# HORTIN II Co Innovation Programme

## *Towards cost effective, high quality value chains*

## Feasibility of extension of shelf life period of Indonesian rambutan

**HORTIN-II Research Report nr. 18**

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Wageningen, The Netherlands, October 2010

The purpose of the HORTIN-II programme is to contribute to the development of cost effective high quality value chains for vegetables and fruits. Among others this can be achieved when technology development takes place in close collaboration between public institutions, farmers and private companies.

On the Indonesian side the programme is carried out by the Indonesian Centre for Horticultural Research and Development **(ICHORD),** Jakarta, with the Indonesian Vegetable Research Institute **(IVEGRI)**, Lembang, and the Indonesian Centre for Agricultural Postharvest Research and Development **(ICAPRD)** in Bogor.

In the Netherlands the Agricultural Economics Research Institute **(AEI)**, Den Haag, Wageningen UR Food & Biobased Research **(FBR)**, Wageningen, Applied Plant Research **(APR)**, Lelystad, and WUR-Greenhouse Horticulture **(WUR-GH)**, Bleiswijk, all partners in Wageningen University and Research centre, are involved in the programme.


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# 1. Introduction

In order to contribute to the development of tropical fruit sector in Indonesia, new packaging concepts are investigated to increase the shelf life of these fruit. The extension of the shelf life will assure easier and longer distribution radius (on national and export levels). The economical fall-out can have significant effects on the Indonesian fruit chain.

First screening tests were implemented in 2009. The main goal of these tests was to determine which packaging is the most suitable to extend the shelf life period of rambutan from 4 days at room temperature to 21 days at 10°C using E-MAP technology. It is concluded that although E-MAP packaging brings a significant benefit, the control of low storage temperature permits to extend significantly the storage period of the rambutan fruits. Concerning the best E-MAP packaging, LDPE bags with antifog layer and with 10 micro-perforations (100µm diameter) are the most promising for this tropical product. Using the knowledge accumulated during the first screening tests, optimization of E-MAP packaging to several potential markets is investigated. The local market and the export market are simulated in order to determine the potential shelf life extension of rambutan in these market segments. Following the traditional export logistic chain, two main aspects are studied within the present report:

- The influence of plane transport on quality of both rambutans packed within E-MAP and in bulk.
- The shelf life of several species of rambutan exported to Europe (using the conventional exportation chain).

Additionally to the E-MAP feasibility study, a control atmosphere test (CA) is also implemented. Using control atmosphere technology, it is theoretically possible to extend the shelf life of some fruits. If the fruit is robust enough to handle the CA conditions, the exportation of the fruits from Indonesia to Europe (or other countries) can be considered by using reefer sea containers. Basing our research on the literature data (A.A Kader – 2002), a matrix of oxygen and carbon dioxide concentrations are tested on three varieties of rambutans for a storage period of 4 weeks.

# 2. Methods

## 2.1. Collection of rambutan and post-harvest treatments

Three varieties of rambutan are used within these tests:

- *Binjai*
- *Lebak bulus*
- *Rapia*

The two first varieties are the most common rambutan varieties on the Java Island. Rapia is less abundant but more appreciated by the local population. This variety is sold with a higher price. Rambutan are harvested in Subang and near Cirebon (week 3 – January 2010) (Picture 1-a) and transported under refrigerated conditions (15°C) to Bogor for further handling (harvesting and transport: 6 hours) (Picture 1-b). Immediately after reception of rambutan at the ICAPRD facilities, rambutans are hand-sorted, graded, washed and dried. The handling and storage period before exporting process take approximately 14 hours. The main criteria for the hand sorting and the grading are the uniformity of the rambutan skin (form and colour); the green coloration of the spinterns and the appropriate red/pink colour of the skin (for Binjai and Lebak bulus) or green colour for Rapia rambutans (Picture 1-c). After washing, with tap water to eliminate the impurity as web spider, black punts, the rambutans are placed directly on the floor for drying process. Fan permits to accelerate this process. Once rambutans are dried, they are packed for export.

Rambutans are conditioned in different packaging in order to study the effects of this during the transport/exportation process. The two packaging treatments tested in this test are:

- E-MAP test consists on packed 550 grams of rambutan per bag (25x25cm). The bag is made of LDPE foil with antifog properties (RKW - 30µm thickness). Each bag is previously perforated with a laser perforation machine in order to make 10 micro-perforations of 100µm of diameter per bag (PerfoTec online Laser Perforation System). The bags are filled up with rambutan and closed with hand seal machine. 5 bags are placed per carton box for the exportation transport (Picture 1-d).
- Rambutans are packed directly in bulk inside the cardboard box for the transport (4 kilograms per box) (one plastic with macro-perforations is first placed inside the box in order to maintain high moisture content in the direct environment of the rambutans). The atmosphere surrounding the rambutan is considered similar to air (21% $O_2$ and 0% $CO_2$). After reception of the rambutan in the Netherlands, the fruits are packed in E-MAP bags (similar one that these used in Indonesia (see first packaging treatment)).

Additionally to these boxes, rambutans destined for the control atmosphere experiment are packed in bulk inside the export box. The control atmosphere test is initiated from the reception of the rambutan at Food & Biobased Research (FBR) facilities in Wageningen. In each box, one temperature logger (I-Button: DS1921G) is introduced before starting the export pilot. This sensor follows the temperature of the product during the complete export trial. This parameter is all the more important to follow, as the temperature is not controlled (temperature in the plane and on the storage area by airports are not constant). After reception of the rambutan by the importer in the Netherlands (Schiphol), one expert of Food and Biobased Research has directly evaluated the quality of the rambutans. This initial evaluation is made in collaboration with the importer in order to define the quality criteria of the rambutan for the European market. After the initial quality check, the rambutans were transported under cool transport (10°C) to FBR facilities (Wageningen).


