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Quality Dynamics of
Fruits and Vegetables in the
Post-Harvest Phase

Abstracts of Seminar Contributions

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The impact of pectin and pectic enzymes on the quality of fruit and vegetable products

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Pectin and pectic enzymes are widely present in fruit and vegetable Tissues. They play an important role on the texture quality of fresh and processed products. During ripening process both Pectinesterase and polygalacturonase are responsible of the softening reaction making the fresh fruits ready for consumption. However, during postharvest they may cause under certain conditions progressive tissue softening, thus negatively affecting the quality and shelf life of the fresh produce. Preservation of fruits and vegetables by canning and freezing can cause loss of texture quality due to acid hydrolysis of pectin and damage of ordered cell wall structure, respectively. The modification of pectin in the cell wall by native pectinesterase, before preservation, can help in improving the texture quality of fruit and vegetable products. Moreover, processing of orange, apple and tomato juices is affected to great extent by the nature of the cell wall pectic substances and the activity of the pectic enzymes. Fruit Juice clarification (desirable or undiserable) as well as the method of processing (hot or cold break) are governed by the changes in the nature of the cell wall pectin.

Inter relationship of some lai (*Durio kutejensis* Hassk.Becc.) cultivars originated from Indonesia, based on fruit morphology, nutrition content, and sensory test

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Lai is kind of fruit, which is originated from East Kalimantan Province, Indonesia. We found that some different cultivars of Lai were cultivated by farmers in Batuah Subdistrict of Kutai Kartanegara Regency. According to sensory evaluation of the fruit flesh and morphological characteristic of the fruit, we found that the cultivars have different respond and characteristic. In this report, we described inter-relationship between the cultivars using cluster analysis based on morphological characteristic, nutritional content and sensory test. The fruits observed were harvested as they were commercially ripe and were kept for three days to get the ripen fruits. Based on fruit morphology, it was found that there were varieties among the observed Lai cultivars, except on number of its segments. The most significant similarity of morphological characteristics was found between Lai Hijau and Lai Semangka, which was about 44.1%. Based on nutritional content, it revealed that the most significant similarity was found between Lai Hijau, Lai Durian, Lai Belimbing and Lai Semangka of about 34.6%. Based on sensory test, the closest similarity was found between Lai Nangka and Lai Kuning of about 45.1%. The cluster analysis based on combine characteristics of nutritional content and sensory test showed that the closest similarity of the cultivars of about 25.6% was found between Lai Durian and Lai Belimbing.

ORAL PRESENTATION

INTER RELATIONSHIP OF SOME LAI (*Durio kutejensis* Hassk.Becc.) CULTIVARS ORIGINATED FROM INDONESIA, BASED ON FRUIT MORPHOLOGY AND NUTRITION CONTENT

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Abstract

Lai is kind of fruit, which is originated from East Kalimantan Province, Indonesia. We found that some different cultivars of Lai were cultivated by farmers in Batuah Subdistrict of Kutai Kartanegara Regency. According to sensory evaluation of the fruit flesh and morphological characteristic of the fruit, we found that the cultivars have different respond and characteristic. In this report, we described inter-relationship between the cultivars using cluster analysis based on morphological characteristic, nutritional content and sensory test. The fruits observed were harvested as they were commercially ripe and were kept for three days to get the ripen fruits. Based on fruit morphology, it was found that there were varieties among the observed Lai cultivars, except on number of its segments. The most significant similarity of morphological characteristics was found between Lai Hijau and Lai Semangka, which was about 44.1%. Based on nutritional content, it revealed that the most significant similarity was found between Lai Hijau, Lai Durian, Lai Belimbing and Lai Semangka of about 34.6%.

Keywords: Lai, *Durio kutejensis*, nutritional content, sensory test, cluster analysis

INTRODUCTION

There are at least six varieties of durian found in East Kalimantan, Durian (*D. zibethinus*), Lai (*D. kutejensis*), Kerantongan (*D. oxleyanus*), Lahong (*D. dulcis*), Labelak (*D. graveolens*), Durian Monyet (*D. grandilorus*), and Durian Kura-kura (*D. testudinarum*). Among the six varieties of durian, only the first two durians stated above have recognized economic value, however Lai fruit is not well known yet outside East Kalimantan compare to Durian (*D. zibethinus*) (Bernardinus, 2002; M Nipan, 2002). The answer of this fact is because Lai is a specific fruit which is found only in East Kalimantan and there is still limited technology to transfer the fruits outside East Kalimantan.

Lai is indigenous fruit and wide spread in East Kalimantan Province of Indonesia. There are many cultivars of Lai, which are different in fruit morphology and flesh type. More and more cultivars were found nowadays, and many of them were already cultivated. In Batuah Sub-district of Kutai Kartanegara Regency we found at least seven cultivars. In this report we described inter relationship among seven Lai cultivars based on morphological characteristics, nutrition content, and sensory characteristics. The seven Lai cultivars were selected according to fact that the Lai have higher economical value among the Lai cultivars found in the area.

MATERIAL AND METHODS

Lai fruits were harvested as they were commercially ripe and were kept for three days to get the ripen fruits. Seven cultivars of Lai fruit from Batuah Subdistrict of Kutai Kartanegara Regency were observed, each with three replications for morphological characteristics and nutrient content assay, and thirty replications for sensory characteristics. The chemical reagents from Merck and Riedel Haen were used in this experiment. Sixteen parameters were applied for morphological characteristics, e.g. fruit diameter, fruit form, fruit weight, fruit length, ripe fruit color, fruit husk thorn, fruit husk thick, fruit cleavability, number of fruit *juring*, number of *pongge* per *juring*, fruit flesh weight per *pongge*, fruit flesh thick, fruit flesh color, seed form, seed color, seed weight. Eight parameters were observed for nutrient content e.g. water content (oven), ash (muffle furnace), fat (soxhlet), protein (semi-micro Kjeldahl), vitamin C (iodometry), sugar content (hand refractometer), carbohydrate (by different), and fiber (gravimetry). All of the methods used for nutrient content analysis were according to Sudarmadji *et al*., 1997). Data were analyzed by cluster analysis according to Andenberg (1973) using Systat version 7.

