CHARACTERIZATION OF RAMBUTAN (*Nephelium lappaceum*) FRUITS FROM OUTSTANDING MEXICAN SELECTIONS[1]

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ABSTRACT - Fruits of five regional selections of rambutan (*Nephelium lappaceum* L.) were characterized to identify those with international marketing quality to promote their propagation in Mexico, improvement and conservation in germoplasm bank. The fruits were harvested in June, July, and August 2008 and, after each harvest, were assessed for shape (length/diameter), firmness, fruit weight, number of fruits per kilogram, weight and percentage of pericarp, seed and aril, total soluble solids, total sugars, vitamin C content, pH, and titratable acidity. In addition, a sensorial evaluation was carried out with 31 panelists who graded each selection for color, sweetness, and acidity. Fruits of five selections were ovoid, and with the following characteristics: firmness values from 43.7 to 51.0 N, fruit weight ranged from 22.4 to 34.7 g, registering from 28.9 to 45.0 fruits per kg; pericarp weight from 10.5 to 17.3 g (45.9 to 49.9% of the total fruit weight); total seed weight from 2.2 to 2.5 g (7.0 to 10.0%); average arils weight from 8.9 to 13.1 g (37.5 to 41.4%). The fruits had high contents of total soluble solids (17.8 to 20.4 ºBrix), total sugars (211.95 to 242.70 mg/100g in the edible portion), vitamin C (37.9 to 69.1 mg/100 g), pH 5.0, and titratable acidity of 0.20 to 0.28%. The fruits from the RT-01 and RT-05 selections had better attributes in fruit weight, total soluble solids and titratable acidity and were better accepted by the panelists. Harvest date significantly affects rambutan fruit quality; at the middle and end of the season harvested fruits had better qualitative characteristics for the marketing.
Index terms: Tropical fruit, *Sapindaceae*, quality attributes, sensory evaluation.

CARACTERIZAÇÃO DE FRUTOS RAMBUTAN (*Nephelium lappaceum*) DE NOTÁVEIS SELEÇÕES MEXICANAS

RESUMO - Frutos de cinco seleções de rambutan (RT-01, RT-02, RT-03, RT-04 e RT-05) foram caracterizados para identificar aqueles com qualidade internacional e selecionar os melhores para aumentar a produção no México, o melhoramento e a conservação no banco de germoplasma. Os frutos foram colhidos nos meses de junho, julho e agosto de 2008. Em cada colheita, avaliaram-se a forma (largura/diâmetro), firmeza, peso do fruto, número de frutos por quilograma, peso e porcentagem do pericarpo, semente e arilo, sólidos solúveis totais, açúcares totais, conteúdo de vitamina C, pH, acidez titulável e foi feita uma avaliação sensorial com 31 provadores, qualificando a cor, forma, doçura e acidez de cada amostra. Os frutos das cinco seleções tiveram forma alargada ou oval, com valores de firmeza de 43,7 a 51,0 N, o peso de cada fruto oscilou entre 22,4 a 34,7g, registrando de 28,9 a 45,0 frutos por quilograma, com um peso de pericarpo de 10,5 a 17,5 g, que correspondeu de 45,9 a 49,9% do peso do fruto. O peso da semente foi de 2,2 a 2,5g (7,0 a 10,0%), o peso médio do arilo foi de 8,9 a 13,1g, equivalentes a 37,5 41,4%. Os frutos apresentaram alto conteúdo de sólidos solúveis totais (17,8 a 20,7 °Brix), açúcares totais (400 a 465,7 mg/100g), vitamina C (37,9 a 69,1 mg/100g de porção comestível), baixo pH (5,0) e elevada acidez titulável (0,7 a 0,8%). Os frutos das amostras RT-01 e RT-05 apresentaram melhores atributos quanto a peso do fruto, sólidos solúveis totais e acidez titulável, características desejáveis para exportação, além de ser de melhor aceitação pelos provadores. A data da colheita influenciou significativamente na qualidade dos frutos, e na metade e ao final da temporada da colheita houve frutos de maior peso, porcentagem de arilo, sólidos solúveis totais, vitamina C, menor pH e acidez titulável.
Termos para indexação: Frutas tropicais, *Sapindaceae*, qualidade, atributos, avaliação sensorial.

