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# Fruit Size and Soluble Solids Content in Relation to Growth and Development of Longan (*Dimocarpus longan*)

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**Abstract** The purpose of this research was to apply measurement of soluble solids content (SSC) which is an important noticeable change to describe the growth during ripening of longan fruits (Biaokhiao cultivar) in order to contribute to the phenology studies and the information can help assist the development of longan management and control protocols. It was found that the SSC increased rapidly in parallel with enhancing fruit size and maturity until around week 27 after floral emergence. At the end of the ripening process, it reached the maximum level at 25.07±1.21 ºBrix when the longan fruits were around 95% of the final size. After that, SSC started to significantly and quickly decrease even though the fruit size was still slightly growing.

**Keywords:** soluble solids content, ripening, longan, fruit size, Biaokhiao

## Introduction

Longan (*Dimocarpus longan*) is a native subtropical fruit tree from Southern Asia. The specie is a member of the Sapindaceae. Longan aged 3 years starts yielding and will fully provide to yield at the seven years of age until 30 years, depending on maintenance. The time from flowering to harvest lasts from 4 to 6 months depending on the environmental conditions and the cultivars. After fertilization, each panicle can finally carry about 60-80 fruits (Davenport and Stern, 2005; Jiang *et al*., 2011; Phama *et al*., 2015).

The marketing of longan grows very strongly with a lot of demand for the product. Biaokhiao, the studied longan cultivar in this research, is popular among numerous longan cultivars in Thailand. It can grow well and tolerate drought. Flowering usually occurs every other year. The tree yields a large full bunch of oblate shapes with noticeable distortion and thick shell fruits. Surface is brown and smooth. Fruit aril is pinkish white and dry with aroma sweet flavor (PVPO, 2002).

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While several studies on production, phenology, floral induction have been performed in longan, little information is available on relation between fruit phenology development and fruit quality in term of aril composition. This research aim is to have an additional work of the observations needed.

Thus, we proposed to apply measurement of soluble solids content which is an important noticeable change to describe the growth stages of longan fruits (Biaokhiao cultivar) in order to contribute to the phenology studies in this crop and the information can help assist the development of longan management and control protocols.

## Materials and methods

### *Study area*

Data were collected from 15 years old adult trees of *Dimocarpus longan* cultivar Biaokhiao, located in Pa Kor Dum district, Mae Lao, Chiang Rai province (latitude 19.77 °N, longitude 99.72 °E). The climate data of the last 5 years showed a mean annual temperature of 25.0 °C, average maximum temperatures of 35.0 °C in April and average minimum temperature of 8.0 °C in December, with an average annual rainfall of 1,250 mm (information from Agriculture Technology Training and service center, Pa Kor Dum district, Mae Lao, Chiang Rai, 2016). Observation and measurement of growth development and soluble solids content (SSC) were carried out during growing seasons of year 2016. Samples were collected from 5 trees and measurement of SSC and fruit size were made in triplicate, once per week during June-August 2016. During the experimental period, the average maximum and minimum temperature were 31.0 °C and 23.0 °C, respectively.

### *Collecting data*

Observation of phenology during different growth stages started since the floral emergence period. The first set of samples was taken for analysis when a majority reached the beginning of fruit development stage (21 weeks after floral emergence), thus their expressed juice could be obtained for the experiment. Fruits were taken from the same trees every week. Sizes (diameter) of individuals were measured soon after the harvest, and soluble solids content (°Brix) was also measured using Brix refractometer (ATAGO 2313 Master series). Length of sample collecting period was 10 weeks, determined by the time in which fruits did not further increase in size.

### *Statistical Analysis*

For the study of relation between harvest day, fruit size and soluble solids content, the corresponding data collected on the sampling date until the ripening period were mutually plotted. All the data was also used for regression analyses. Measured characteristics were analyzed by a one way analysis of variance (ANOVA). Also, significantly different means were separated by the Duncan's test at the 5% level.

## Results

### *Observation of Longan fruits during growth and development*

This syudy included observation on inflorescence development, flowering, fruit development, and fruit maturity. Flower buds developed and flowering emergence occurred in May and continued to around 30-40 days. During full flowering to the end of flowering stage, nearly 90-100% of flowers opened and allowed fruits to set and be found. Then, the growth of Longan fruits developed further. Within 2 months after anthesis, pericarp and aril development started while the seed coat, embryo and endosperm could be observed. The next stage, seed coat hardening, pericarp thinning, development of aril and the maturation process were detected.

During fruit maturity stage, the fruits were still growing. They were ready for harvest when the skin is thin, tough, leathery and completely smooth, and the color fully changed to yellow-brown. The fruit ripening proceeded in parallel with development in fruit size. Biaokhiao cultivar grew and continued to mature for ready to harvest at around week 27 after floral emergence period. During ripening, fruits became soft textured and accumulated aroma volatiles as well as soluble sugars.