RESULTS AND DISCUSSIONS

Inter Relationship Based on Morphological Characteristics

The morphological characteristics of seven Lai cultivars observed were shown in Table 1 for the fruit morphological parameters and in Table 3 for the *pongge* morphological parameters, while the analyzed data were shown in Table 2 and 4, respectively. The average of fruit diameter, fruit weight, fruit length, and fruit husk thick were 48.49 cm, 1.29 kg, 16.83 cm, and 0.71 cm, respectively. The average of flesh fruit thick, seed weight, flesh fruit weight per *pongge*, and number of *pongge* were 0.64 cm, 13.71 g, 25.46 g, and 2-6, respectively. From this data, it could be calculated that the weight of flesh fruit of the Lai cultivars cultivated by farmers in Batuah Sub-district is around 254.6-763.8 g per 1,290 g of fruit weight, it refers to about 20-60%.

Table 1. Fruit morphological characteristics of 7 Lai cultivars from Batuah Sub-district of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Fruit diameter (cm)	Fruit weight (kg)	Fruit length (cm)	Fruit husk thick (cm)	Fruit form	Ripe fruit color	Fruit thorn husk	Fruit cleavability
Lai Hijau	48.80	1.36	14.80	0.63	RR	G	SC	RDC
Lai Belimbing	49.30	1.26	18.20	0.63	O	Y	SC	EC
Lai Semangka	45.90	1.11	14.50	0.60	RR	YG	SC	REC
Lai Durian	45.80	1.36	18.50	0.87	LC	Y	SC	EC
Lai Besar	51.20	1.57	19.00	0.70	O	Y	SBR	EC
Lai Nangka	49.10	1.17	17.40	0.80	O	YG	SBR	EC
Lai Kuning	49.30	1.18	15.40	0.77	RC	DY	SBR	EC
Average	48.49	1.29	16.83	0.71				

Note: Data were calculated from 3 replications, *Hijau* = green; *Belimbing* = starfruit; *Semangka* = water melon; *Besar* = big; *Nangka* = jackfruit; *Kuning* = yellow.

Table 2. Score of morphological fruit characteristics parameters of the Lai cultivars for cluster analysis based on morphological characteristics

Lai cultivars	Fruit diameter	Fruit weight	Fruit length	Fruit husk thick	Fruit form	Ripe fruit color	Fruit thorn husk	Fruit cleavability
Lai Hijau	4	3	2	3	1	1	2	2
Lai Belimbing	4	3	3	3	3	3	2	4
Lai Semangka	4	3	2	3	1	2	2	3
Lai Durian	4	3	3	4	5	3	2	4
Lai Besar	5	4	3	3	3	3	4	4
Lai Nangka	4	3	3	4	3	2	4	4
Lai Kuning	4	3	3	4	1	4	4	4

Note:

Fruit diameter
1 = Very Small (VS) (≤ 20,00 cm)
2 = Small (S) (20.01-31.00 cm)
3 = Medium (M) (31.01-40.00 cm)
4 = Big (B) (40.01-50.00 cm)
5 = Very Big (VB) (> 50.00 cm)

Fruit weight
1 = Very Light (VL) (≤ 0.50 kg)
2 = Light (L) (0.50-1.00 kg)
3 = Medium (M) (1.00-1.50 kg)
4 = Heavy (H) (1.50-2.00 kg)
5 = Very Heavy (VH) (> 2.00 kg)

Fruit length
1 = Very Small (VS) (< 10,00 cm)
2 = Small (S) (10,10-15,00 cm
3 = Medium (M) (15,10-20,00 cm)
4 = Big (B) (20,10-25,00 cm)
5 = Very Big (VB) (> 25,00 cm)

Fruit husk thick
1 = Very Thin (VT) (≤ 0.25 cm)
2 = Thin (T) (0.25-0.50 cm)
3 = Medium (M) (0.51-0.75 cm)
4 = Thick (T) (0.76-1.00 cm)
5 = Very Thick (VT) (> 1.00 cm)

Fruit form
1 = Rather Circular (RR)
2 = Circular (C)
3 = Oval (O)
4 = Ellipse (E)
5 = Long circular (LC)

Ripe fruit color
1 = Green (G)
2 = Yellowish Green (YG)
3 = Yellow (Y)
4 = Dark Yellow (DY)
5 = Reddish Yellow (RY)

Fruit husk form
1 = Sharply Very Close (SVC)
2 = Sharply Close (SC)
3 = Sharply Medium (SM)
4 = Sharply Big (SB)
5 = Sharply Very Big (SVB)

Fruit cleavability
1 = Very Difficult to be Cleaved (VDC)
2 = Difficult to be Cleaved
3 = Rather Easy to be Cleaved
4 = Easy to be Cleaved (EC)
5 = Very Easy to be Cleaved (VEC)

Table 3. *Pongge* morphological characteristics of 7 Lai cultivars from Batuah Sub-district of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Flesh fruit thick (cm)	Seed weight (g)	Flesh fruit weight per *pongge* (g)	Number of *pongge* per *juring*	Flesh fruit color	Seed form	Seed color	Number of *juring*
Lai Hijau	0.64	8.99	21.58	2-4	Y	LC	B	5
Lai Belimbing	0.61	17.93	26.84	4-6	Y	OT	B	5
Lai Semangka	0.62	8.31	26.85	3-5	O	OT	B	5
Lai Durian	0.56	16.70	19.80	3-4	Y	CO	DB	5
Lai Besar	0.59	13.49	31.15	3-5	O	LC	B	5
Lai Nangka	0.64	15.64	20.13	2-4	O	CO	DB	5
Lai Kuning	0.79	14.92	31.84	2-6	O	CO	DB	5
Average	0.64	13.71	25.46	2-6				5

Note: Data were calculated from 3 replications.

