A Study on the Ripening Process of 'Namwa' Banana

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Abstract

'Namwa' banana (Musa ABB 'Kluai Namwa') was kept at room temperature, 30-35℃, for eight days to study the physiological changes during the ripening process. The amount of ethylene, a plant hormone controlling ripening process, rapidly rose up on the fourth day and reached its climacteric peak on the fifth day of storage, then, declined onwards. Starting from green mature, the color of the banana peel changed to yellow on the third and fourth day as the result of chlorophyll degradation that unmasked carotenoid pigments. The fruit lost its weight steadily to 18.5%, possibly from rapid metabolism and high transpiration of the fruit, which coincided with fruit firmness that was reduced from 5.63 N of the firm mature to 1.39 N of the overripe. Chemical analysis on moisture content, total soluble solid (TSS) and acidity were related well with the physical observation. Moisture content of the flesh increased sharply the on the fourth day from 57 to 65%, at the same time TSS increased from 5% to more than 25%, and steadily increased to about 30% on the last day of storage. Acidity reached its peak around 0.7% on the fifth day and declined afterwards.

Keywords: *Climacteric, overripe, senescence, fruit firmness, ethylene production, starch degradation, cell wall solubilization.*

Introduction

The banana is one of most important food crops grown and consumed all over the world. In Thailand, there are many cultivars of the bananas, the most common are: 'Kluai* Hom', 'Kluai Khai' and 'Kluai Namwa' and 'Kluai Hakmuk'. Most of the studies on physiological changes during ripening of the bananas in Thailand were done with 'Kluai Hom' and 'Kluai Khai' since they are potential exporting crops. However, 'Kluai Namwa', the most common banana in Thailand, is not of interest as the others simply, because it is used only for domestic consumption. Nonetheless, Thai people have known how to process 'Kluai Namwa' into many products, from traditional Thai deserts to banana chips and banana fig. The purpose of this research is to study the physiological changes of 'Kluai Namwa' during the ripening process, in order to determine a suitable stage for the production of quality banana figs.

Bananas are climacteric fruits and most are harvested in the unripe stage when the fruits are still green and firm. The harvested bananas pass through three physiological developmental stages, namely the pre-climacteric or 'green life' stage, the climacteric or ripening stage which covers the eat-ripe, and finally the senescence stage when the fruits are over-ripe and dying. Technically, ripening process can be induced by an introduction of ethylene gas. Ethylene is the only plant hormone that is in the form of gas. It has many functions in plant metabolism, one of which is to trigger and accelerate ripening process.

The ripening process includes several noticeable changes that take place simultaneously. The peel and flesh tissues become soften when starch, the storage nutrient of the fruit, is converted into sugar, some of which is subsequently used to provide energy which is necessary for metabolic processes, while the rest remains in the fruit, making it sweet. At the same time, numerous intermediate products produced from various metabolic

* *'Kluai' is a Thai word for banana.*

processes contribute to a formation of certain aromatic compounds that characterize the ripe banana odor. Rupture of the cell wall by enzymatic activities helps soften of the fruit. Breakdown of the chlorophyll in the peel unmasks the yellow color of carotenoid pigments. As a result, the banana peel turns from light green to a yellow color. Finally, the peel turns brown from high enzymatic browning reaction. The flesh loses its firmness and becomes brown and gelatinous.

Materials and Methods

Raw Material

The fruit bunches of 'Kluai Namwa' were obtained from the Kao Ka District, Nakhon Nayok province. The fruits had 80% ripening, i.e. having green, unripe fruits with angular cross sections. Bunches were transported from an orchard to the laboratory where they were cleaned with tap water and allowed to dry at room temperature. Then the fruits were wrapped loosely with paper and kept in the baskets in a good ventilated room for further study.

Methods

The bananas were checked every day during the seven to eight days of storage, to measure the following criteria:

Peel color: This is done by photographing the bunch or individual fruit, on the dorsal and ventral sides for the bunch, and side view from the individual fruit. Peel color change was observed together with an appearance of the fruit peel and the remnant of the anther and petiole.

Weight loss: Expressed in percentage in comparison with the initial weight.

Fruit firmness: Expressed in Newton, using Fruit Firmness Tester, Effigi # F011, with 1 kg and 0.2-cm diam. plunger for the unripe banana and 0.5-cm diam. plunger for the ripe banana, repeating three times for each fruit, pressing depth of 0.5 cm.

