Deterioration Model for the Assessment of Longan Senescence and Decay

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ABSTRACT

The correlation of browning index (BI) to decay parameters was determined using total soluble solid content (TSS), ethanol and ethanol/TSS ratio. Longan fruits were harvested traditionally and compared with precooling technique. It was found that longan fruit, harvested without cooling, exhibited better colour retention, and less off-flavour production. All parameters except TSS gave a good correlation with storage time. The relations of BI to ethanol and ethanol/TSS were also observed and high regression coefficients were also found (R^2>0.80). The data all fitted well with linear regressions, thus giving the model to predict storage time of the longan fruit after harvest as: (D=2.14x-0.6, R^2= 0.75) where x = BI×(E/T).

Key words: Post harvest decay, Longan, Deterioration model, Maturity index, Ethanol content and browning index

INTRODUCTION

Longan (*Dimocarpus longan Lour.*) is a fruit of the family *Sapindacea*. It is considered to be nonclimateric as the fruit cannot ripe off the tree (Jiang et al., 2002; Huang et al., 2005). The fruit is harvested on the basis of eating quality: a particular shape, skin colour and flavour of each cultivar (Fletcher, 1995; Su et al., 2005). Jiang et al., (2002) reported that the respiration rate and ethylene content increased after the fruit has been harvested which were associated with temperature, desiccation and the decay caused by micro-organism. After longan fruit is harvested, it can be stored for a few days at 30°C (Tongdee, 1997) and 30 days at 1-5°C (Tian et al., 2002). It then gives brown colour at the pericarp and signs of senescence, e.g., decrease in sugar content and increase in ethanol (Jiang et al., 2002).

In order to harvest fruits at the best quality, maturity index has been used in *Spindaceae* family, including longan, for a decade (Batten, 1989). Total soluble solid content is used at a minimum of 15.5-16% for standard maturity of longan (Tongdee, 1997). However, no one has yet applied this criterion to post harvest decay index before. The benefit of such an index is that it can be used for the prediction of the storage life of the fruit after harvest. Drinnan (2004) reported that two main factors diminishing the storage life and marketability of longan fruits are microbial decay and skin browning. These two parameters detract the appearance and relate to off-flavours of the aril (edible portion). Thus, the objective of this study was to determine the relation of microbial decay parameters, TSS, ethanol and ethanol/TSS, to browning appearance and eventually set up the deterioration model.

MATERIALS AND METHODS

Longan cv. *Daw* at full-maturity stage, yellow-brown colour, smooth skin approximately 18-20 % TSS, was harvested in late October 2006 at Phrao, Chiang Mai, Thailand. The fruits were divided randomly into two lots after harvest. Fruits of the first lot, after removing the stalk, were packed in the basket covered with leaves and transported to the laboratory at Faculty of Agriculture, Chiang Mai University. To extend the storage life and retard the generation of browning appearance, field heat was removed by dipping the fruits in ice slurry for 10 min, drained and transported to the laboratory. This variant could then be used to confirm the relationship of the microbial decay criterion with browning index. At the laboratory, fruits from each lot were subjected to the climate chamber at 10?C, 90%RH and withdrawn for shelf life study. Browning index was assessed by measuring the visible brown area on the pericarp of each of the 10 fruits with the scale of 1 (no browning, excellent quality); 2 (slight browning); 3 (<25% brown); 4 (25-50% brown) and 5 (>50% brown) (Zheng and Tian, 2006). The index (%) was calculated using the following formula:

$$\Sigma \text{ (browning scale / proportion of corresponding fruit within each class)} \quad (1)$$

After the arils of 20 longan fruits were homogenized, fruit puree was filtrated through filtering paper (Whatman No.4). The filtrate was then used for total soluble solid determination as % Brix, using digital refractometer (PAL-1, Atago®, Japan). Three values were obtained. Redistilled water was used to calibrate the refractometer before starting the analysis and for control measurement after each sample. Refractometer readings (% $Brix_{ref}$) were corrected for the titratable acidity of the sample (IFU No.8, 2000), resulting in the contents of $TSS_{corr.}$ (% $Brix_{corr.}$). The titratable acidity was measured by titrating 25 mL of the filtrate with 0.1 N NaOH (titrisol, Merck®, Germany) to pH 8.1 as malic acid, using digital titrator (BUCHI, Dosimat®, Switzerland) equipped with pH meter (PP-50, Sartorious, Germany). The total titratable acidity was calculated as a percentage of mallic acid which is a predominant acid in longan fruit. The calculation of titratable

acidity can be made, using the following equation:

$$\textit{Titratable acidity (g/L malic acid)} = \frac{\textit{(mL NaOH)}\times 6.7}{\textit{mL sample}} \quad (2)$$