Table 4. Score of *pongge* morphological characteristics parameters of the Lai cultivars for cluster analysis based on morphological characteristics

Lai cultivars	Flesh fruit thick	Seed weight	Flesh fruit weight per *pongge*	Number of *pongge* per *juring*	Flesh fruit color	Seed form	Seed color	Number of *juring*
Lai Hijau	3	2	3	3	3	2	3	5
Lai Belimbing	3	4	3	5	3	3	3	5
Lai Semangka	3	2	3	4	4	3	3	5
Lai Durian	3	4	2	4	3	4	4	5
Lai Besar	3	3	4	4	4	2	3	5
Lai Nangka	3	4	3	3	4	4	4	5
Lai Kuning	4	3	4	4	4	4	4	5

Note:

Flesh Fruit thick
1 = Very Thin (VTh) (≤ 0.25 cm)
2 = Thin (Th) (0.26-0.50 cm)
3 = Medium (M) (0.51-0.75)
4 = Thick (Tc) (0.76-1.00 cm)
5 = Very Thick (VTc) (> 1.00 cm)

Fruit seed weight
1 = Very Light (VL) (≤ 0.50 g)
2 = Light (L) (0.51-1.00 g)
3 = Medium (M) (1.01-1.50 g)
4 = Heavy (H) (1.51-2.00 g)
5 = Very Heavy (VH) (> 2.00 g)

Flesh fruit weight per *pongge*
1 = Very Light (VL) (< 10.00 g)
2 = Light (L) (10.01-15,00 g)
3 = Medium (M) (15,01-20,00 g)
4 = Heavy (H) (20,01-25,00 g)
5 = Very Heavy (VH) (> 25,00 g)

Number of *Pongge* per *juring*
1 = Very View (VV)
2 = View (V)
3 = Medium (M)
4 = A Lot (AL)
5 = Very Lot (VL)

Color of flesh fruit
1 = White (W)
2 = Light Yellow (LY)
3 = Yellow (Y)
4 = Orange (O)
5 = Red (R)

Seed form
1 = Circular (C)
2 = Long Circular (LC)
3 = Oval Thin(OT)
4 = Circular Oval (CO)
5 = Very Long (VL)

Seed color
1 = White (W)
2 = White Yellowish (WY)
3 = Brown (B)
4 = Dark Brown (DB)
5 = Black (Bk)

Number of *juring*
5 = 5 in average

According to cluster analysis applied to the seven Lai cultivars based on morphological characteristics, they could be clustered into two big clusters with only 10% similarity. The seven cultivars were then grouped into four clusters as shown in Table 5. Lai Hijau and Lai Semangka were in the same cluster, which have the highest similarity of 44.1%, followed by cluster of Lai Durian and Lai Belimbing with the similarity of 35.0%. The dendrogram of the Lai cultivars based on morphological characteristics is shown in Figure 1.

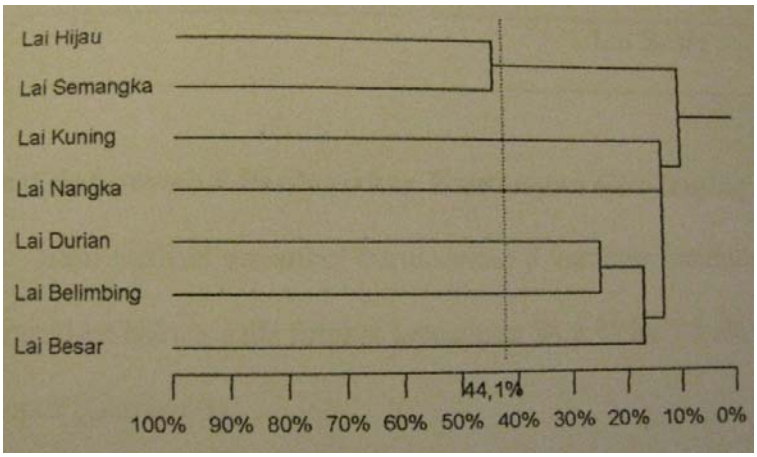


Figure 1. Dendogram of Lai cultivars observed based on morphological characteristics

Table 5. Cluster of the seven Lai cultivars observed

Cluster	Lai Cultivar	Similarity (%)
I	Lai Hijau and Lai Semangka	44.1
II	Lai Durian and Lai Belimbing	35.0
III	Lai Durian, Lai Belimbing, and Lai Besar	17.5
IV	Lai Kuning, Lai Nangka, Lai Durian, Lai Belimbing, and Lai Besar	12.5

Inter Relationship Based on Nutrient Content

The nutrient content characteristics of seven Lai cultivars observed were shown in Table 6, while the analyzed data for cluster analysis were shown in Table 7. The average of flesh fruit characteristics, like water content, ash, fat, protein, vit C, sugar, carbohydrate, fiber were 63.93%, 1.34%, 1.28%, 2.26%, 9.43%, 6.50%, 30.96%, and 3.20%, respectively.