### *Relation between harvest date, fruit size and soluble solids content*

The fruit size, defined by diameter, rapidly increased between the $21^{th}$ week and the $27^{th}$ week after floral emergence before reaching a stable size, indicating that the fruit was not fully ripe until around week 27 after floral emergence. The size of longan fruit increased from about 20.41 (± 1.34) mm at the beginning of the fruit development to about 30.89 (± 1.59) mm in week 27 before reaching the maximum at 32.53 (± 2.23) mm in week 29 as shown in Table 1. The result showed that the significant increase of fruit maturation occurred during week 21-27 which was corresponded to 1.50 mm per week in average. After the 27th week, an average fruit size increase was only 0.5 mm per week. During the observed periods, the increase in fruit size was positively correlated with fruit maturation as shown in figure 1.

Similarly, the soluble solids content (SSC) of expressed longan juice did not reach its maximum level until the the 27th week. It varied between 13.97 (± 2.32) and 25.07 (± 1.21) °Brix as shown in Table 1. This is equal to an increase of approximately 1.8 unit per week. After that, the obvious lower SCC values were detected from the 8th week onwards. The decrease was small but significant ($P < 0.05$). It seemed that the change of SSC level during ripening period was mainly a function of time and the data fit well with the second degree polynomial model as shown in Figure 2.

**Table 1.** Fruit size and soluble solids content (SSC) of longan fruits from the 21st - 30th week after floral emergence

| Week after floral emergence | fruit size (mm) | SSC (°Brix) |
|---|---|---|
| 21 | 20.41 ± 1.34 a | 13.97 ± 2.32 a |
| 22 | 22.77 ± 1.20 b | 16.37 ± 1.49 b |
| 23 | 24.24 ± 1.97 c | 19.21 ± 2.30 c |
| 24 | 27.27 ± 1.27 d | 23.61 ± 1.26 d |
| 25 | 28.00 ± 2.52 d | 21.73 ± 1.46 e |
| 26 | 26.24 ± 1.53 e | 24.20 ± 1.70 d |
| 27 | 30.89 ± 1.59 f | 25.07 ± 1.21 f |
| 28 | 31.80 ± 2.66 f | 21.91 ± 1.64 e |
| 29 | 32.53 ± 2.23 fg | 20.31 ± 1.47 g |
| 30 | 31.04 ± 1.60 f | 19.27 ± 1.47 c |

*Means ± SD within a column followed by the same letter are not significantly different at 5% level.

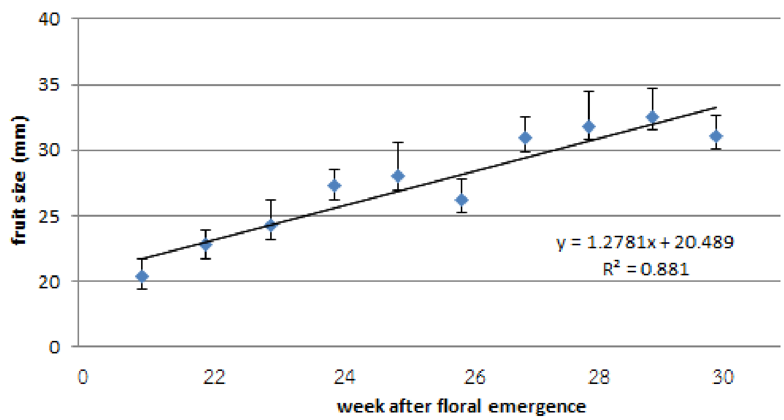


**Figure 1.** Regression of change in fruit size in related with fruit maturation.

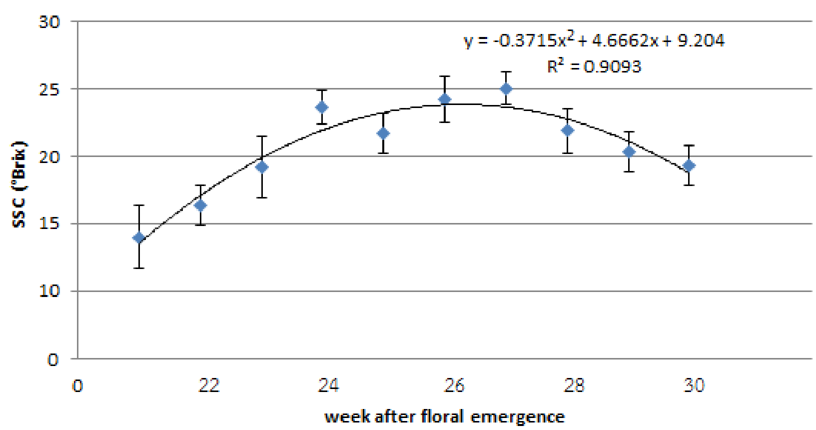


**Figure 2.** Change in soluble solids content (SSC) in related with fruit maturation.

It could be implied that SSC increased in parallel with fruit size only until around week 27 after floral emergence. After that, the fruit size still slightly increased while SSC significantly dropped in proportion with the delay of harvest. The correlation between the two characteristics during the whole 10 week period was, therefore, low (Figure 3). Following falling of SSC, it was not proper for harvest as the pericarp color turned brown and the pulp became fibrous.

