Tropentag 2008
University of Hohenheim, October 7-9, 2008
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Utilisation-orientated harvest time decision - a chance to enhance the marketability of fresh longan fruits

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Introduction

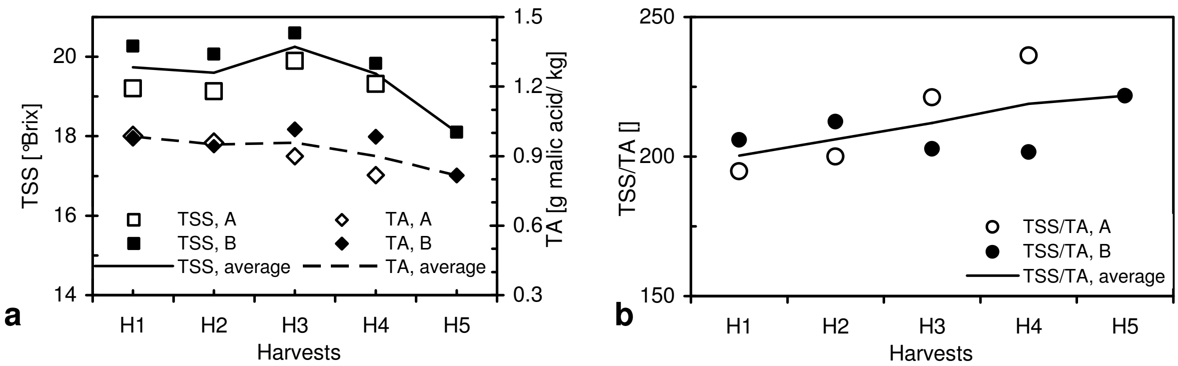
Fresh longan fruits (*Dimocarpus longan* Lour.) play a key role in income generation of farmers in Northern Thailand. The profit is limited by the high perishability of this fruit, sold on local markets and partly exported within Asia. Pre-treatments like sulphur fumigation are common to avoid decay and browning, but make the produce less suitable for international markets. Income security may be improved through enhanced fresh fruit marketability and access to more distant export markets, demanding sustainable fruit production and special quality aspects.
Depending on the markets, customers request diverse sensory qualities of dessert fruits, which differ from quality standards for fresh fruits used in processing. The required shelf life depends on distribution ways and storage times needed. Since post-harvest ripening of non-climacteric fruit is impossible, the selection of proper raw material and harvest time decision are crucial for high-quality longans.
This study was aimed at exploring the levels of utilisation-orientated quality and shelf life that are achievable through proper physiological maturity without any further post-harvest treatment.

Material and Methods

Longans cv. Daw were obtained during main harvest season 2007 from a research orchard near Lamphun in Northern Thailand. By selecting 5 harvest dates (H1-H5) relative to the usual commercial harvest time (UCH), the whole harvest period was covered. Sound fruits were harvested 10 days (H1, "unripe") and 5 days (H2, "half-ripe") before UCH, at UCH (H3, "ripe"), as well as 5 days (H4, "fully ripe") and 10 days (H5, "overripe") after UCH. Harvests were followed by sorting according to size (g/fruit) into 2 categories (A: 9.4-10.6 g; B: 11.4-13.0 g). The maturity-depending fruit quality was assessed directly after harvest. For monitoring of shelf life, all samples were stored for 21 days at 5 °C and 90% relative humidity (RH). Outer and inner quality parameters of the fruit, i.e. colour, firmness of the aril, moisture content, titratable acids (TA, as malic acid) and total soluble solids (TSS), were regularly analysed by analogy to VÁSQUEZ-CAICEDO et al. (2006). To evaluate the firmness of the peel, an Instron Universal Texture Analyser (3365, Instron Corporation, USA), equipped with a 5 mm puncture needle, was used. Respiration rates, based on gaschromatographic CO_2 quantification, and enzymatically assayed ethanol contents were included as physiological and chemical indicators of senescence and microbial decay. Shock-frozen, lyophilized peels were extracted as described by VÁSQUEZ-CAICEDO et al. (2007) for spectrophotometric analysis of polyphenoloxidase (PPO) and peroxidase (POD) activities (SCHILLING et al., 2008).