Table 6. Nutrient content (%) of 7 cultivars of Lai from Batuah Subdustrict of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Water Cotent	Ash	Fat	Protein	Vit C	Sugar	Carbo-hydrate	Fiber
Lai Hijau	65.64	1.12	1.31	2.23	9.04	6.83	27.71	1.90
Lai Belimbing	65.35	1.17	1.44	2.02	8.92	6.44	0.02	2.83
Lai Semangka	71.46	1.33	1.04	2.38	8.80	6.05	23.80	3.36
Lai Durian	65.51	1.34	1.22	2.45	9.68	6.45	29.48	2.72
Lai Besar	59.46	1.33	0.96	2.05	9.97b	6.44	36.20	3.30
Lai Nangka	60.83	1.62	1.45b	2.38	10.27	6.44	33.72	4.04
Lai Kuning	59.23	1.47	1.54	2.33	9.33	6.83	35.76	4.25
Average	63.93	1.34	1.28	2.26	9.43	6.50	30.96	3.20

Note: Data were calculated from 3 replications, *Hijau* = green; *Belimbing* = starfruit; *Semangka* = water melon; *Besar* = big; *Nangka* = jackfruit; *Kuning* = yellow

Table 6. Score of nutrient content parameter of the Lai cultivars for cluster analysis based on nutrient content

Lai cultivars	Water content	Ash	Fat	Protein	Vit C	Sugar	Carbo-hydrate	Fiber
Lai Hijau	4	2	2	3	2	3	3	2
Lai Belimbing	4	2	2	3	2	3	4	3
Lai Semangka	4	2	2	3	2	3	3	4
Lai Durian	4	2	2	3	2	3	3	3
Lai Besar	3	2	1	3	2	3	4	4
Lai Nangka	4	2	2	3	3	3	4	5
Lai Kuning	3	2	2	3	2	3	4	5

Note:

Water content
1 = Very Low (VL) (≤ 20.00%)
2 = Low (L) (20.00-40.00%)
3 = Medium (M) (40.01-60.00%)
4 = High (H) (60.01-80.00%)
5 = Very High (VH) (> 80.00%)

Ash
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Fat
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.00-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Protein
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Vit C
1 = Very Low (VL) (≤ 5.00%)
2 = Low (L) (5.00-10.00%)
3 = Medium (M) (10.01-15.00%)
4 = High (H) (15.01-20.00%)
5 = Very High (VH) (> 20.00%)

Sugar
1 = Very Low (VL) (≤ 2.50% brix)
2 = Low (L) (2.51-5.00% brix)
3 = Medium (M) (5.01-7.50% brix)
4 = High (H) (7.51-10.00% brix)
5 = Very High (VH) (> 10.00% brix)

Carbohydrate
1 = Very Low (VL) (≤ 10.00%)
2 = Low (L) (10.01-20.00%)
3 = Medium (M) (20.01-30.00%)
4 = High (H) (30.01-40.00%)
5 = Very High (VH) (> 40.00%)

Fiber
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

According to cluster analysis applied to the seven Lai cultivars based on nutrient content, they could be clustered into two clusters with only 9% similarity. Lai Hijau, lai Durian, Lai Belimbing, and Lai Semangka were group in first cluster with similarity of 34,6%, while the second cluster consist of Lai Besar, Lai Kuning, and Lai Nangka have the similarity of 20%. The dendrogram of the Lai cultivars based on morphological characteristics is shown in Figure 2.

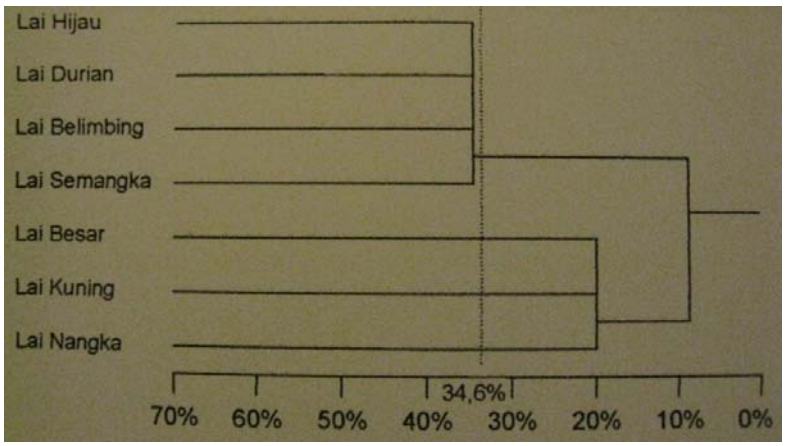


Figure 2. Dendogram of Lai cultivars observed based on nutrient content characteristics