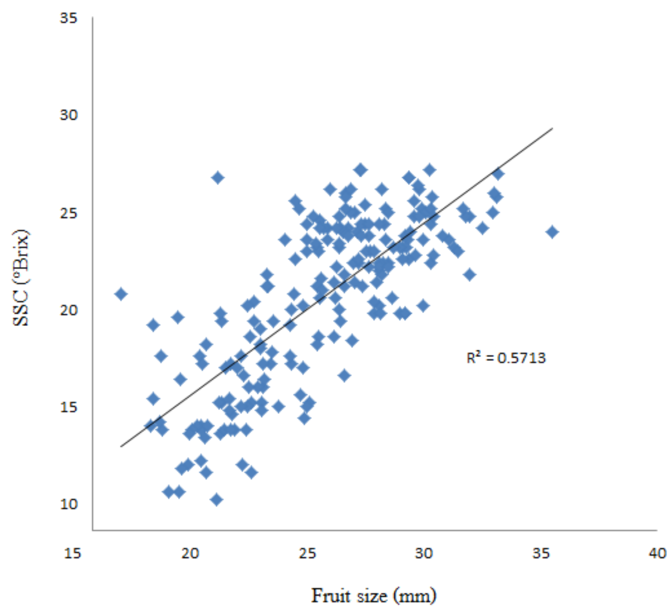


**Figure 3.** Relationship between soluble solids content (SSC) and fruit size

## Discussion

Taste of the fruit is caused by combination of internal chemical compositions. In each phase of development, flavor of individual fruit changes throughout a period of growth according to whole amount of water soluble solids (Total Soluble Solids: TSS), often referred as the quantities of sugar, starch, organic acids, tannin and specific odor unique to the fruit type. Normally, when the fruit is still young, it usually has a sour, astringent bitter taste. Sourness and bitterness will gradually decrease when the fruit is aging. The most noticeable change of flavor during ripening is caused by the sugar and organic acid level. For non-climacteric fruits, such as longan, fruits are still attached to the tree during ripening while sugar content in fruits continues to increase through the moving sucrose delivered from leaves. Sucrose, then, is further digested to glucose and fructose by sucrose hydrolyzing enzyme. Thus, high sugar quantity is detected when fruits undergo ripeness (Xu *et al*., 2009; Xu *et al*., 1997).

The soluble sugars are the largest contributor to the total soluble solids content. Therefore, the sweetness of the fruit can be measured by a tool called Refractometer which is a device for measurement of the refractive index of solution resulting from quantity of total soluble solids. Overall amount of soluble solids showed a good correlation with the sum of glucose plus fructose as reported in the previous work that studied postharvest soluble solids and sugar content and found that the SSC is in agreement with the measured amount in glucose and fructose concentration (Beckles, 2012). Other studies have shown that total soluble solids content of longan was positively correlated with the total sugar ($r^2 = 0.849^{**}$) and sucrose content ($r^2 = 0.851^{**}$) (Shuai *et al*., 2016).

The accumulation of sugars is one of the main factors of ripening process. The major sugars accumulated in longan arils are sucrose, glucose and fructose. These sugars are soluble and determine fruit taste depending on their content and composition (Itai and Tanahashi, 2008). In addition, expression of SSC in °Brix is a commonly used method for assessing fruit quality. In this study, SSC of the expressed juice of longan arils rose during maturation and reached the peak when it was proper for harvest while the average fruit size was around 95% of the final size. The high soluble solids content level retained for short time. After that, sweetness tended to decline gradually in later stages as total SSC decreased in proportion with the delay of harvest.

## Conclusions

Total soluble solids content (°Brix) increased rapidly during the fast enhancing phase of fruit size until around the 27$^{th}$ week after the flowering emergence period when it was proper for harvest. At the end of the ripening process, Biaokhiao cultivar reached the maximum SSC level of 25.07±1.21 ºBrix when longan fruits were around 95% of the final size. The high SSC level retained for short time before it started to quickly drop even though the fruit size was still increasing slightly. Following falling of SSC, the pericarp color turning brown and the pulp became fibrous.

## Acknowledgement

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