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INTRODUCTION

Rambutan (*Nephelium lappaceum* L.) is a tropical fruit belonging to the *Sapindaceae* family. The fruits are ovoid, with a red or yellow pericarp covered with soft spines that vary in coloring from green, yellow and red. They possess an edible aril (rich in vitamin C) that is white or translucent, sweet and juicy and clings to the testa seed (NAKASONE; PAULL, 1998; SMITH *et al.*, 1992; WALL, 2006). This exotic fruit, grown in Mexico, is originally from Malaysia and Indonesia, but its cultivation has extended to the Philippines, Singapore, Thailand, Vietnam, India, Syria, Zaire, South Africa, Madagascar, and Australia (SMITH *et al.*, 1992; TINDALL, 1994).

For the consumer, the fundamental attributes of fruit quality are its visual aspect (size, color, shine, shape, texture, firmness, absence of defects), aroma, and content of nutrients, vitamins and minerals, among others (WILLS *et al.*, 1981; KADER, 2001). Rambutan fruit should satisfy the following requirements to be considered of international quality: uniform red color; free of lesions, insects and diseases; clean; weight above 30 g; spines no longer than 1 cm; thick, firm aril that readily separates from the seed, and a total soluble solid content of 16 to 18% (LANDRIGAN *et al.*, 1996; KADER, 2006). Fruits can be classified in the Category 'extra' if they are of superior quality, in Category I if they are of good quality but with some defects and Category II if they satisfy only the minimum requirements established in the Codex Norm for Rambutan 246-2005 (CODEX ALIMENTARIUS, 2008).

Rambutan varieties from Malaysia and Indonesia were introduced in Mexico in the 1950s (FRAIRE, 2001). In Mexico, rambutan was reproduced by seed, and actually there are selections that have good production and quality for marketing. These selections are few and should be promoted and propagated by graft (PEREZ and POHLAN, 2004). The present study was conducted to characterize the fruits of five outstanding rambutan selections by evaluating physical and biochemical parameters, which confer attractive properties for the domestic and international consumer.

MATERIALS AND METHODS

The fruits of rambutan (*Nephelium lappaceum* L.) used were obtained of tree propagated by seed, which were selected among four orchards because of the high quality fruits. These were from six-year-old orchards in the state of Chiapas, on three dates during June, July, and August, 2008. The experimental unit consisted of six fruits, and four replications per selection and harvest date. The fruits were harvested at eating ripeness, when they had red coloring. Later, they were chosen by uniform size and color. They were placed in plastic bags and transported (20 ± 2°C) to the laboratory of Fruit Physiology at the Universidad Autonoma Chapingo.

Pericarp resistance (N) to penetration was measured using a penetrometer (Mecmesin CE 200 N) with a conical probe. After, each fruit was weighed and later divided into its components (pericarp, aril, and seed) to be weighed separately on a digital balance. The percentage of each of the fruit components relative to total fruit weight was estimated.

Total soluble solids (ºBrix) content was determined by each fruit with an ATAGO-Pelete PR-101 digital refractometer. Total sugars were quantified in a UNICO 1100RS spectrophotometer at 630 nm (WITHAM *et al*., 1971).

Vitamin C was determined by titration with a 0.01% Tillman solution (AOAC, 1990). Titratable acidity was determined by titration with NaOH 0.1 N on the basis of malic (AOAC, 1990). PH was measured directly with a Hanna HI 8314 digital potentiometer.

A sensorial evaluation of each selection was conducted during first harvest with 31 panelists. The variables analyzed were color, shape, sweetness, and acidity, each of which was graded using a scale of 1 = poor, 2 = average, 3 = good, and 4 = excellent.

Statistical analysis

The data were analyzed using a complete random bi-factorial design. An analysis of variance was performed with the general linear model (GLM) and means were compared with the Tukey test with a level of significance of 0.05 using SAS (SAS INSTITUTE, 1999). The data of the sensorial analysis were transformed to ranges using Minitab statistical software and analysis of variance in a complete random design, considering the 31 panelists as replications and the selections as treatments.