REFERENCES

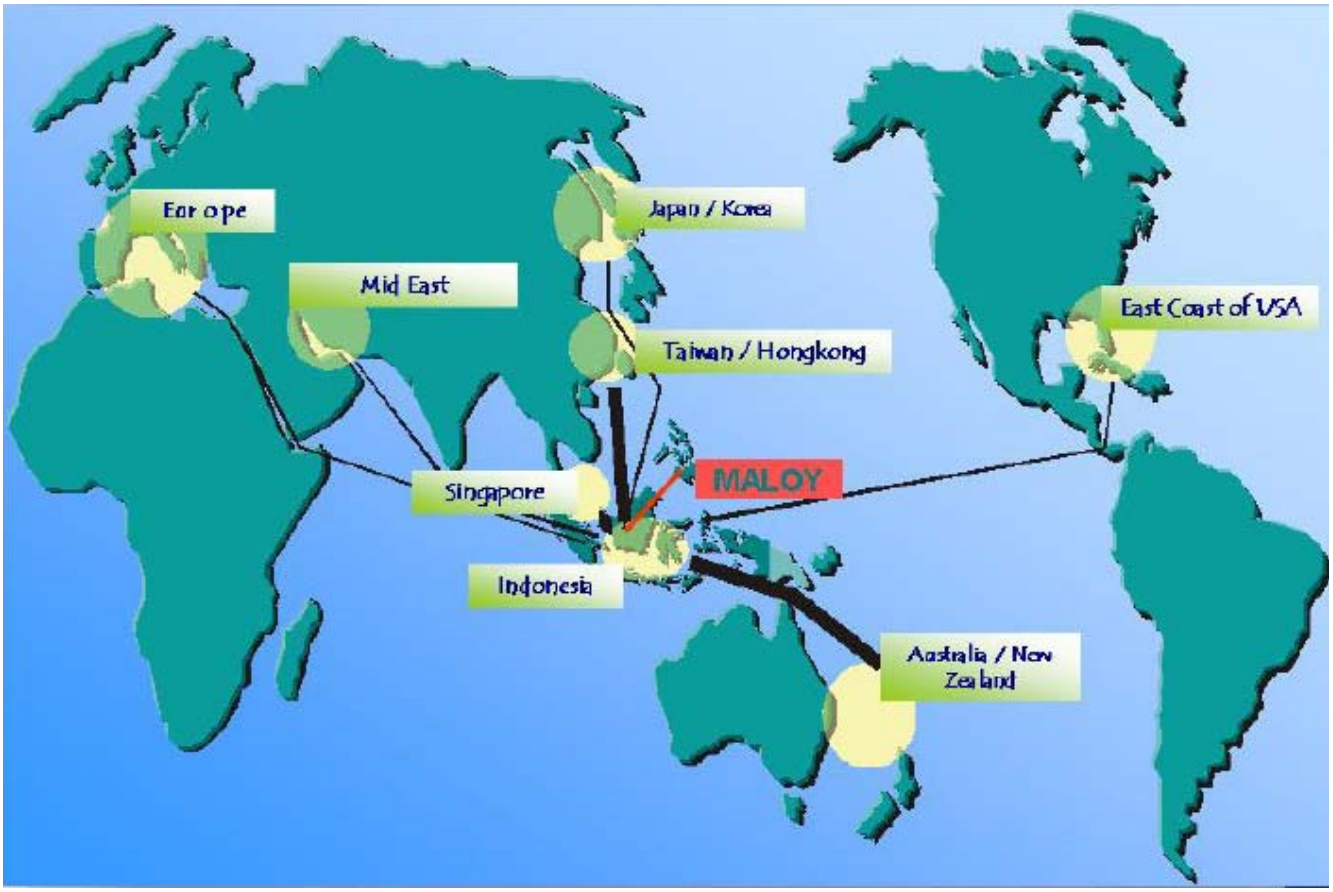
Adenberg MR (1973) Clustering Analysis for Application. Academic Press, New York.

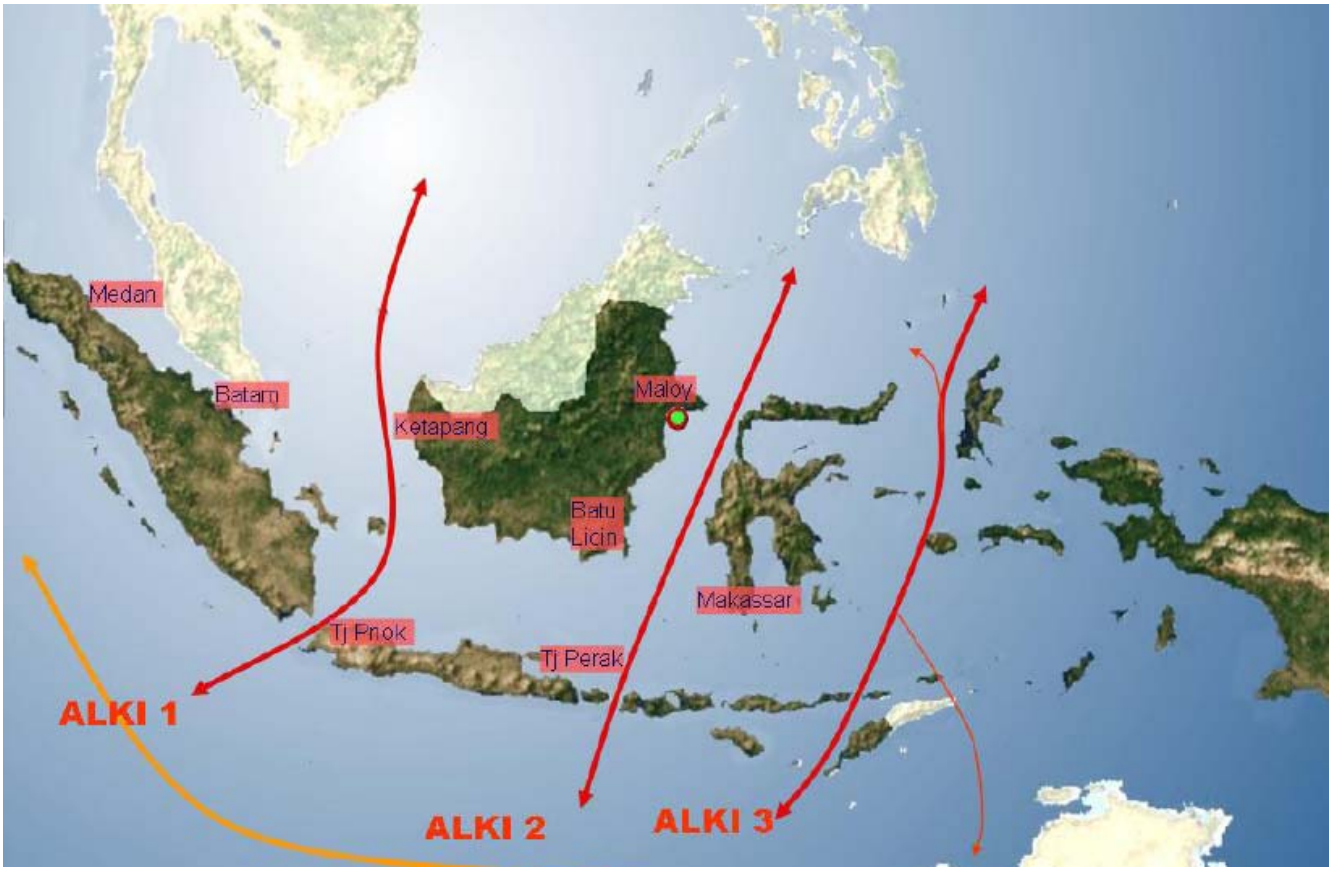
Sudarmadji S, Bambang H, Suhardi (1997) Prosedur Analisa untuk Bahan Makanan dan Pertanian. 4th ed. Penerbit Liberty, Yogyakarta.