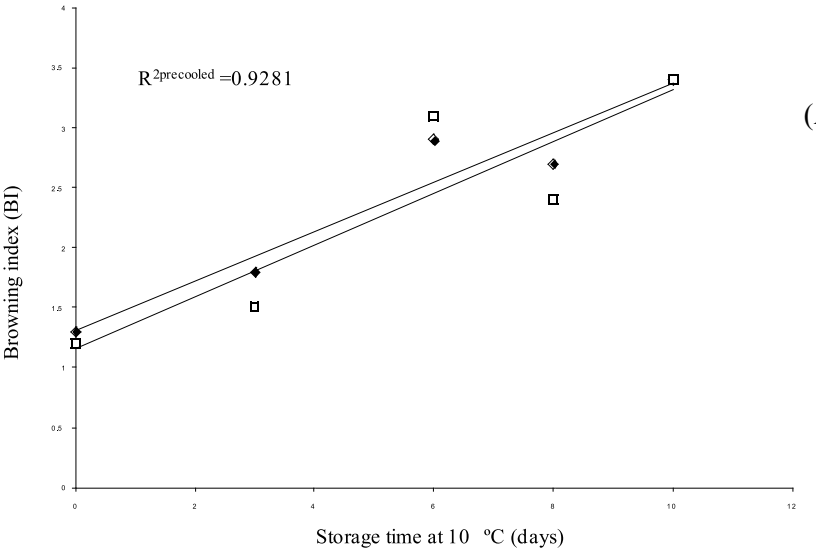
Approximately 10 g of the puree was weighed into a 100 mL volumetric flask and diluted with distilled water. The diluted puree was then filtrated through the filtering paper. Before proceeding to the enzymatic tests, exact 25 mL of the filtrated puree was adjusted pH with 0.2 M NaOH to 8.0-8.5 and then diluted into a 50 mL volumetric flask with distilled water. Ethanol content is a direct indicator of microbiological fermentation that was determined by Boehringer Mannheim enzymatic bioanalysis and food analysis test kits. The procedure was determined at 20°C and spectometrically measured at λ340 nm as describe in the manual. The calculation was followed as described in the manuals. The amount of ethanol was calculated in g/kg sample. The analyses were performed at day 0, 3, 6, 8 and 10. The correlations between browning index and TSS, ethanol and ethanol/TSS were statistically analyzed by Pearson's correlation analysis, using Statistix ver 8.0 program. The linear regression was plotted for every correlated relation by Microsoft Excel. The ratio of ethanol and TSS at unacceptable browning scale was used as the deterioration index of longan fruit.

RESULTS AND DISCUSSION

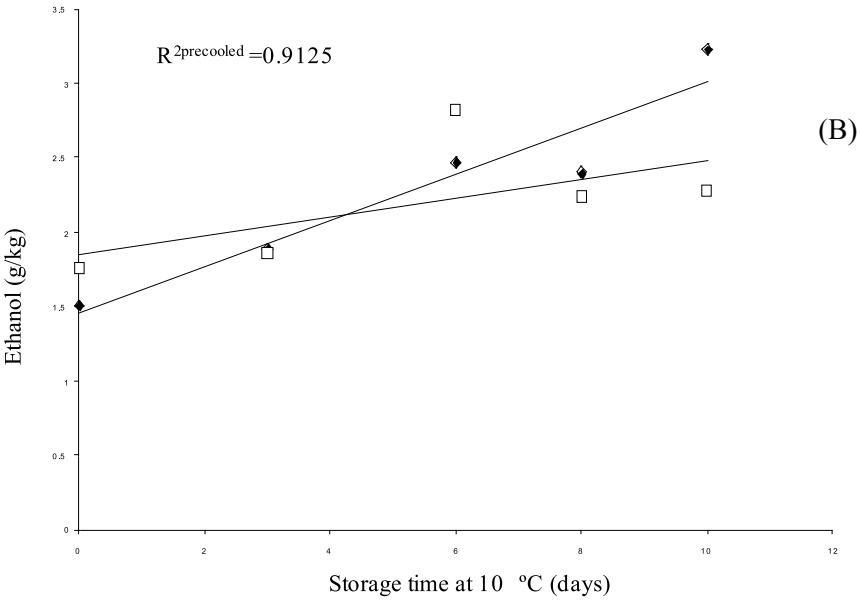
Effect of precooling on the retention of fruit quality