*Figure 1. Harvesting and export process for rambutan. A) harvested rambutans from Subang; B) Transport of rambutan under refrigerated conditions; C) hand sorting of rambutans; D) rambutans are placed in bags for further transport.*

## 2.2. Set-up

Two tests have been applied in Europe: an export test and control atmosphere test. For both tests, three varieties of rambutan are studied: Binjai, Lebak bulus and Rapia.

Each variety is conditioned in two different ways during the transport from Indonesia to the Netherlands:

- 500 grams of rambutans were packed inside the LDPE bags with the optimal number of micro-perforations to reach modified atmosphere conditions. Once packed, 6 bags were placed inside a carton box for the transport.
- 4 kilograms of Rambutans in bulk were packed directly inside the carton box for the transport (one plastic with macro-perforations was first placed inside the box in order to assure high moisture content in the direct environment of the Rambutans.

Once the rambutans are collected at the airport by the importer, they are stored at 10°C until the arrival of Food and Biobased Research (FBR) (Wageningen University) expert. Gas concentration of E-MAP packaging is measured (PBI DanSensor CheckMate II) and sensorial evaluation is investigated in collaboration with the importer. Rambutan not analyzed were transported to FBR facilities and processed (re-packed or CA test) the day after (Friday 22nd January 2010).

### 2.2.1 E-MAP test set-up

*Due to miscommunication, some of the rambutans already packed inside the E-MAP bags in Indonesia were transferred from their initial bag to new bag (with same properties). Although the packaging material was identical, the gas conditions inside the bag have been changed during the re-packing process. Under this condition, it is important to exploit carefully the results obtained during this export test.*

The rambutans repacked within LDPE bags, after their arrival in Europe, are analyzed on the following days:

- Oxygen and carbon dioxide concentrations: on day 2, 3, 7, 11, 14, 18 and 22
- Color of spintern and in general: on day 7, 11, 14, 18 and 22
- Taste and colour of the flesh fruit: on day 7, 14, 18 and 22

The rambutans not re-packed after export trial were analyzed on the following day:

- Oxygen and carbon dioxide concentrations: on day 7, 11, 14, 18 and 22
- Color of spintern and in general: on day 7, 11, 14, 18 and 22
- Taste and colour of the flesh fruit: on day 22

The quality analysis consists on following the quality attributes of the Rambutans during the complete storage period. These attributes are judged according to the following scales:

The colour of spintern:

- 0 = 100 to 40% of spinterns are still green
- 1 = 10 to 30% of spinterns are green [dark green]
- 2 = <9% of spinterns still green [red is mainly the colour of the spintern]
- 3 = spinterns are with dark red colour [auburn]
- 4 = spinterns are completely brown

Color of the Rambutan skin in general:

- 0 = rambutan completely red
- 1 = 1 to 20% of the total surface with brown coloration
- 2 = 21 to 50% with brown coloration
- 3 = 51 to 80% with brown coloration
- 4 = 81 to 100% of the fruit surface with brown coloration

Taste:

- 1 = no off-taste (fresh taste)
- 2 = no off-taste (flavourless)
- 3 = light off-taste
- 4 = moderate off-taste
- 5 = strong off-taste

Colour of the endocarp (inside skin):

- 1 = white and shinny colour
- 2 = white and mat colour
- 3 = yellow colour
- 4 = brown colour

### 2.2.2 Control atmosphere set-up

For the control atmosphere test, the rambutans are sent to Europe via Air-cargo (4 kg rambutan in bulk within cardboard box). The 3 varieties of rambutan are used within this experiment. A matrix of several atmosphere conditions is applied to the 3 varieties of rambutan (see Table 1)

**Table 1. Oxygen and carbon dioxide concentrations applied to the 3 varieties of rambutans during the control atmosphere experiment (at 10°C)**

| Oxygen concentration | Carbon dioxide concentration | Binjai | Rapia | Lebak bulus |
|---|---|---|---|---|
| 20% | 0% | X | X | X |
| 3% | 5% | X | | X |
| 3% | 10% | X | | X |
| 3% | 14% | X | X | X |
| 3% | 17% | X | X | X |
| 3% | 20% | X | | X |

The Rambutans are placed inside containers of 67 litres within the different atmosphere conditions are applied. The container is continuously flushed with the appropriate gas mixture (flow of 400ml/min) during the complete test period (22 days). Quality attributes of the rambutan are analyzed at opening of the containers. The same quality analysis protocol is applied as used for the E-MAP test.

# 3. Results and discussion

## 3.1. Temperature during transport process

The transport under cooling conditions is not common in Indonesia. Fruits and vegetables are transported from the farm to the market place directly stacked up on trucks and simply covered with plastic cover. 'The cooling is assured by the air flow engendered thanks to the speed of the truck' (Figure 2).


*Figure 2. Truck transporting fruits and vegetables from the production area to Jakarta (consumption area). Ambient temperature 30˚C.*

During the exportation process, the temperature of the product is also not actively controlled (not under refrigerated condition). This engenders huge range of temperature fluctuation (fluctuation of 22°C in 2 days of transport). The fluctuations are presented on the Figure 3. The large fluctuations of temperatures can be explained by the long waiting periods at air/room temperature between two flights and the bad temperature control during the flight (Air-cargo does not regulate the temperature inside the plane during the flight).