Bernardinus TWW (2002) Bertanam Durian. 2nd ed. Agromedia Pustaka, Jakarta.

M Nipah AH (2002) Prospek Agrobisnis Berkebun Durian. 1st ed. Effhar, Semarang.

INTER RELATIONSHIP OF SOME LAI (*Durio kutejensis* Hassk.Becc.) CULTIVARS ORIGINATED FROM INDONESIA, BASED ON FRUIT MORPHOLOGY AND NUTRITION CONTENT





East Kalimantan Province

Types of durian

- There are 4 varieties found in East Kalimantan
  1) Durian (*Durio zibethinus*)
  2) Lai (*Durio ketejensis*)
  3) Kerantongan (*Durio oxleyanus*)
  4) Lahong (*Durio dulcis*)
  5) Labelak (*Durio graveolens*)
  6) Durian Kura-kura (*Durio testudinarum*)

Durian tree

Durian tree and its fruit

Durian fruit

Lai tree and its fruit

Lai and its fruit

Lai Belimbing (*Belimbing* = Starfruit)

Lai Hijau (*Hijau* = Green)

Background and aim of research

- Background
  1) There are many cultivars of Lai
  2) It is important to find out which cultivar(s) has high economic value
- Aim of Reseach
  1) To find out the fruit and flesh fruit characteristcs
  2) To find out the similarity of fruit from the Lai cultivars

Materials and methods

- Materials
  - Seven lai cultivars from Batuah Subdistrict, Kutai Kartanegara Regency
    - Lai Hijau
    - Lai Belimbing
    - Lai Semangka
    - Lai Durian
    - Lai Besar
    - Lai Nangka
    - Lai Kuning
- Methods
  - Cluster analysis
    - Based on morphological characteristics of fruit and pongge (16 parameters)
    - Based on nutrient content (8 parameters)

Result and discussion

Table 1. Fruit morphological characteristics of 7 Lai cultivars from Batuah Sub-district of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Fruit diameter (cm)	Fruit weight (kg)	Fruit length (cm)	Fruit husk thick (cm)	Fruit form	Ripe fruit color	Fruit thorn husk	Fruit cleavability
Lai Hijau	48.80	1.36	14.80	0.63	RR	G	SC	RDC
Lai Belimbing	49.30	1.26	18.20	0.63	O	Y	SC	EC
Lai Semangka	45.90	1.11	14.50	0.60	RR	YG	SC	REC
Lai Durian	45.80	1.36	18.50	0.87	LC	Y	SC	EC
Lai Besar	51.20	1.57	19.00	0.70	O	Y	SBR	EC
Lai Nangka	49.10	1.17	17.40	0.80	O	YG	SBR	EC
Lai Kuning	49.30	1.18	15.40	0.77	RC	DY	SBR	EC
Average	48.49	1.29	16.83	0.71				

Note: Data were calculated from 3 replications, *Hijau* = green; *Belimbing* = starfruit; *Semangka* = water melon; *Besar* = big; *Nangka* = jackfruit; *Kuning* = yellow.

Result and discussion

Table 3. *Pongge* morphological characteristics of 7 Lai cultivars from Batuah Sub-district of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Flesh fruit thick (cm)	Seed weight (g)	Flesh fruit weight per *pongge* (g)	Number of *pongge* per *juring*	Flesh fruit color	Seed form	Seed color	Number of *juring*
Lai Hijau	0.64	8.99	21.58	2-4	Y	LC	B	5
Lai Belimbing	0.61	17.93	26.84	4-6	Y	OT	B	5
Lai Semangka	0.62	8.31	26.85	3-5	O	OT	B	5
Lai Durian	0.56	16.70	19.80	3-4	Y	CO	DB	5
Lai Besar	0.59	13.49	31.15	3-5	O	LC	B	5
Lai Nangka	0.64	15.64	20.13	2-4	O	CO	DB	5
Lai Kuning	0.79	14.92	31.84	2-6	O	CO	DB	5
Average	0.64	13.71	25.46	2-6				5

Note: Data were calculated from 3 replications.