RESULTS AND DISCUSSION

It is known that variability among rambutan trees is high because of crossed pollination and propagation by seed, numerous cultivars have been selected by the growers for its high yield and fruit quality (SMITH *et al.*, 1992); however, these selec-

tions have been adapted to specific conditions and thus can behave differently in other environments and harvest dates. Although there are numerous cultivars and selections worldwide, their behavior and adaptation to regions of productive potential in each country should be studied.

In general, rambutan fruits vary widely in their physical characteristics. In our study, all of the selections (RT-01, RT-02, RT-03, RT-04 and RT-05) had oblong or ovoid shape fruits. This shape is a characteristic presented in the most of the Asiatic cultivars (HIRANPRADIT *et al.*, 1992). Also, significant differences ($P \leq 0.05$) were found among the selections for the variables firmness, fruit weight and number of fruits per kg (Table 1). The selections RT-01, RT-04 and RT-05 were firmer, with values from 47.5 to 51.0 N probably due to the turgidity of the pericarp as well as to the number, shape and length of the spines, which differ from variety to variety.

Individual fruit weight reported for rambutan is 20 to 60 g (PAULL; CHEN, 1987; DE ANDRADE *et al.*, 2008). However, the international market recommends 30 g for the categories 'extra' and I (KADER, 2006; CODEX ALIMENTARIUS, 2008), and the widely cultivated cultivars 'Rong Rien' and 'See-Chompoo' from Thailand produce from 25 to 32 fruits per kg (HIRANPRADIT *et al.*, 1992). Our results show that Mexican selections compare favorably with these references. Among the selections studied, the heaviest fruits (34.7 g) were produced by the RT-01 selection, resulting in 29 fruits per kg; thus, the RT-01 and RT-05 selections, with 32.1 g average weight per fruit, satisfy this requirement for selection and classification in these categories, while the remaining selections were classed in category II. Selections RT-01 and RT-02 produce fruits that, in terms of weight as well as their bright red color, can be classified in the category 'extra' and category I of the Codex Alimentarius.

The most desirable chemical characteristics for fresh rambutan are 16% total soluble solids, low acidity (0.3%) and vitamin C content of 70 mg/100 g of flesh as quality parameters and harvest index (KADER, 2006; CODEX ALIMENTARIUS, 2008). In our study, the selections RT-01 and RT-05 have high total soluble solids contents (20.4 and 20.9 °Brix) significantly different from RT-02, RT-03 and RT-04 (Table 1). It has been observed that the content of total soluble solids in rambutan varies from 16.9 to 21.0 °Brix in different varieties, environment conditions, harvest dates and years (KETSA; KLAEWKASETKORN, 1992; WALL, 2006). For example, in selections from Brazil, the total soluble solids are from 8.0 to 19.5% (DE ANDRADE *et al.*, 2008).

Significant differences were observed in total sugars, selections RT-01, RT-03 and RT-05 had high content (227.6 to 242.7 mg/100 g) significantly different from RT-02 and RT-04 (211.9 and 207.3 mg/100g) (Table 2). In other hand, average pH was 5.0 for all the selections (non-shown data).

The content of ascorbic acid in others *Sapindaceae* is relatively high; in longan levels from 55.3 to 63.3 mg/100 g are found, in litchi from 27.6 to 33.2 mg/100 g, while the rambutan varieties 'Jitlee', 'R162' and 'Rong Rien' the vitamin C content is from 22.0 to 47.8 mg/100 g of pulp (WALL, 2006). Among our selected varieties, four of the five selections had higher vitamin C content than the above references, and RT-01 and RT-03 had the highest quantity with 67.9 and 69.1 mg/100 g. Also, titratable acidity in our selections is similar to levels found in "Rong Rien" with 0.25 – 0.29% (KETSA; KLAEWKASETKORN, 1992). While significant differences in titratable acidity were found among the studied selections; a maximum of 0.28% in RT-05 and a minimum of 0.20% in RT-03 were determined (Table 1).