Rate of ethylene production: This is done by using the gas chromatograph apparatus, GC-8A, Shimadzu, available at Kamphaeng Saen Campus of Kasesart University, with flame ionization detector (FID), column temperature at 80°C, an injector and detector temperature at 110°C, glass column of 3.2-mm. inside diam. and 5-mm. outside diam., packed with Porapack Q (80/100 mesh) and nitrogen gas as a carrier gas.

Moisture content: Sample of banana flesh was taken to determine moisture content (in percentage), using AOAC (1984) method.

Total titrable acidity (TTA): Expressed as percentage of citric acid, using AOAC (1984) method.

Total soluble solid (TSS): Expressed as °Brix, using Abbé hand refractometer.

Finger drops: The number of fingers dropped from the hand, determined from the over-ripe bunch.

Results and Discussion

Ethylene Production

Unripe bananas showed a constant low level of ethylene production. At the onset or ripening, ethylene production rose up which was followed by a high rate of respiration (Seymour *et al.,* 1993). The rate of ethylene production was almost stable in the first four days of storage, then; the rate rapidly rose up and reached its peak, 70 μl/kg, on the fifth day, and started to decline afterward (Fig. 1.) The result demonstrated three stages of ripening process of unripe 'Kluai Namwa'. The pre-climacteric stage started from the first day to the fourth day, while the climacteric rose on the fourth day to the fifth day, and reached a climacteric peak on the fifth day, then, entered its senescence on the sixth day and onwards. Many physiological changes occurred on the fruits during these periods.

Peel Color

As shown in Fig. 2, the peel color of 'Kluai Namwa' changed from light green to yellow on the fourth day as the result of chlorophyll degradation that gradually unmasked carotenoid pigments lying underneath in the unripe fruit. During ripening the amount of chlorophyll decreased to zero in the ripe fruit

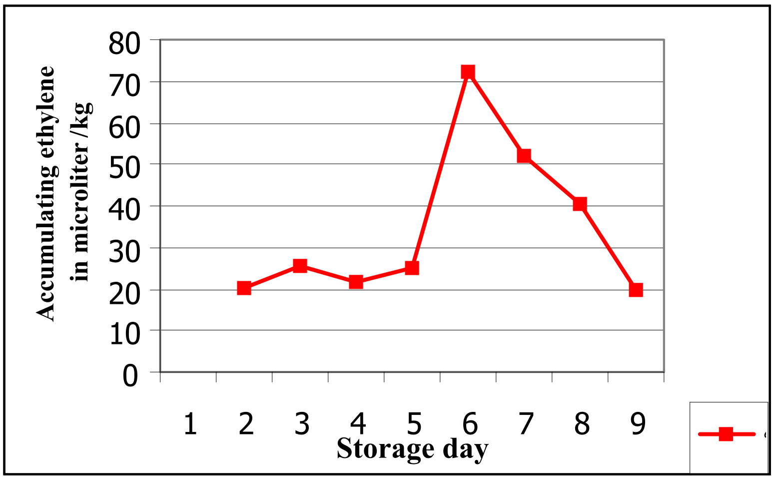

Fig. 1. Ethylene accumulation during banana ripening

(Von Loesecke 1929), while the amount of carotenoid pigments had reduced slightly with the major carotenoids found in yellow-ripe banana were α-carotene, β-carotene and lutein (Gross, *et al*. 1976). On the fifth day, the fruit started to show a sign of senescence or dying with brown areas on the peel, which coincided with a height of the ethylene accumulation (Fig. 1) Since banana peel is rich of phenolic compounds, it is rapidly oxidized by polyphenoloxidase (Palmer 1971). During the senescence period, the enzyme activity was high and more dark areas developed that would cover the entire fruits in the seventh day.

Fig. 2. Photographs of peel color of banana during ripening

Weight Loss

The percent of the weight loss of 'Kluai Namwa' increased continuously during ripening due to a high storage temperature, ~30°C. Like all chemical reactions a plant metabolism increases with temperature. Since high energy is required to run the process, hence, starch is converted to sugar and used as energy. The excess energy produced from the respiration process is released from the tissue by the vaporization of water, which will subsequently be transpired from the fruit, causing a weight loss. Some of the moisture loss through the peel could be observed through shrinkage on the peel (Fig. 1).