Table 2. Score of morphological fruit characteristics parameters of the Lai cultivars for cluster analysis based on morphological characteristics

Lai cultivars	Fruit diameter	Fruit weight	Fruit length	Fruit husk thick	Fruit form	Ripe fruit color	Fruit thorn husk	Fruit cleavability
Lai Hijau	4	3	2	3	1	1	2	2
Lai Belimbing	4	3	3	3	3	3	2	4
Lai Semangka	4	3	2	3	1	2	2	3
Lai Durian	4	3	3	4	5	3	2	4
Lai Besar	5	4	3	3	3	3	4	4
Lai Nangka	4	3	3	4	3	2	4	4
Lai Kuning	4	3	3	4	1	4	4	4

Note:

Fruit diameter
1 = Very Small (VS) (≤ 20,00 cm)
2 = Small (S) (20.01-31.00 cm)
3 = Medium (M) (31.01-40.00 cm)
4 = Big (B) (40.01-50.00 cm)
5 = Very Big (VB) (> 50.00 cm)

Fruit weight
1 = Very Light (VL) (≤ 0.50 kg)
2 = Light (L) (0.50-1.00 kg)
3 = Medium (M) (1.00-1.50 kg)
4 = Heavy (H) (1.50-2.00 kg)
5 = Very Heavy (VH) (> 2.00 kg)

Fruit length
1 = Very Small (VS) (< 10,00 cm)
2 = Small (S) (10,10-15,00 cm
3 = Medium (M) (15,10-20,00 cm)
4 = Big (B) (20,10-25,00 cm)
5 = Very Big (VB) (> 25,00 cm)

Fruit husk thick
1 = Very Thin (VT) (≤ 0.25 cm)
2 = Thin (T) (0.25-0.50 cm)
3 = Medium (M) (0.51-0.75 cm)
4 = Thick (T) (0.76-1.00 cm)
5 = Very Thick (VT) (> 1.00 cm)

Fruit form
1 = Rather Circular (RR)
2 = Circular (C)
3 = Oval (O)
4 = Ellipse (E)
5 = Long circular (LC)

Ripe fruit color
1 = Green (G)
2 = Yellowish Green (YG)
3 = Yellow (Y)
4 = Dark Yellow (DY)
5 = Reddish Yellow (RY)

Fruit husk form
1 = Sharply Very Close (SVC)
2 = Sharply Close (SC)
3 = Sharply Medium (SM)
4 = Sharply Big (SB)
5 = Sharply Very Big (SVB)

Fruit cleavability
1 = Very Difficult to be Cleaved (VDC)
2 = Difficult to be Cleaved
3 = Rather Easy to be Cleaved
4 = Easy to be Cleaved (EC)
5 = Very Easy to be Cleaved (VEC)

Table 4. Score of *pongge* morphological characteristics parameters of the Lai cultivars for cluster analysis based on morphological characteristics

Lai cultivars	Flesh fruit thick	Seed weight	Flesh fruit weight per *pongge*	Number of *pongge* per *juring*	Flesh fruit color	Seed form	Seed color	Number of *juring*
Lai Hijau	3	2	3	3	3	2	3	5
Lai Belimbing	3	4	3	5	3	3	3	5
Lai Semangka	3	2	3	4	4	3	3	5
Lai Durian	3	4	2	4	3	4	4	5
Lai Besar	3	3	4	4	4	2	3	5
Lai Nangka	3	4	3	3	4	4	4	5
Lai Kuning	4	3	4	4	4	4	4	5

Note:

Flesh Fruit thick
1 = Very Thin (VTh) (≤ 0.25 cm)
2 = Thin (Th) (0.26-0.50 cm)
3 = Medium (M) (0.51-0.75)
4 = Thick (Tc) (0.76-1.00 cm)
5 = Very Thick (VTc) (> 1.00 cm)

Fruit seed weight
1 = Very Light (VL) (≤ 0.50 g)
2 = Light (L) (0.51-1.00 g)
3 = Medium (M) (1.01-1.50 g)
4 = Heavy (H) (1.51-2.00 g)
5 = Very Heavy (VH) (> 2.00 g)

Flesh fruit weight per *pongge*
1 = Very Light (VL) (< 10.00 g)
2 = Light (L) (10.01-15,00 g)
3 = Medium (M) (15,01-20,00 g)
4 = Heavy (H) (20,01-25,00 g)
5 = Very Heavy (VH) (> 25,00 g)

Number of *Pongge* per *juring*
1 = Very View (VV)
2 = View (V)
3 = Medium (M)
4 = A Lot (AL)
5 = Very Lot (VL)

Color of flesh fruit
1 = White (W)
2 = Light Yellow (LY)
3 = Yellow (Y)
4 = Orange (O)
5 = Red (R)

Seed form
1 = Circular (C)
2 = Long Circular (LC)
3 = Oval Thin(OT)
4 = Circular Oval (CO)
5 = Very Long (VL)

Seed color
1 = White (W)
2 = White Yellowish (WY)
3 = Brown (B)
4 = Dark Brown (DB)
5 = Black (Bk)

Number of *juring*
5 = 5 in average

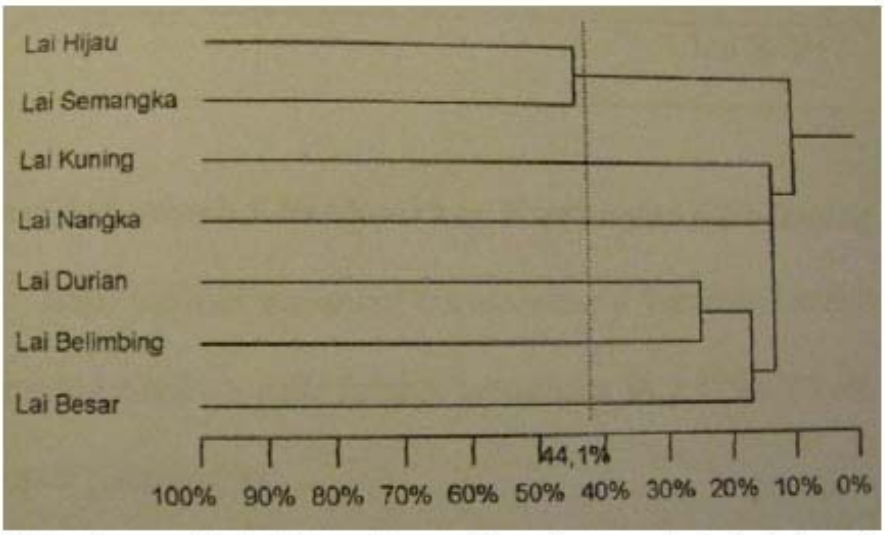


Figure 1. Dendogram of Lai cultivars observed based on morphological characteristics