Results and Discussion

During on-tree maturation, TSS rose until UCH (H3A/B) up to a temporary maximum of 20.3 °Brix (**Figure 1a**). Since TA declined on the average (**Figure 1a**), the TSS/TA ratio accumulated from H1A/B to H4A/H5B (**Figure 1b**). The latter has therefore been recommended as maturity criterion complementing TSS (JIANG et al., 2002; TONGDEE, 1997). During storage, fruits of different ripeness differed in their rates of acid catabolism, which led to considerable increase in TSS/TA, particularly when the initial TSS/TA levels were low (**Figure 1c**).



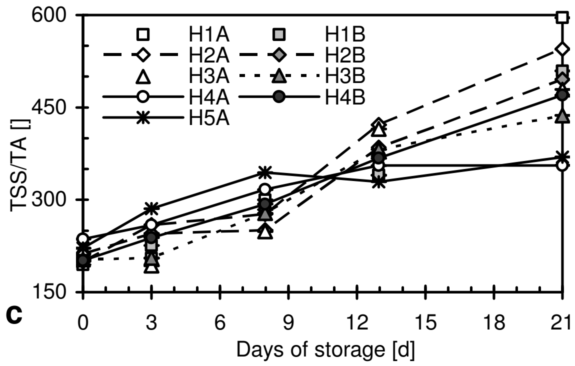


Figure 1 Maturity at harvest (**a**, **b**) and quality during storage (**c**) of longan fruits: Initial **s**ugar (TSS, CV ≤ 2.96%) and acid contents (TA, CV ≤ 4.77%) (**a**) and sugar-acid ratios (TSS/TA, CV ≤ 4.80%) (**b**) (day 0). TSS/TA (CV ≤ 6.55%) during 21 days of storage (5°C, 90% RH) (**c**). H1-5, harvest dates (5 days interval; H3: usual commercial harvest time); A-B, fruit size category.

As expected for longan fruit under cold storage (TONGDEE, 1997), fruit respiration (**Figure 2a**) declined, while passing through a slight maximum. Irrespective of the harvest date, smaller fruits (size class A) developed higher respiration rates than bigger fruits (size class B), due to their larger surface/volume ratio (S/V) (**Table 1**).

Fruits harvested post UCH (H4A-B, H5B) showed the lowest physiological activities. Acid catabolism (**Figure 1c**) and ethanol production (**Figure 2b**) were reduced in those late-harvested fruits. Hence, there was less anaerobic metabolism compared with overripe litchi fruits (PESIS et al., 2002). However, longans are extremely susceptible to microbial decay due to their strikingly high pH value > 6.5. Observed ethanol contents may thus be ascribed to microbial fermentation (**Figure 2b**). Since the unripe fruits (H1A-B, H2A-B) had thinner peels, they were less resistant to microbial infections and more prone to enhanced ethanol production.

Irrespective of harvest maturity, high perishability became evident by rapid changes in peel properties within three days of storage (**Table 1**). The thicker peels of late-harvested fruits (H4A-B, H5B) made them less susceptible to desiccation and embrittling. Longan cultivars with thick peels were reported to be more appropriate to chilled storage and transport (JIANG, 1999).