For weight and percentage of the fruit components (pericarp, seed and aril, or edible portion) there were significant differences ($P \leq 0.05$) among selections (Table 2). The selection RT-01 had the highest weight and percentage of pericarp (17.3 g or 49.4%). Seed weight was not significantly different among the selections with an average of 2.3 to 2.5 g, but RT-03 had the smallest seeds. The highest aril weight (12.2 to 13.1 g) was found in the selections RT-01, RT-04 and RT-05; however, the largest edible portion was found in RT-03, RT-04 and RT-05 (40.2 to 41.4%), while RT-01 and RT-02 had the lowest percentage of aril. The cultivar 'Rong Rien', one of the best known and most cultivated in Thailand has an aril, or edible portion, that makes up 30 to 50% of the entire fruit (PAULL; CHEN, 1987), some others in Brazil have up 18 to 50% (DE ANDRADE *et al.*, 2008).

In the sensory analysis, the selection RT-03 had the most attractive color to the panelists. For fruit shape, there was no difference. The selection RT-01 was preferred because of its greater sweetness, while did not have differences among the other selections. The selection RT-03 was qualified with the lowest acidity. In the ease of detachment of the testa seed and aril, there were no differences between the selections (Fig. 1). Summarizing, our selections have both physical and chemical characteristics that place them among the most widely accepted varieties in the world. Three selections (RT-01, RT-03 and RT-05) satisfy international physical quality requirements

and almost all are sweeter, equally acid and have higher vitamin C content. In addition, the selections were well-accepted by a panel because their sweetness, low acidity and better in appearance for their color.

In Mexico, rambutan fructification and harvest periods is concentrated in June, July and August (FRAIRE, 2001). Differences in fruit quality and nutrient of the selections content were found among different harvest dates. The fruits with greater weight (43.6 to 49.3 g) and thus the smaller number of fruits per kilogram (20.3 to 23.8) were in the RT-02 selection in the three harvest dates, while other selections had greater variability among harvest dates. The higher content of acidity was determined in the selection RT-01 from the first harvest and in the selections RT-01, RT-02 and RT-05 of the second harvest. Also, the higher content of vitamin C was determined in the selections RT-01 and RT-03 (85.3 to 86.5 mg/100 g) in the middle harvest and in all selections in the last harvest (84.1 to 85.3 mg/100g) except in the selection RT-02 (Table 3).

Moreover, the fruits of selections RT-01 and RT-05 had the same pericarp weight (16.2 to 17.8 g) in the three harvests. However, practically did not have difference in the percentage of pericarp among selections nor the three harvest dates. So, the highest weight (2.9 to 3.1 g) and percentage of seed (12.0 to 12.7 g) occurred at the beginning of the production season, in June, while the highest weight (14.0 to 15.9 g) and percentage of aril (42.5 to 45.1 %) was recorded in intermediate harvest (July) and at the end of August. While the highest total sugar contents (238.8 to 265.8 mg/100 g) were founded in the middle harvest in June in al selections except in RT-04 (Table 4). The pH (4.6 to 5.5) was statistically the same in all the selections during the three harvests (non-shown data). Differences were observed in the chemical composition of the fruits harvested on different dates, coinciding with the report of Ketsa and Klaewkasetkorn (1992) for the variety 'Rong Rien', suggesting that the harvest date affects fruit size and quality.

The results of our study identified selections that compare favorably with other species of *Sapindaceae* and recognized rambutan varieties around the world, and thus are marketable under international standards.

TABLE 1 - Firmness, fruit weight, number of fruits per kilogram, total soluble solids (TSS), titratable acidity and vitamin C content of five selections of rambutan (*Nephelium lappaceum* L.). Chiapas, México, 2008.

Selection	Firmness (Nw)	Fruit weight (g)	Fruits per kilogram	Total soluble solids (°Brix)	Titratable acidity (%)	Vitamin C (mg/100 g)
RT-01	48.4a*	34.7a	28.9d	20.4a*	0.27a	67.9a
RT-02	46.7b	22.4e	45.0a	18.0b	0.22b	37.9d
RT-03	43.7b	25.6d	39.7b	17.9b	0.20b	69.1a
RT-04	47.5a	29.7c	34.0c	17.8b	0.24a	54.1c
RT-05	51.0a	32.1b	32.1c	20.9a	0.28a	62.3b

*Means with the same letter in each column were not significantly different (P≤0,05).