Longan subjected to hydro-cooling was compared to longan harvested without precooling process. The result illustrated that there was an increase in browning index (BI) with time in both samples and fitted well with linear regression (R^2>0.90), Fig. 1, A. After precooling, longan fruits seemed to lose their fresh colour faster than the ordinary harvest. This might probably be ascribed to chilling injury as it was evidently related to skin browning (Pan et al., 1996). Although it had been corrected by detracting the organic acid content, the fluctuation of total soluble solid (TSS, %Brix) was still found in the two samples during storage. Ray et al., (2004) explained that the fluctuation in TSS reading was due to the variations in other soluble ingredients rather than sucrose which is a major constituent for TSS measurement. Ethanol, as a by-product of fermentation, is used as the indicator of micro-organism spoilage. In this experiment, the amount of ethanol increased with time in both samples. Tongdee (1997) stated that the deterioration of longan fruit is mainly on account of fruit rotting, caused by the contamination of micro-organism and dehydration of the peel. After the damage the peel (rind) by excessive loss of water, it was easy for the micro-organism to contaminate from the peel into the aril, resulting in the ethanol production or off-flavour of the fruits. Tian et al., (2002) observed that ethanol content of longan fruit slightly increased with storage time due to high sucrose content of the fruit. Fruit undergone precooling was found to have higher content of ethanol than the control fruit. This might be attributed to the damage of the cell wall during

pre-cooling, leading to less rigidity of the peel and caused the microbial damage through the cell wall. The linear regression also fitted well with the content of ethanol and storage time (Fig. 1, B). Similar to the ethanol content, ethanol to total soluble solid ratio also increased with storage time and showed high regression coefficient with the a storage time (Fig. 1, D).



(A)



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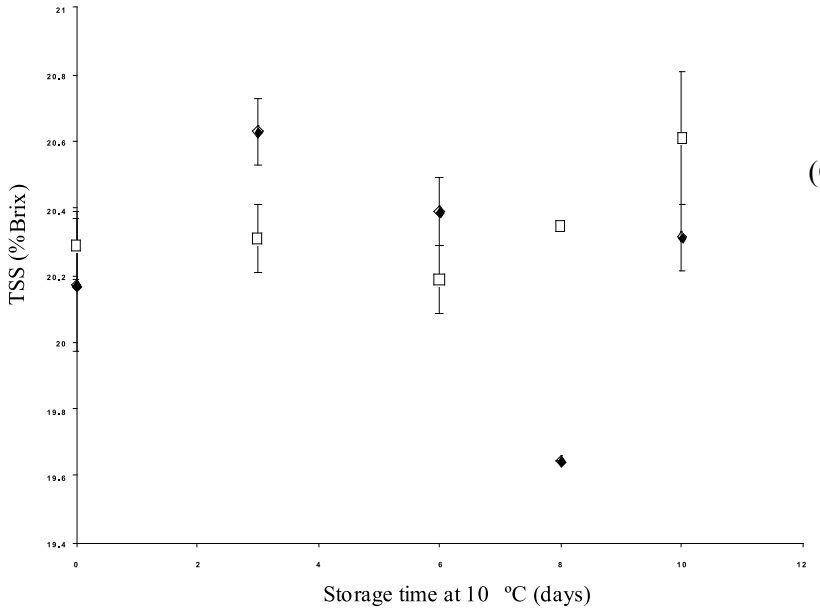
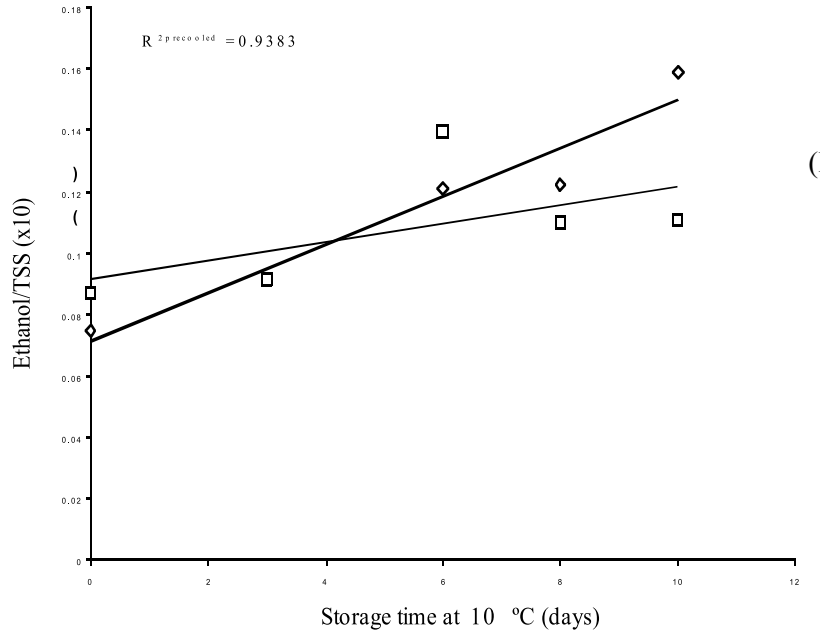


(C)



(D)

Figure 1. Change of browning index (A), ethanol (B) total soluble solid (C) (TSS %Brix), ethanol to TSS ratio(D) during 10 days of analysis: □ sample without precooling after harvest (control) ♦ sample with pre cooling (hydro-cooling).