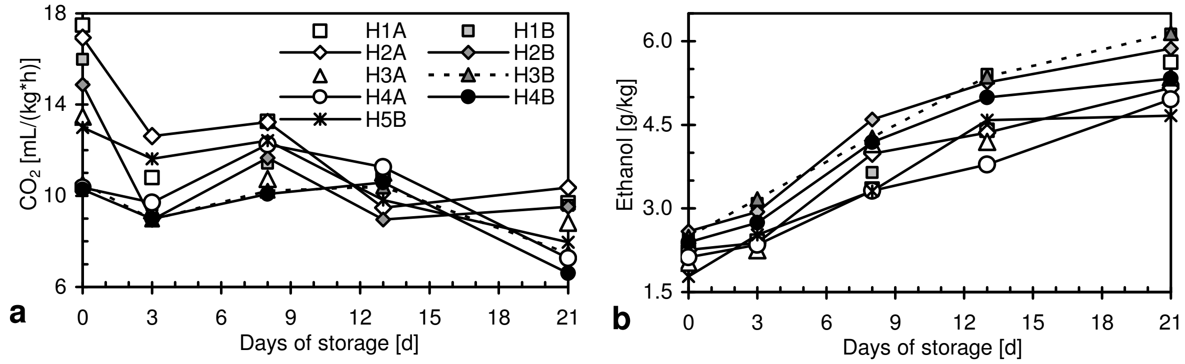


Figure 2 Respiration rates (CV ≤ 9.98%) (**a**) and ethanol contents (CV ≤ 7.78%) (**b**) of longan fruits during storage (21 days, 5°C, 90% RH); H1-H5, harvest dates; A-B, fruit sizes.

Table 1 Peel properties of longan fruits with sizes A-B from different harvests H1-H5 at days 0 and 3 of storage (5°C, 90% RH).

	S/V	**Browning[a]: a* []**		**Moisture content[b] [%]**		**Brittleness[c] [N/mm]**		**Thickness[d] [mm]**	
		Day 0	**Day 3**	**Day 0**	**Day 3**	**Day 0**	**Day 3**	**Day 0**	**Day 3**
H1A	2.46^{a}	$-0.10^{\alpha\ ab}$	$5.63^{\gamma\ ab}$	$54.15^{\alpha\ a}$	$22.05^{\beta\ b}$	$10.06^{\alpha\ a}$	$17.20^{\beta\ bc}$	$0.66^{\alpha\ bc}$	$0.34^{\beta\ c}$
H2A	2.43^{ab}	$+1.26^{\alpha\ bc}$	$5.32^{\gamma\ ab}$	$56.60^{\alpha\ a}$	$20.56^{\beta\ b}$	$8.56^{\alpha\ a}$	$18.05^{\beta\ bc}$	$0.64^{\alpha\ bc}$	$0.30^{\beta\ c}$
H3A	2.33^{abc}	$+0.80^{\alpha\ abc}$	$6.14^{\beta\ abc}$	$55.66^{\alpha\ a}$	$22.09^{\beta\ b}$	$9.47^{\alpha\ a}$	$14.64^{\alpha\beta\ abc}$	$0.71^{\alpha\ abc}$	$0.31^{\beta\ c}$
H4A	2.30^{bcd}	$-0.64^{\alpha\ a}$	$7.20^{\gamma\ cd}$	$56.34^{\alpha\ a}$	$25.17^{\beta\ ab}$	$10.20^{\alpha\ a}$	$13.44^{\alpha\beta\ ab}$	$0.80^{\alpha\ ab}$	$0.38^{\beta\ bc}$
H1B	2.29^{bcd}	$+0.05^{\alpha\ ab}$	$5.12^{\gamma\ a}$	$55.23^{\alpha\ a}$	$23.07^{\beta\ b}$	$9.89^{\alpha\ a}$	$19.37^{\beta\ c}$	$0.61^{\alpha\ c}$	$0.35^{\beta\ c}$
H2B	2.24^{dc}	$+1.21^{\alpha\ bc}$	$5.28^{\gamma\ ab}$	$57.66^{\alpha\ a}$	$25.31^{\beta\ ab}$	$8.21^{\alpha\ a}$	$14.59^{\beta\ abc}$	$0.68^{\alpha\ abc}$	$0.36^{\beta\ bc}$
H3B	2.17^{d}	$+0.77^{\alpha\ abc}$	$6.08^{\gamma\ abc}$	$54.68^{\alpha\ a}$	$22.13^{\beta\ b}$	$9.60^{\alpha\ a}$	$14.83^{\alpha\beta\ abc}$	$0.73^{\alpha\ abc}$	$0.32^{\beta\ c}$
H4B	2.17^{d}	$+0.54^{\alpha abc}$	$7.67^{\gamma\ d}$	$55.85^{\alpha\ a}$	$25.84^{\beta\ ab}$	$9.71^{\alpha\ a}$	$13.72^{\alpha\ ab}$	$0.65^{\alpha\ bc}$	$0.49^{\beta\ ab}$
H5B	2.29^{bcd}	$+2.03^{\alpha\ c}$	$6.61^{\beta\ bcd}$	$55.16^{\alpha\ a}$	$30.50^{\beta\ a}$	$7.84^{\alpha\ a}$	$11.84^{\beta\ a}$	$0.85^{\alpha\ a}$	$0.52^{\beta\ a}$