Improving the temperature profile during the exportation phases is possible but within a certain limit. It is well known that the control of the temperature inside the plane (air-cargo or inside baggage compartment) is almost impossible as no control is performed on the logistic chain. Packing the rambutan inside cool box (white polystyrene box) can help to reduce the range of temperature fluctuation; however taking into account the exportation time, the effect of the cool-box is still considered as limited. Furthermore it is not recommended to pack the rambutan within this kind of box with ice. Rambutan is sensible to chilling injuries that occurred with a storage temperature lower than 10°C. Furthermore taking into account that the E-MAP packaging has been optimized for a constant storage temperature around 10°C, it is not recommended to send the rambutan already packed inside the E- MAP bag without controlling the temperature during the transport.

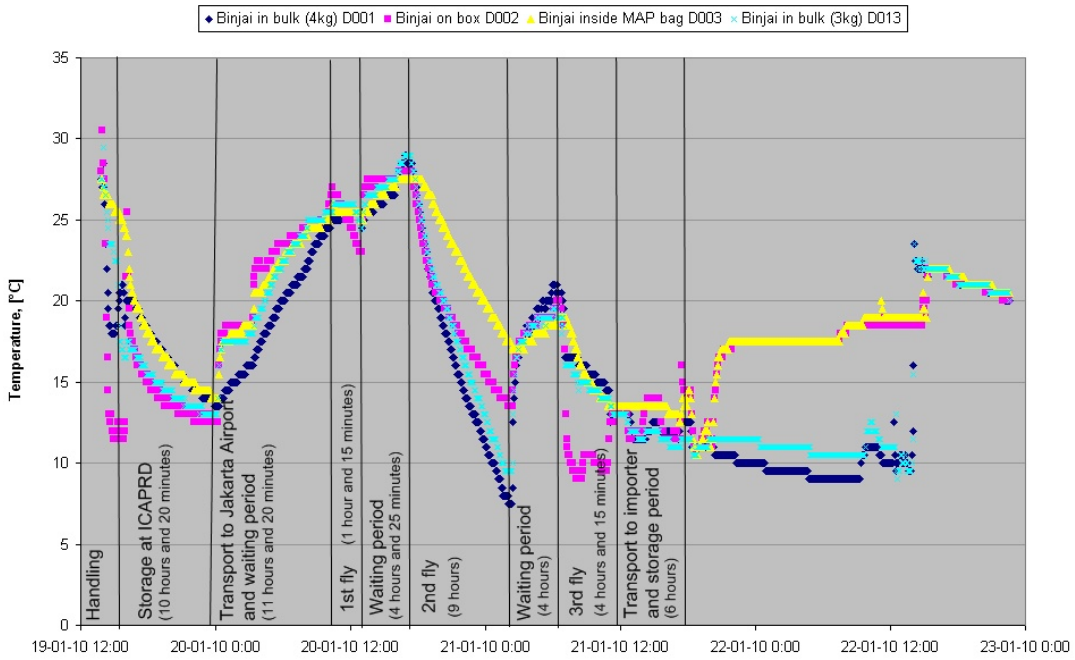


*Figure 3. Temperature profile during transport of rambutan Binjai from Indonesia to the Netherlands.*

## 3.2. Quality of rambutans at their arrival in the Netherlands

Rambutans are collected from the airport by the importer. On the same day, the quality inspection is processed in presence of the importer and one expert of Wageningen University. It appears that the consumer appreciates differently the quality attributes of the product according to its geographic origin (Indonesian or European consumer). For instance, the variety Rapia is not appreciated and is judged negatively at its completion, due to the green colour of the fruit. Green fruit is assimilated by the European consumer as unripe fruit. Furthermore the initial quality of the Rapia rambutan was not optimal before the exportation (the majority of the rambutan spinterns is black). Pink/red fruit (Binjai and Lebak bulus) are more appreciated by European consumer.

## 3.3. Quality of rambutans packed under equilibrium modified atmosphere

### 3.3.1 E-MAP test set-up

The activity of the rambutan is characterized by its capacity to consume oxygen and produce carbon dioxide. The optimum modified atmosphere packaging reduces the activity of the product at its minimum without allowing any anaerobic conditions inside the package. Figure 4 and figure 5 present respectively the oxygen and carbon dioxide concentrations measured inside the several packages. No significant difference between the treatments has been observed. It seems that packing the rambutan before or after the transport does not have a significant effect on the respiration activity of the rambutan. However significant differences between the varieties of rambutan are observed. This confirms that the activity of rambutan is cultivar dependant. The oxygen concentrations aim to one equilibrium at the end of the storage period.