Correlation of browning index to decay parameters

The correlations between BI and TSS, ethanol content and Eethanol/TSS ratio are shown in Table 1. It was found that data for ethanol in both cases, control and pre cooled samples, were well correlated, illustrating the relation of browning appearance to off-flavour production. Sugar is used as a substrate for the fermentation, causing the increase in ethanol production. Tian et al., (2002) reported that the higher amount of ethanol found in longan after harvest is attributed to the high soluble solid content and the TSS measured is highly associated with sucrose content. Thus, the ratio of ethanol and TSS was chosen for a decay indicator. Good correlation between the ratio of ethanol and TSS with BI was also observed in both samples.

Scattered plots of those correlations were drawn (Fig. 2-3). The linear regression plot was used to find the relationship of BI ,ethanol and ethanol/TSS ratio because it was also applied with taste rating on TSS of litchi fruit (Batten,1989) and ,more over, ethanol is the by-product of sugar fermentation. The result showed high regression coefficient (R^2>0.7).

The data obtained could be interpreted that storage time (D) is a function of BI and the ratio of ethanol and TSS, linear curves were well fitted with all relations. Thus, the predicted storage time of longan (D) can be expressed as:

$$D = f(x), \text{ where } x = BI \times (E/T) \quad (3)$$

Figure 4 illustrates the linear regression of the function, providing the model (D=2.14x-0.6, R^2= 0.75) where x = BI×(E/T).

Table 1. Peason's correlation coefficient (r) and probability (p) of browning index (BI),TSS (°Brix), ethanol (g/kg) and the ratio of ethanol and TSS (×10).

variable1	variable 2	correlation	
		r	p
$BI_{control}$	$TSS_{control}$	0.4188	0.4827
$BI_{precooled}$	$TSS_{precooled}$	-0.1483	0.8119
$BI_{control}$	$Ethanol_{control}$	0.8340	0.0792
$BI_{precooled}$	$Ethanol_{precooled}$	0.9726	0.0054
$BI_{control}$	$Eth/TSS_{control}$	0.8098	0.0967
$BI_{precooled}$	$Eth/TSS_{precooled}$	0.9758	0.0045

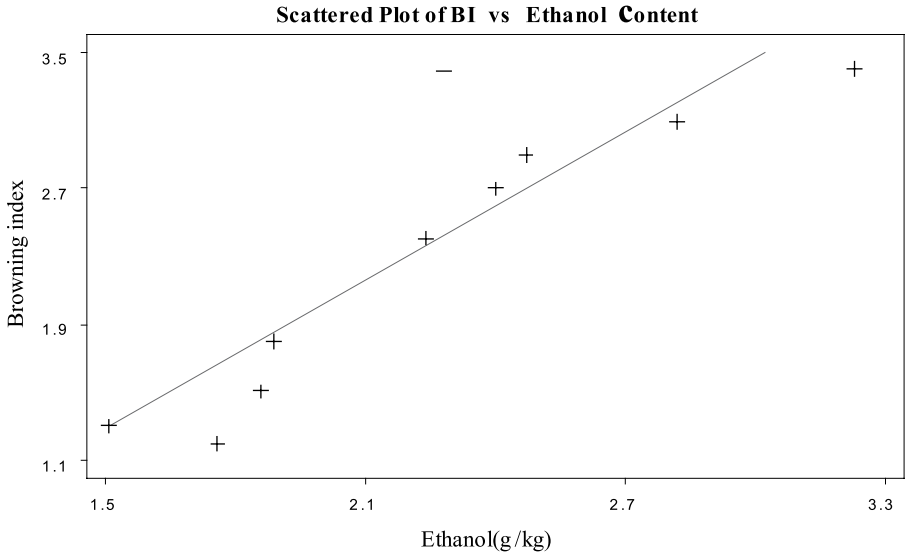


Figure 2. Browning index and ethanol content (g/kg) for longan fruit. Equation for fitted curve: BI=0.5319E+0.9856, R^2=0.77.