Different letters α-γ horizontally indicate significant differences due to storage, different letters a-d vertically significant differences due to harvest time and size (Tukey's standardized range (HSD) test, $\alpha = 0.05$); **S/V**: surface-volume ratio, calculated as scalene ellipsoid with callipered length, width and depth, surface approximated using Thomsen's formula modified by Cantrell (MICHON, 2008); [a] as indicated by the CIE green (-)/ red (+) colour coordinate a*; [b] determined gravimetrically after drying of the peel (105 °C, 2d); [c] as quotient of max. load and displacement at max. load by puncturing with a 0.5 cm probe; [d] calliper reading.

Rapid peel browning occurred within the first 2-3 days of storage, as indicated by the rising CIE a* value (**Table 1**). It was assumed to be more pronounced for the more mature fruits (PAULL and CHEN, 1987), as confirmed by the slightly but significantly higher a* values observed after 3 days for the peel of fruits from H4A-B and H5B. However, unlike prevalent reports (LIN et al., 2001; TIAN et al., 2002), rapid browning did not correlate with PPO activities, which were overall low (0.7-3.4 µkat/100g). Peel POD was 10-100 times more active (day 0-3), particularly when browning was fast (H4B, H5B) (**Figure 3b**). Hence, in addition to PPO, POD seems to be decisively involved in enzymatic browning of longan fruits, consistent with the reported increase in peel POD activity associated with browning of packed longan fruits stored at ambient temperature (DUAN et al., 2007). Despite considerable changes of peel characteristics, only minor alterations in colour and firmness of the aril were noted.

Conclusion

Fruits of usual commercial harvest (H3B) were preferred for local markets, because they displayed maximum TSS at harvest. Late harvest (H4A, H5B; TSS/TA ~220-240) was conducive to shelf life for distant markets because of the thicker peel as well as reduced physiological activity of the fruit and embrittling of the peel during storage. Particularly, small fruits, which realise minor prices on local markets, were most suitable, because they were less prone to fermentation. However, fast pericarp browning occurred regardless of harvest time. Thereby, the peroxidase is assumed to play an important role.

For the longan farmers, information obtained in this study makes utilisation-orientated harvest time decision more reliable. The latter may mainly be based on both TSS and TSS/TA. Current analogous studies will show to which extent this knowledge is applicable to the litchi fruit, where a lower pH is characteristic and peel colour retention is of utmost importance.

Acknowledgement

As part of the Uplands Program, this research project is funded by Deutsche Forschungsgemeinschaft (DFG), Bonn, Germany: Project SFB 564-E2.3.

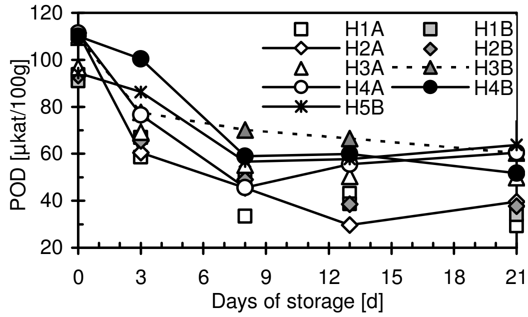


Figure 3 Peroxidase activities (POD) (CV ≤ 15.38%) of longan fruits during storage (21 days, 5°C, 90% RH); H1-H5, harvest dates; A-B, fruit sizes.

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