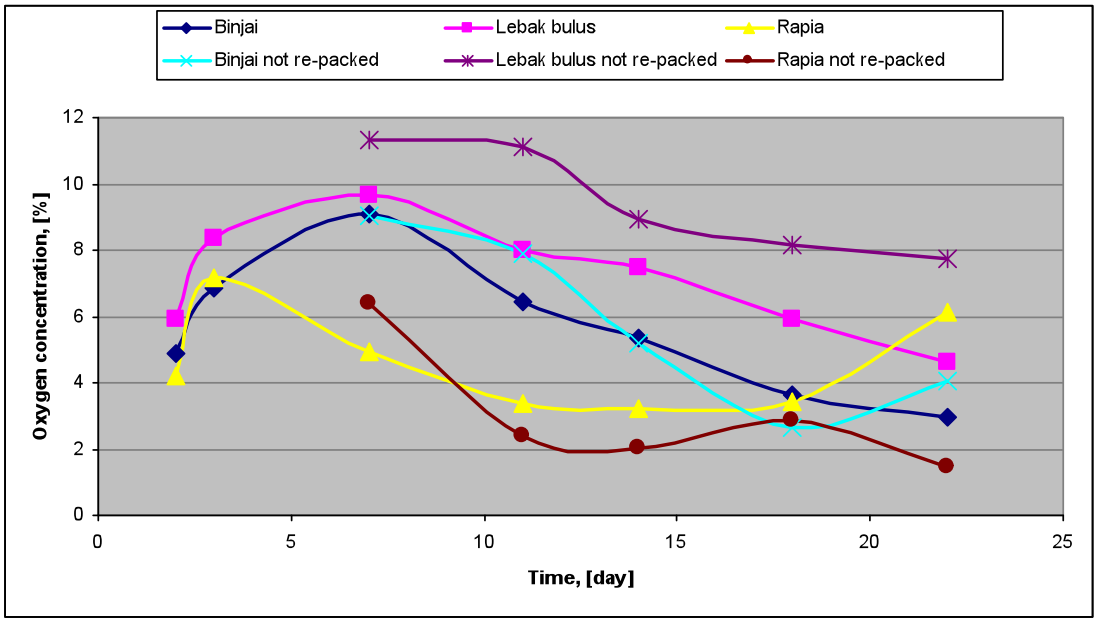


*Figure 4. Oxygen concentration of the E-MAP packages during the storage period of 22 days at 10˚C.*

The rambutans are considered as active until the last day of the storage period.

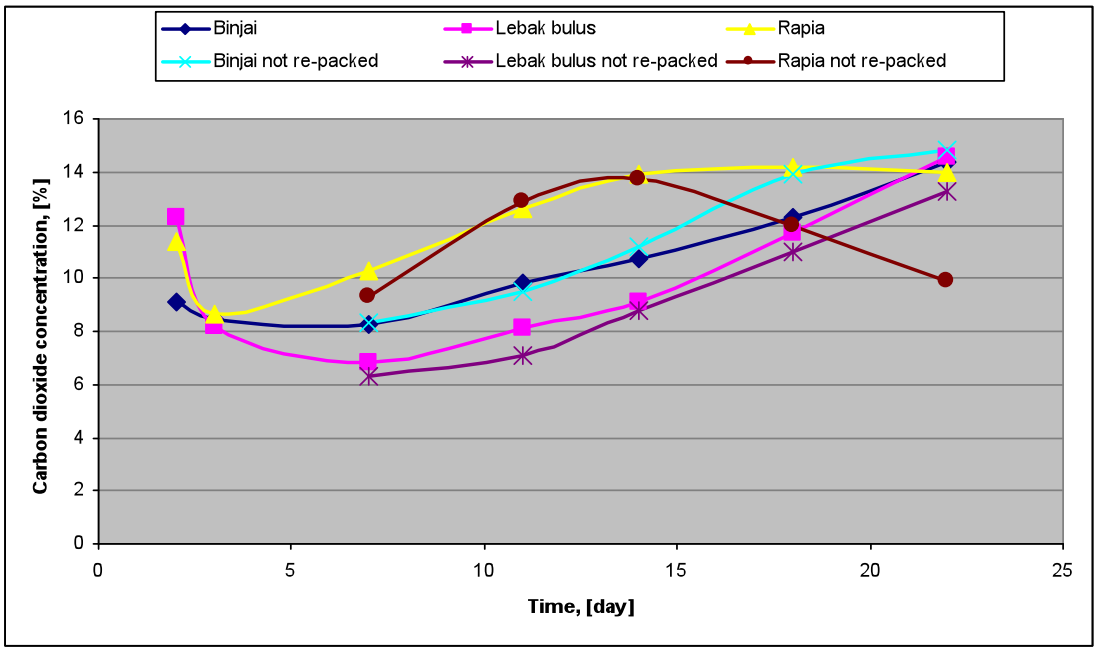


*Figure 5. Carbon dioxide concentration of the E-MAP packages during the storage period of 22 days at 10˚C.*

The carbon dioxide concentrations reach an equilibrium concentration around 12-14% after few days of storage. This concentration permits to slow down the activity of the rambutan without causing any off-taste development. It is possible to conclude regarding the gas concentrations, that the modified atmosphere packages are adapted to the activity of the rambutan (under the present storage condition).

### 3.3.2 Evolution of the quality parameters

#### *3.3.2.1 Spintern colour*

The spintern colour of rambutan (Figure 6) is maintained in the first week of storage for the varieties Binjai and Lebak bulus. The colour of the spintern of Rapia rambutan is not preserved by the E-MAP conditions (Picture 7). This phenomenon can be mainly explained by the poor initial quality of the samples. Rambutan packed in Indonesia (before exportation) presents less green spintern during the storage period in Europe. This can be explained by the high temperature fluctuation imposed during the exportation chain. Rambutans packed under E-MAP are more sensible to quality disorders if the temperature is not adapted to the oxygen, carbon dioxide and water permeability properties of the packaging.