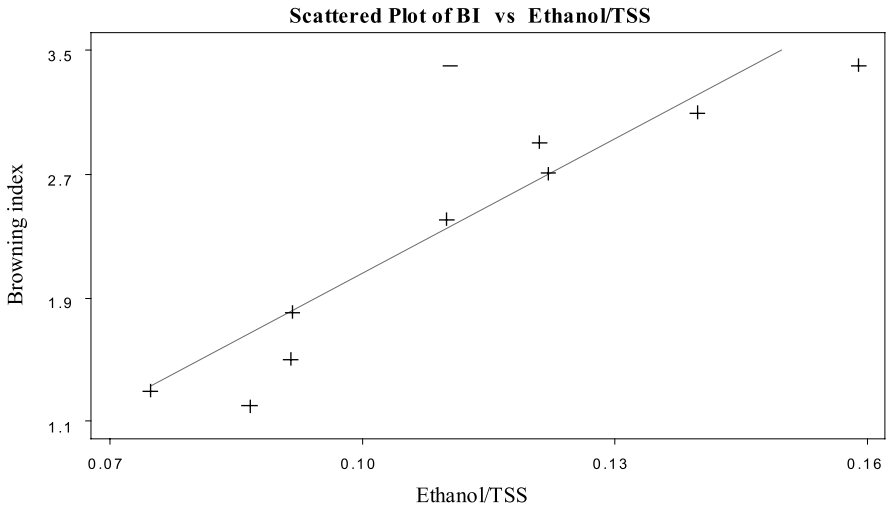


Figure 3. Browning index and ethanol to total soluble solid ratio, E/T (×10), for longan fruit. Equation for fitted curved: BI=28.99(E/T)-0.8408, R^2=0.75.

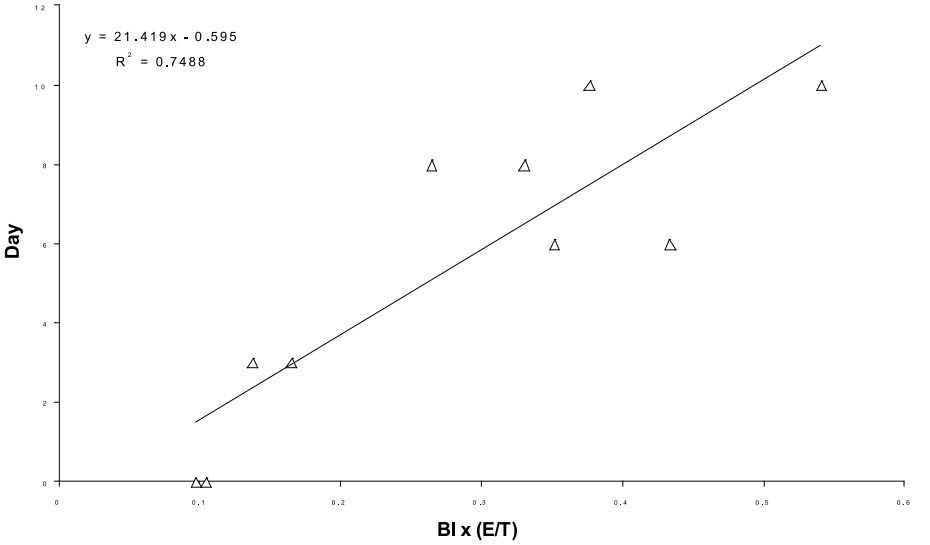


Figure 4. Prediction of storage time of longan fruit as a function of BI and ethanol/ TSS ratio.

CONCLUSION

The relations of storage time with BI, ethanol and ethanol to TSS ratio were found in longan fruits stored at 10°C for 10 days. In comparison to the ordinary harvest, longan pre cooled with ice slurry was found to have less shelf-life stability due to cell damages by excessive cold water. Good correlation between BI to ethanol, BI to ethanol/TSS was also observed and fitted well with the linear regression. All of these data could be generated as a model to predict the storage life of longan fruits, *i.e.*, the storage time is a function of BI and the ratio of ethanol and TSS. The equation model also provides the linear relationship, that is: $D=2.14x-0.6$, $R^2= 0.75$ where $x = BI\times(E/T)$.

ACKNOWLEDGEMENTS

The data used in this study were a part of the research project on sustainable land use and rural development in mountainous regions of Southeast Asia, subproject E2.3. The authors would like to thank SFB, Germany and Thai government for funding and opportunity. Thanks are also given to Dr. Sybille Neihart and Prof. Reinold Carle for project leading and Ms. Mareike Reichel for her capable scientific practices.

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