TABLE 2 - Weight of pericarp, aril, seed, their percentages and total sugars content of five selections of rambutan (*Nephelium lappaceum* L.). Chiapas, México, 2008.

Selection	Pericarp weight (g)	% pericarp	Seed weight (g)	% seed	Aril weight (g)	% aril	Total sugars (mg/100 g)
RT-01	17.3a*	49.9a	2.4a	7.0c	13.0a	37.5c	227.6a
RT-02	10.5e	46.9b	2.3a	10.0a	8.9c	39.8b	211.9b
RT-03	11.7d	45.9b	2.2b	8.7b	10.7b	41.4a	229.4a
RT-04	13.9c	46.7b	2.5a	8.5b	12.2a	40.7a	207.3b
RT-05	15.4b	48.0a	2.4a	7.6c	13.1a	40.2a	242.7a

*Means with the same letter in each column were not significantly different (P≤0.05).

TABLE 3 - Effect of harvesting date on the firmness, fruit weight, number of fruits per kilogram, total soluble solids (TSS), titratable acidity and vitamin C content of five selections of rambutan (*Nephelium lappaceum* L.). Chiapas, México, 2008.

Harvest Season	Selection	Firmness (Nw)	Fruit weight (g)	Fruits per kilogram	TSS (°Brix)	Titratable acidity (%)	Vitamin C (mg/100 g)
Early	RT-01	43.7a	29.2d	34.2a	19.8b	0.6b	34.3d
	RT-02	41.8b	42.0b	23.8c	16.9c	0.6b	34.3d
	RT-03	44.3a	45.1a	22.3c	16.0d	0.6b	35.5c
	RT-04	44.4a	36.1b	27.8b	16.4c	0.7b	37.8c
	RT-05	49.4a	36.2b	27.7b	18.0c	1.1a	48.5b
Middle	RT-01	50.4a	27.9d	35.9a	19.3b	0.8a	85.3a
	RT-02	48.0a	43.6a	23.1c	18.7b	0.8a	41.4c
	RT-03	39.8b	38.4b	26.2b	18.5b	0.4b	86.5a
	RT-04	47.7a	35.8b	27.9b	17.2c	0.7b	39.0c
	RT-05	51.9a	30.3c	33.0a	22.3a	0.8a	54.4b
Latest	RT-01	51.2a	29.6c	33.9a	22.0a	0.7b	84.1a
	RT-02	50.2a	49.3a	20.3c	18.4b	0.6b	37.8c
	RT-03	46.9a	35.6c	28.1b	19.3b	0.6b	85.3a
	RT-04	50.3a	30.1c	33.3a	19.9b	0.7b	85.3a
	RT-05	51.7a	28.2d	35.5a	22.4a	0.6b	84.1a

*Means with the same letter in each column were not significantly different (P≤0.05).

TABLE 4 - Effect of harvesting date on the weight of pericarp, aril, seed, their percentages and total sugars content of five selections of rambutan (*Nephelium lappaceum* L.). Chiapas, México, 2008.

Harvest	Selection	Pericarp weight (g)	Pericarp (%)	Seed weight (g)	Seed (%)	Aril weight (g)	Aril (%)	Total sugars (mg/100g)
Early	RT-01	17,2a	50,2a	3,1a	9,0c	10,8c	31,7d	227,2a
	RT-02	10,5d	44,1b	3,0a	12,7a	7,9d	33,6c	203,3b
	RT-03	10,5d	47,2a	2,7b	12,0a	7,7d	34,6c	193,2b
	RT-04	12,8c	46,2a	3,1a	11,2b	9,3c	33,4c	182,3b
	RT-05	16,5a	48,6a	2,9a	10,4b	9,2c	33,2c	225,7a
Middle	RT-01	17,8a	49,4a	2,2c	6,3d	13,8b	38,4b	242,4a
	RT-02	10,8d	47,2a	2,0b	8,7c	10,4c	45,1a	236,8a
	RT-03	11,6c	44,4b	1,9d	7,4d	11,8b	45,0a	265,8a
	RT-04	13,1c	46,9a	2,2c	8,0c	12,3b	44,0a	208,2b
	RT-05	16,2a	49,3a	2,0c	6,2d	14,0a	42,5a	238,8a
Latest	RT-01	17,0a	50,0a	2,0d	5,8e	14,4a	42,4a	213,3b
	RT-02	10,0d	49,3a	1,7d	8,5c	8,3d	40,7b	195,7b
	RT-03	13,0c	46,2a	1,9d	6,7d	12,5b	44,4a	229,3b
	RT-04	15,6b	47,0a	2,1c	6,3d	14,9a	44,7a	231,4a
	RT-05	16,4a	46,0a	2,2c	6,1d	15,9a	44,7a	263,6a