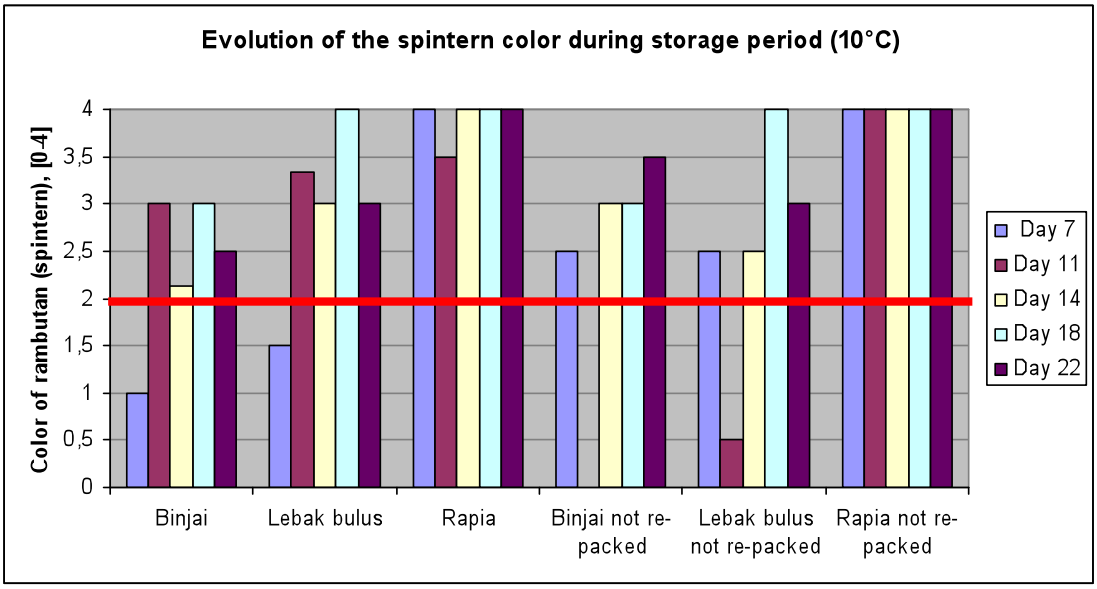


*Figure 6. Evolution of the colour of the rambutan spinterns during the storage period at 10°C after exportation. (0= 100 to 40% of spinterns are still green; 1= 10 to 30% of spinterns are green [dark green]; 2= <9% of spinterns still green [red is mainly the colour of the spintern]; 3= spinterns are with dark red colour [auburn]; 4= spinterns are completely brown).*