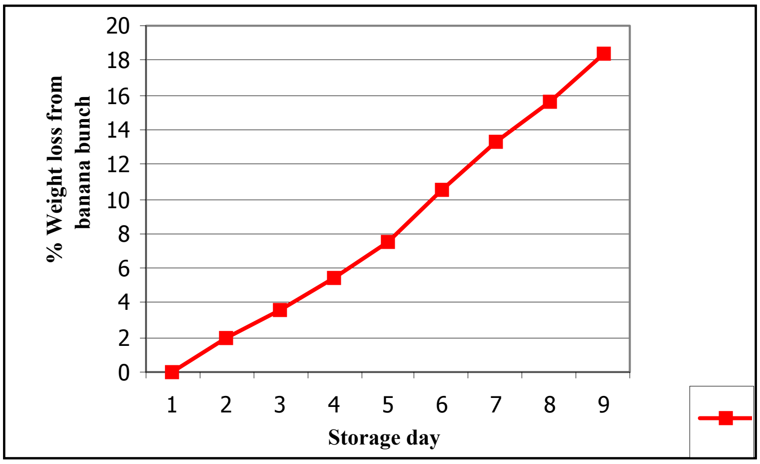

Fig. 3. Weight loss (%) of banana bunch during ripening

Fruit Firmness

Softening of fruits is related to a change in cell wall component and starch degradation (Seymour 1993). The starch granules, packed in the tissue of banana flesh give rise to the toughness of the unripe fruit, and are hydrolyzed to sugar while an increase of the cell wall solubility allows water and nutrients to pass in and out of the cells. Fruit firmness decreased steadily during the seven-day storage. It was expected that during those periods all starch would be completely converted to sugar.

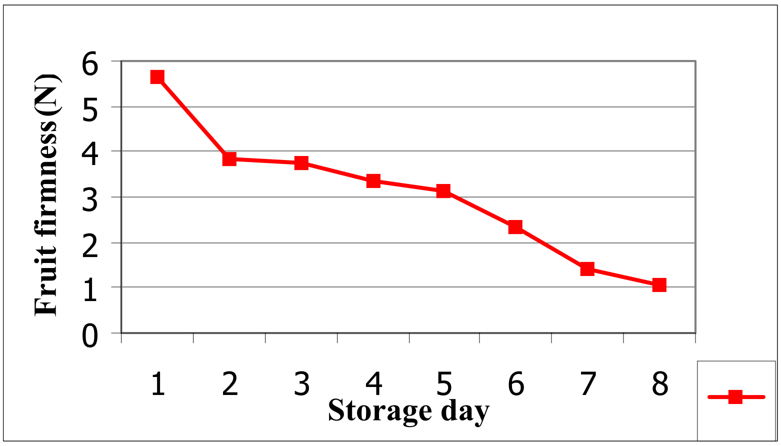

Fig. 4. Fruit firmness (N) of banana during ripening

Moisture Content

A movement of moisture from the peel into the flesh could be a reason for an increase in percent moisture content. Percent moisture content of banana flesh increased rapidly during the first two days of the storage due to the respiratory breakdown and osmotic movement of water from the banana peel into the flesh.

After the second day, a slight change in the moisture content was observed, around 64%. Nonetheless, the water could still be lost from the fruit. Even though the shrinkage of the peel might prevent more water to come out from the flesh.

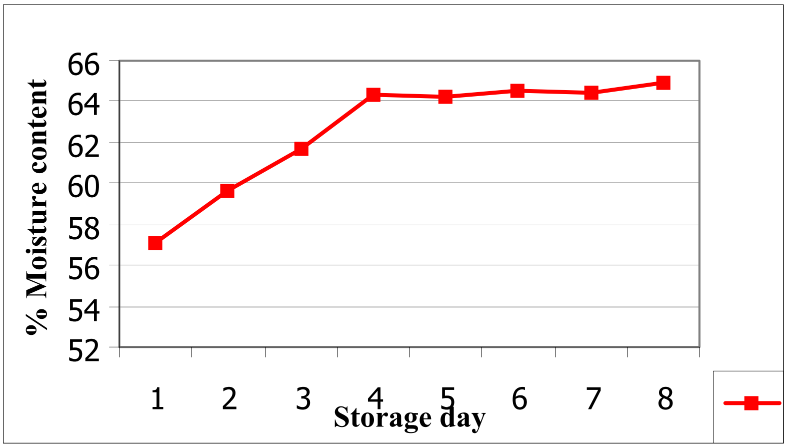

Fig. 5. Moisture content (%) of banana flesh during ripening

Acidity

In banana flesh, the total amount of acid increases during ripening; the main acids being: malic, citric and oxalic acid. While the first two acids are responsible for tartness in the unripe banana, oxalic acid is contributed to astringent taste of the fruit (Seymour 1993). As the fruit ripened, these acids were reduced and, the taste changed to a sweet taste, mainly from the hydrolyzed sugar from the starch degradation. Total titrable acid increased to its peak in the fifth day coincided with the peak of ethylene accumulation and started to decline onwards.