*Means with the same letter in each column were not significantly different (P≤0,05).

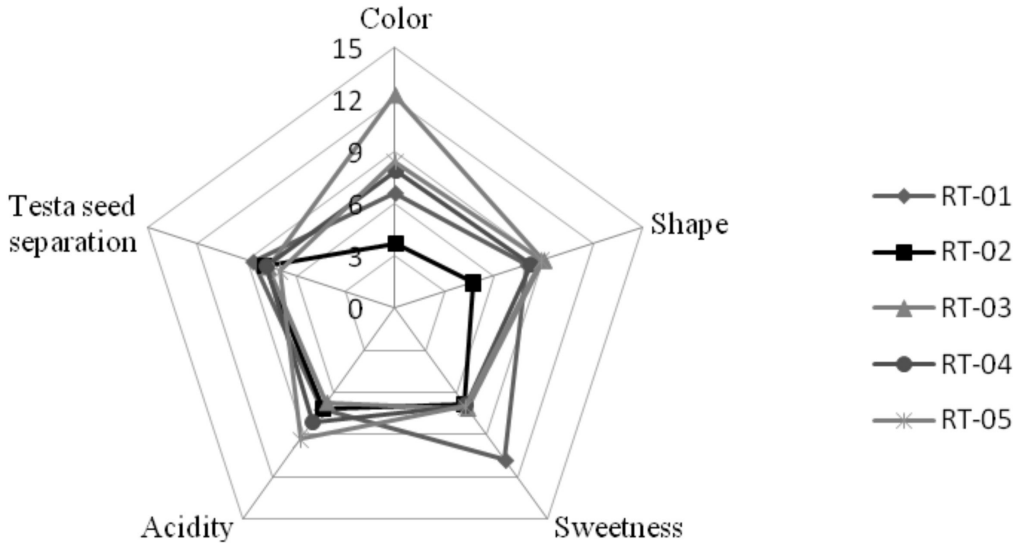

FIGURA 1- Sensory profiles of five rambutan selections from Chiapas state, Mexico.

CONCLUSION

The selections of rambutan considered in our study are only a few of those that grow in Mexico, since each grower has selected and propagated the best of his trees. Our study has identified two selections that produce fruits of international quality. Selections RT-01 and RT-05 exhibited the best attributes of fruit weight, total soluble solids and titratable acidity, desirable traits for export fruit. The selections RT-01, RT-03 and RT-05 were the most attractive for panelists because they were sweeter, less acid and had better appearance. Harvest date has a significant influence on rambutan fruit quality; harvest at the middle and end of the season produced heavier fruits with larger percentage of aril, total soluble solids, total sugars, vitamin C, lower pH and titratable acid. It is necessary to do further research to evaluate and determine the real productive and domestic and international marketing potential of rambutan.

REFERENCES

AOAC. **Official methods of analysis.** Washington: Association of Official Analytical Chemist, 1990. 1191 p.

CODEX ALIMENTARIOUS. **Standard for Rambutan 246-005.** 2005. Disponível em: <http://www.codexalimentarius.net/web/standard_list.do?lang=en>. Acesso em: 05 jan. 2009.

CRANE, J.; ZEE, F.; BENDER, G.; FABER, B.; BRUNNER, B.; CHIA, C. Commercial Sapindaceus fruit production. **Acta Horticulture**, Wageningen, v. 665, p.93-101. 2005.