Table 5. Cluster of the seven Lai cultivars observed

Cluster	Lai Cultivar	Similarity (%)
I	Lai Hijau and Lai Semangka	44.1
II	Lai Durian and Lai Belimbing	35.0
III	Lai Durian, Lai Belimbing, and Lai Besar	17.5
IV	Lai Kuning, Lai Nangka, Lai Durian, Lai Belimbing, and Lai Besar	12.5

Table 6. Nutrient content (%) of 7 cultivars of Lai from Batuah Subdustrict of Kutai Kartanegara Regency, East Kalimantan Province, Indonesia

Lai cultivars	Water Cotent	Ash	Fat	Protein	Vit C	Sugar	Carbo-hydrate	Fiber
Lai Hijau	65.64	1.12	1.31	2.23	9.04	6.83	27.71	1.90
Lai Belimbing	65.35	1.17	1.44	2.02	8.92	6.44	0.02	2.83
Lai Semangka	71.46	1.33	1.04	2.38	8.80	6.05	23.80	3.36
Lai Durian	65.51	1.34	1.22	2.45	9.68	6.45	29.48	2.72
Lai Besar	59.46	1.33	0.96	2.05	9.97b	6.44	36.20	3.30
Lai Nangka	60.83	1.62	1.45b	2.38	10.27	6.44	33.72	4.04
Lai Kuning	59.23	1.47	1.54	2.33	9.33	6.83	35.76	4.25
Average	63.93	1.34	1.28	2.26	9.43	6.50	30.96	3.20

Note: Data were calculated from 3 replications, *Hijau* = green; *Belimbing* = starfruit; *Semangka* = water melon; *Besar* = big; *Nangka* = jackfruit; *Kuning* = yellow

Table 6. Score of nutrient content parameter of the Lai cultivars for cluster analysis based on nutrient content

Lai cultivars	Water content	Ash	Fat	Protein	Vit C	Sugar	Carbo-hydrate	Fiber
Lai Hijau	4	2	2	3	2	3	3	2
Lai Belimbing	4	2	2	3	2	3	4	3
Lai Semangka	4	2	2	3	2	3	3	4
Lai Durian	4	2	2	3	2	3	3	3
Lai Besar	3	2	1	3	2	3	4	4
Lai Nangka	4	2	2	3	3	3	4	5
Lai Kuning	3	2	2	3	2	3	4	5

Note:

Water content
1 = Very Low (VL) (≤ 20.00%)
2 = Low (L) (20.00-40.00%)
3 = Medium (M) (40.01-60.00%)
4 = High (H) (60.01-80.00%)
5 = Very High (VH) (> 80.00%)

Ash
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Fat
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.00-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Protein
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

Vit C
1 = Very Low (VL) (≤ 5.00%)
2 = Low (L) (5.00-10.00%)
3 = Medium (M) (10.01-15.00%)
4 = High (H) (15.01-20.00%)
5 = Very High (VH) (> 20.00%)

Sugar
1 = Very Low (VL) (≤ 2.50% brix)
2 = Low (L) (2.51-5.00% brix)
3 = Medium (M) (5.01-7.50% brix)
4 = High (H) (7.51-10.00% brix)
5 = Very High (VH) (> 10.00% brix)

Carbohydrate
1 = Very Low (VL) (≤ 10.00%)
2 = Low (L) (10.01-20.00%)
3 = Medium (M) (20.01-30.00%)
4 = High (H) (30.01-40.00%)
5 = Very High (VH) (> 40.00%)

Fiber
1 = Very Low (VL) (≤ 1.00%)
2 = Low (L) (1.01-2.00%)
3 = Medium (M) (2.01-3.00%)
4 = High (H) (3.01-4.00%)
5 = Very High (VH) (> 4.00%)

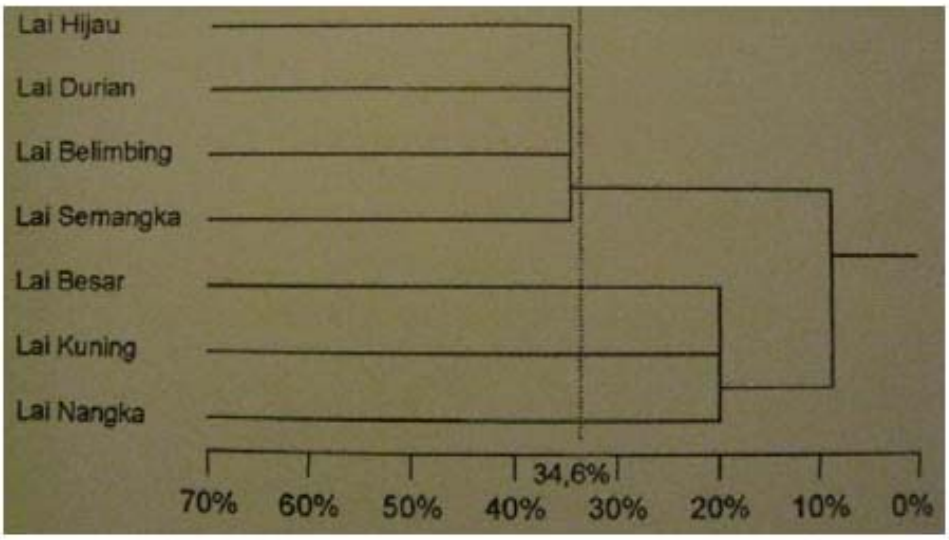


Figure 2. Dendrogram of Lai cultivars observed based on nutrient content