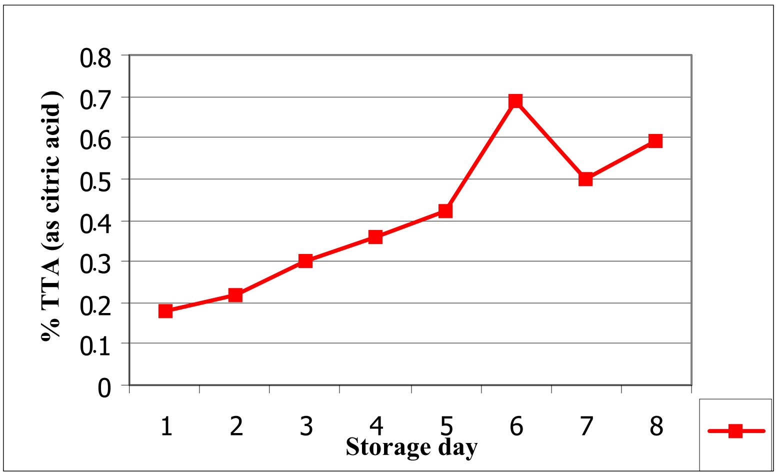

Fig. 6. Percent acidity of banana flesh during ripening

Total soluble solid

A change in total soluble solid followed the same pattern as the percent moisture content, with a sharp rise in the first three days and steadily leveled of afterwards (Figs. 5 and 7). In the flesh more movement of water and the degradation of starch to soluble sugar within the cell contributed to the increase of TSS.

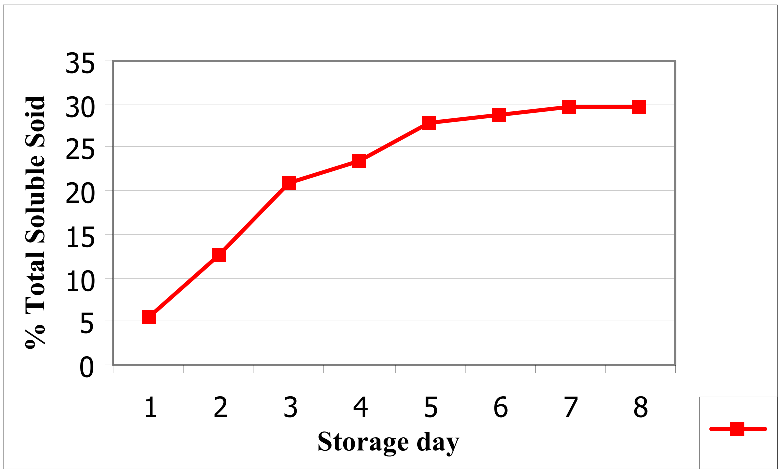

Fig. 7. Total soluble solid (%) of banana flesh during ripening

Finger-Drop

The remarkable change in the senescence stage of 'Kluai Namwa' was the finger drop. Over-ripe banana demonstrated a detachment of individual fruit from the hand. The finger drop was observed on the seventh day and increased afterwards. A continued study showed that more than 50% of the finger-drop was present on the ninth day.

Conclusion

As a climacteric fruit, several noticeable changes took place during ripening of the Kluai 'Namwa'. The ethylene concentration became rather stable during the pre-climacteric phase in the first three days of storage. The increase in ethylene production from the fruit triggered the onset of the ripening process, reaching its peak on the fifth day of storage. The peel color turned from light-green in the unripe to yellow-ripe stage on the fourth day. Development of the dark areas on the peel as a result of rapid poly-phenoloxidase started on the fifth day, at the same time that the ethylene accumulation reached its peak. Fruits soften through starch degradation and cell wall solubilization. Fruits lost their weight due to transpiration of water to release excess heat created from metabolic process and was shown as the peel shriveled. A movement of moisture from the peel, solubilization of cell wall and starch degradation resulted in high moisture content and high total soluble solid in the banana flesh. The senescence phase was demonstrated with the increase in finger drop from the seventh to ninth day of the storage.

In order to produce quality banana fig, the banana should be at the senescence or over-ripe phase, when the fruit is soft and sweet. The fruit was characterized by dark colored peel, fruit firmness of 1.08 N, 15.6% weight loss, 30% total soluble solid, 0.5% acidity (as citric acid), 65% moisture content, and 50% finger drop.

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