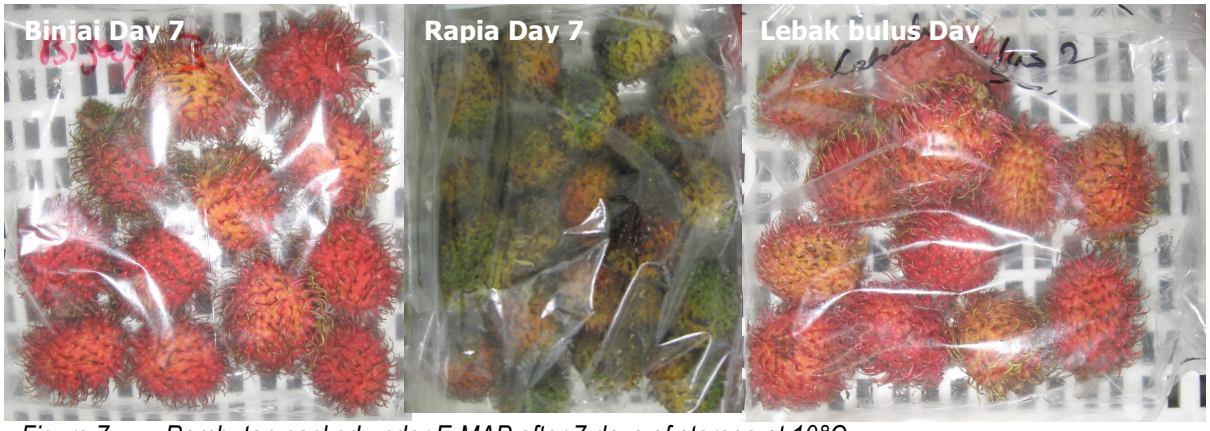


*Figure 7. Rambutan packed under E-MAP after 7 days of storage at 10°C.*

### 3.3.2.2 General colour of rambutan

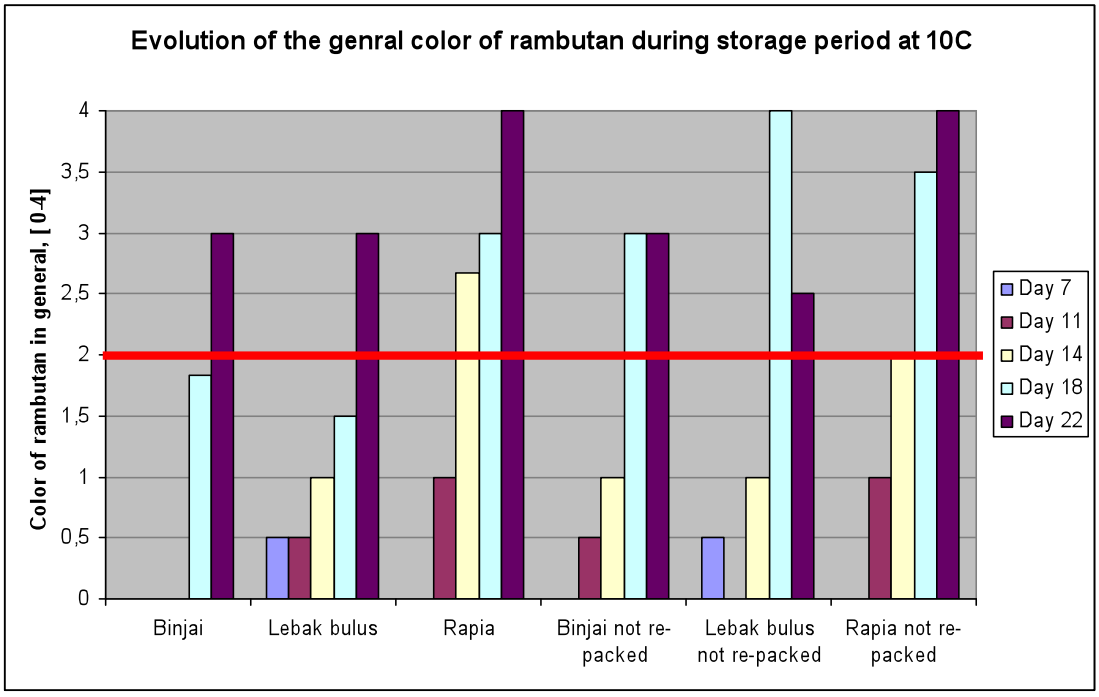


*Figure 8. Colour of the rambutan during the storage period at 10˚C (0: rambutan completely red; 1: 1 to 20% of the total surface with brown coloration; 2: 21 to 50% with brown coloration; 3: 51 to 80% with brown coloration; 4: 81 to 100% of the fruit surface with brown coloration).*

The colour of the outside skin is judged acceptable until day 18 for Binjai and Lebak bulus Rambutans (Figure 8). After 11 days of storage, the colour of the Rapia skin is judged not acceptable anymore (brown coloration). The colour of the rambutan packed under E- MAP in the Netherlands is judged more acceptable that one's packed in Indonesia. This difference is visible after 14 days of storage.


*Figure 9. Rambutan after opening the E-MAP bag and 18 days of storage at 10°C.*

### 3.3.2.3 Other quality attributes

Additionally to the colour evolution of the Rambutans, the taste, coloration of the inside skin and the color of the endocarp (flesh of the fruit) were analyzed.
Following, the main remarks have been drawn:

- Off-taste development was observed for Lebak bulus (after 18 days of storage) and Rapia (after 14 days of storage).
- The inside skin get a brown coloration in the last days of the storage period (Figure 10).

- For Lebak Bulus, it has been observed that the endocarp (inside skin) is coming loose from the rest of the skin after one week of storage.

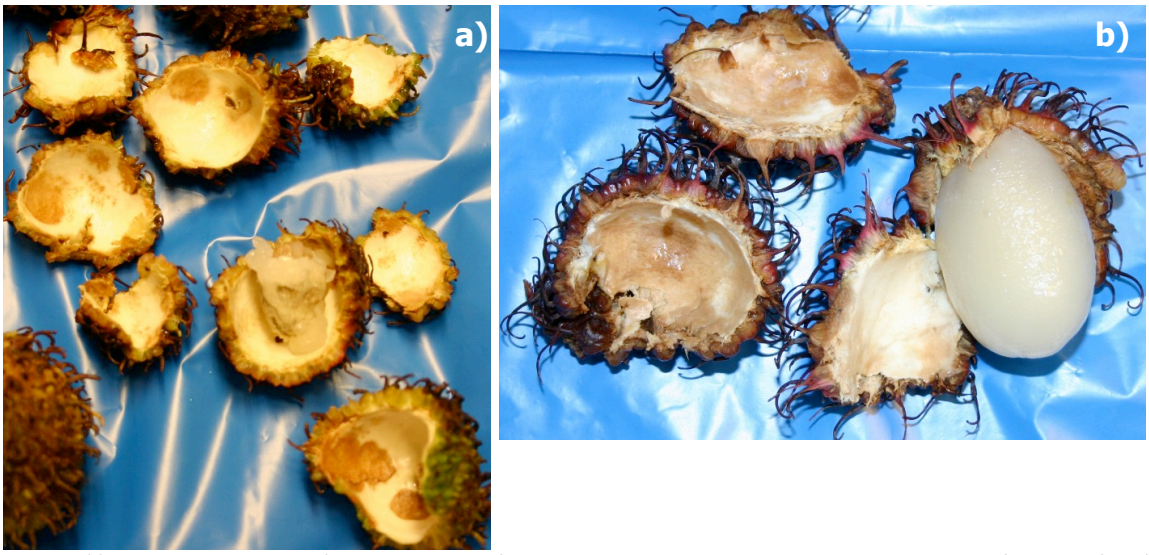


*Figure 10. Discolorations of the inner part of the rambutan mesocarp. a: brown coloration of Rapia after 14 days of storage at 10°C. b: brown coloration of Binjai mesocarp after 21 days of storage at 10°C.*

## 3.4. Quality of rambutans stored under CA

### 3.4.1 Respiration rate

In parallel to the CA test, the respiration rates of the rambutan stored under modified atmosphere is determined during the complete test period. The table 2 presents the average respiration rate of the rambutans of the first 13 days of storage under control atmosphere conditions.

