturally, should one samples strawberries of different maturity, one would feel the inferiority and superiority of the fruits. Among the 3 groups of 21-40, 41-60 and 61-80% color, their eating quality is comparable that the difference is minimal, if the strawberries are eaten at the same color stage.

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