DE ANDRADE, R. A.; DE MACEDO, L. E.; GERALDO, M. A.; DE PAULA, R. C.; PITTA, J. J.; Caracterização morfológica e química de frutos de rambután. **Revista Brasileira de Fruticultura,** Jaboticabal, v. 30, n. 4, p.958-963. 2008.

FRAIRE, V. **El rambutan: alternativa para la producción frutícola del trópico húmedo de México.** Chiapas: INIFAP, 2001. 41 p. (Folleto, 1).

HIRANPRADIT, H.; PAIBOONRAT, P., CHANDRAPARNIK, S., JANTRAJOO, S. Quality standardization of rambutan (*Nephelium lappaceum* L.). **Acta Horticulture**, Wageningen, v. 321, p. 708-712, 1992.

HUANG, X.; HUANG, H.; GAO, A.; XIAO, Z. Production of rambutan in China. **Acta Horticulture**, Wageningen, v. 665, p. 73-79, 2005.

KADER, A. Quality assurance of harvested horticultural perishables. **Acta Horticulture**, Wageningen, v. 553, p. 51-55, 2001.

KADER, A. **Rambutan:** recommendations for maintaining postharvest quality**.** Disponível em: <http://postharvest.ucdavis.edu/Produce/ProduceFacts/Fruit/rambutan.html>. Acesso em: 18 fev. 2009.

KETSA, S.; KLAEWKASETKORN, O. Postharvest quality and losses of "Rongrein" rambutan fruits in markets. **Acta Horticulture**, Wageningen, vol. 321, p. 771-777, 1992.

LANDRIGAN, M.; SARAFIS, V.; MORRIS, S.; MCGLASSON, W. Structural aspects of rambutan (*Nephelium lappaceum*) fruits and their relation to postharvest browning. **Journal of Horticultural Science**, Alexandria, v. 69, n. 3, p. 571-579, 1994.

LANDRIGAN, M. L.; MORRIS, S. C.; MCGLASSON, W. B. Postharvest browning of rambutan a consequence of water loss. **Journal of the American Society for Horticultural Science,** Alexandria, v.121, n.4, p. 730-734, 1996.

LEE, S. K.; KADER, A. A. Preharvest and postharvest factors influencing vitamin C content of crops. **Postharvest Biology and Technology**, Amsterdan, v.20, p.207-220, 2000.

NAKASONE, H.; PAULL, R. **Tropical fruits.** New York: CAB International, 1998. 445 p.

PAULL, R. E.; CHEN, N. J. Changes in longan and rambutan during postharvest storage. **Hortscience**, Alexandria, v. 22, n. 6, p. 1303-1304, 1987.

PEREZ R. A.; A. POHLAN. Practicas de cosecha y postcosecha del rambutan en el Soconusco, Chiapas, México. **LEISA Revista de Agroecología,** Lima, v.20, n.3, p.1-5, 2004.

SAS INSTITUTE. **SAS system for Windows: v**ersion 8. Cary: SAS Institute, 1999.

SMITH, N. J.; WILLIAMS, J. T.; PUCKNETT, D. L.; TALBOT, J. P. **Tropical forests and their crops.** Ithaca: Cornell University Press, 1992. 568 p.

TINDALL, H. D. **Rambutan cultivation.** Roma: FAO, 1994. 163 p.

WALL, M. M. Ascorbic acid and mineral composition of longan (*Dimocarpus longan*), lychee (*Litchi chinensis*) and rambutan (*Nephelium lappaceum*) cultivars grown in Hawaii. **Journal of Food Composition and Analysis**, San Diego, v. 19, p. 655-663, 2006.

WILLS, R. B.; LEE, T. H.; GRAHAM, D.; MCGLASSON W. B.; HALL E. **Postharvest:** an introduction to the physiology and handling of fruits and vegetables**.** Oxford: AVI Publishing Company, 1981. 161 p.

WITHAM, F. H.; BLAYDER, D. F.; DEVLIN, R. M. **Experiments in plant physiology**. New York: Van Nostrand, 1971. 245 p.