**Table 2. Average respiration rate of the 3 varieties of rambutan under several control atmospheres. Rambutans are stored 13 days at 10˚C and control atmosphere.**

| Control atmosphere conditions | Binjai | | Rapia | | Lebak Bulus | |
|---|---|---|---|---|---|---|
| | $O_2$ consumption [nmol/kg · s ] | $CO_2$ production [nmol/kg · s ] | $O_2$ consumption [nmol/kg · s ] | $CO_2$ production [nmol/kg · s ] | $O_2$ consumption [nmol/kg · s ] | $CO_2$ production [nmol/kg · s ] |
| 21% $O_2$ – 0% $CO_2$ | 186 | 190 | 150 | 164 | 141 | 164 |
| 3% $O_2$ – 14% $CO_2$ | 118 | 184 | 117 | 186 | 87 | 156 |
| 3% $O_2$ – 20% $CO_2$ | 103 | 172 | 121 | 189 | 86 | 139 |

The respiration rate depends on the rambutan varieties and the atmosphere conditions. The low oxygen concentration applied during the storage period permits to reduce significantly the respiration rate of the product. It seems that increasing the CO2 concentration and maintaining low oxygen concentration has a limiting effect on the total respiration rate. Whereas some differences of respiration rate values are observed between the varieties of rambutan, it seems that the difference is not important enough to optimize the permeability of LDPE bag used for the E-MAP storage.

### 3.4.2 Sensorial evaluation

The sensorial evaluation is processed directly after opening the control atmosphere containers (22 days). Rot development is observed in each container. The intensity of the fungi development depends on the gas composition applied during the storage period. Under air atmosphere (21% O2 and 0% CO2), the fungi infection

is the most abundant, whereas the fungi development is slightly reduced under low oxygen concentration (3%) and high carbon dioxide concentration (> 14%).
The fungi infection is also favoured by the high relative humidity inside the container. However the high relative humidity is essential to maintain the spintern with green/red coloration. In order to reduce the fungi development, it is recommended to reduce the initial amount of fungi spore by cleaning properly the rambutan and using fungicide (in accordance with the food regulation of Indonesia and of the importer country).

The colour of the rambutan skin is judged not acceptable after 4 weeks of storage (whatever the treatments applied). However low oxygen content with 14 or 17% carbon dioxide contents reduces slightly the brown coloration of the rambutan skin and of the fruit flesh.
The Table 3 summarizes the evaluation of the different quality attributes of the rambutan after the Control Atmosphere test.

**Table 3. Sensorial evaluation of rambutans stored under control atmosphere (10˚C) after 22 days of storage**

| Gas conditions | | | Lebak Bulus | Rapia | Binjai |
|---|---|---|---|---|---|
| 21% $O_2$ | 0% $CO_2$ | Fungi development | ++ | ++ | ++ |
| | | Colour of outer skin | Grey | Black | Brown |
| | | Inside colour of skin | Brown | | Brown |
| | | Colour of fruit flesh | | | |
| | | Taste | | | |
| 3% $O_2$ | 5% $CO_2$ | Fungi development | ++ | | |
| | | Colour of outer skin | Brown | | Brown |
| | | Inside colour of skin | 20% brown | | Brown |
| | | Colour of fruit flesh | White | | Brown |
| | | Taste | ++ | | |
| 3% $O_2$ | 10% $CO_2$ | Fungi development | + | | |
| | | Colour of outer skin | 20% still red | | 5% still red |
| | | Inside colour of skin | 50% white | | Brown |
| | | Colour of fruit flesh | White | | Yellow |
| | | Taste | + / - | | ++ |
| 3% $O_2$ | 14% $CO_2$ | Fungi development | | | |
| | | Colour of outer skin | 20% still red | Black | 10% still red |
| | | Inside colour of skin | 75% brown | Darker brown | Brown |
| | | Colour of fruit flesh | Grey | White | Yellow |
| | | Taste | - | -- (off taste) | + / - |
| 3% $O_2$ | 17% $CO_2$ | Fungi development | | | |
| | | Colour of outer skin | 20% still red | Darker brown | 10% still red |
| | | Inside colour of skin | 50% white | Brown / darker brown | Brown |
| | | Colour of fruit flesh | White / light yellow | Light grey | Yellow / light yellow |
| | | Taste | ++ | -- | ++ |
| 3% $O_2$ | 20% $CO_2$ | Fungi development | | | |
| | | Colour of outer skin | 13% still red | | 5% still red |
| | | Inside colour of skin | Light brown | | Brown |
| | | Colour of fruit flesh | White / Yellow | | Yellow / light yellow |
| | | Taste | ++ | | - |

Although some differences are visible between the varieties and the storage treatments, the quality of the rambutan is judged not acceptable for all of them (Figure 11). Despite of some improvements possible concerning the fungi infection for instance, the storage under control atmosphere condition does not permit to keep the quality attributes of the Rambutan at an acceptable level. It is possible to conclude that under the present conditions, the transport of Rambutan from Indonesia to Europe within control atmosphere reefer container is not conceivable.

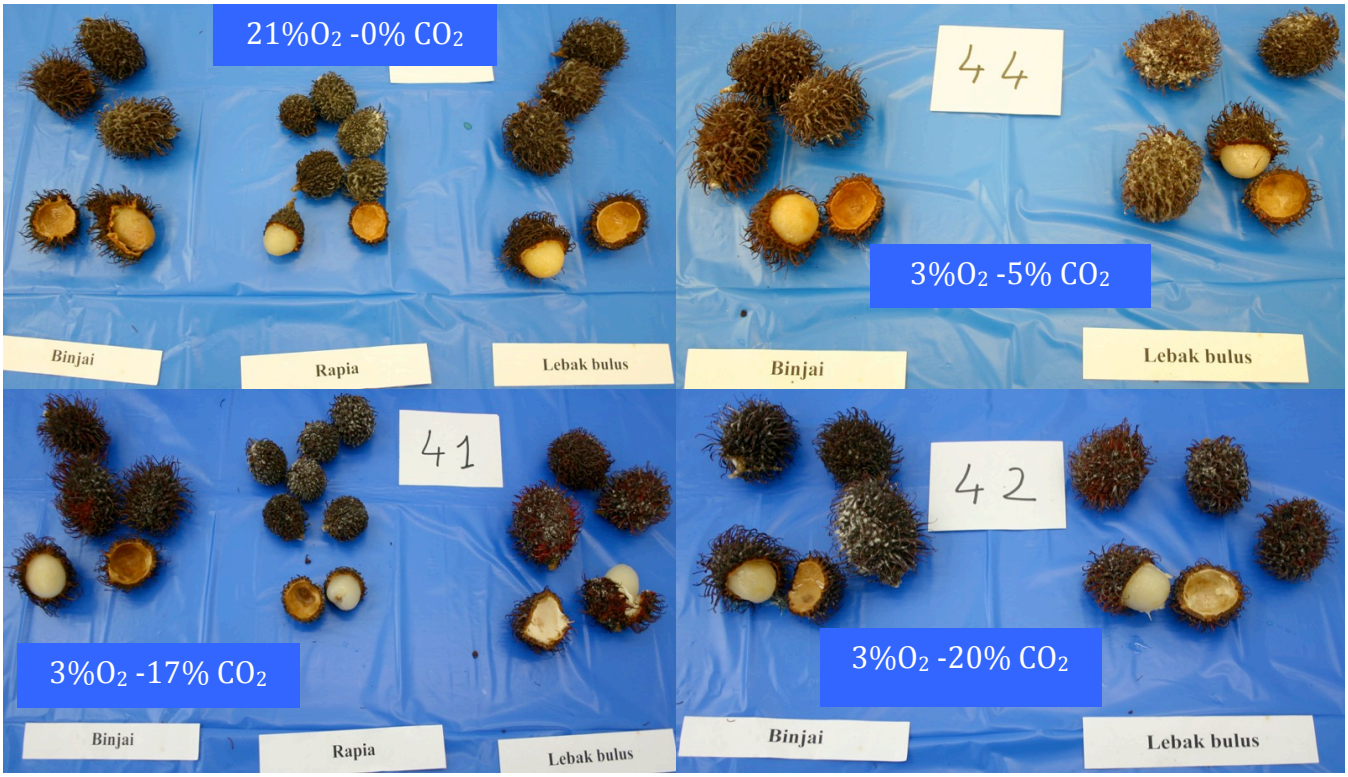


*Figure 11. Rambutan after 4 weeks of Control Atmosphere storage.*

# 4. Conclusions

Rambutans are subjected to huge temperature fluctuations during the transport per plane. It appears that the waiting period at the airport has a non-negligible impact on the storage temperature of the rambutan. As expected, packing the rambutans inside LDPE bags assures the optimal modified atmosphere condition. However, taking into account the high range of temperature occurring during the exportation of the fruits, it is recommended to postpone the packing process to the arrival of the rambutan in Europe.

Taking into account the temperature profile of the exportation trail and the results of the experiments, it is recommended to pack under E-MAP packaging once the Rambutans are imported in the Netherlands. When the Rambutans are stored under E-MAP conditions, a strict control of the storage temperature is needed. This control is easily assured in the European countries (facilities available and temperate climate).

Improving the temperature of the product during the exportation by using cooling box (with aeration holes) and reducing the transit period between the different planes can help to maintain the quality of the fruits.

Rapia variety is not well appreciated by European consumer (importer and experts of Wageningen University). The green colour of the fruit gives the impression that the fruit is not ripe enough. European consumers accept rambutan with red hair and dark red colour of the rambutan skin. As the European consumer is not familiar with the fresh fruit, he/she is less critical with quality attributes of the fruit. Shelf life of 18 days reached for Binjai and Lebak bulus and only 14 days for Rapia (colour and taste not acceptable after 14 days of storage).

*Control atmosphere conclusions*
Knowing that rambutan is a non-climacteric fruit, it is not possible to harvest unripe fruit, transport them to Europe under Control Atmosphere and applied an ethylene choc treatment to induce ripening process. Transport under CA conditions is only possible by using mature rambutan. The present screening showed that long transport under control atmosphere is not possible for rambutan. Indeed after 4 weeks of storage under several control atmosphere conditions, the quality of the rambutan was not maintained to assure any commercialization of the product. Fungi development is one of the main problems met at the opening of the containers. Additionally to this sanitary problem, brown coloration and off-taste development has been observed for the non-optimized atmosphere. CA transport can be probably envisaged for shorter distance. By applying a good sanitary control of the Rambutans and limiting the storage period to 2 weeks, the quality attributes of the Rambutan should be still acceptable for commercialisation upon their arrival.

Additional remarks:

- For exportation purpose, standardization of the Rambutans' quality is needed. Special attention should be given to the control of the ripening stage, the color, the form and the taste of the rambutan.
- Sorting and cleaning are essential to facilitate the exportation of this fruit. In order to avoid the fungi development during the CA transport, appropriated cleaning protocol should be applied and fungicide is may be needed.

## References

A. A. Kadel (2002). “Postharvest technology of horticultural crops.”3rd edition. University of California Agriculture and natural resources 535pp.