STORAGE LIFE OF RAMBUTAN PACKED BY USING MICROPERFORATED EMAP AND CAS TECHNIQUES FOR LONG DISTANCE TRANSPORTATION

Setyadjit[1], Jeroen A. Knol[2], Maxemre Paillart[2], Sri Yuliani[1], Sulusi Prabawati[3], Wisnu Broto[1] and Yessy Rosalina[4].

[1] Balai Besar Penelitian dan Pengembangan Pascapanen Pertanian
Jl. Tentara Pelajar No. 12, Cimanggu, Bogor, Indonesia, 16114
[2] Wageningen University, The Netherland
[3] Pusat Penelitian dan Pengembangan Hortikultura, Balitbangtan, Kementan
[4] Departemen Teknologi Industri Pertanian, Fateta, IPB
Email: Pascapanen@yahoo.com

(Diterima 15-05-2017, Disetujui 10-08-2017)

ABSTRACT

There are many techniques to increase storage life of rambutans, which is a non-climacteric fruit, among others EMAP (Equllibrium Modified Atmosphere Packaging) technique, and CA (Controlled Atmosphere) technique. The laboratory experiment using EMAP technique on rambutan cv. Binjai and Lebak Bulus was conducted using 4 levels of micro-perforation LDPE film, i.e. 0, 5, 10, 30 holes (100 µm), and stretch film (control supermarket); combined with storage temperature (ambient vs10^{o}C). Prior to placing the the fruit at 10 ^{o}C storage room, they have been adapted to 15^{o}C for 24 h. EMAP 10 micro-perforations has been found superior to keep fruit freshness up to 21 days at 10 ^{o}C for both 'Binjai' and 'Lebak Bulus'. Applied EMAP 10 micro-perforation in air transported container from Jakarta to the Netherland (Amsterdam, 40 h; 11365 km distance) showed 18 days of storage for Binjai and Lebak Bulus, only 14 days for Rapiah. Storage by using CA, cannot reached 30 days. Low oxygen (3%) plus CO_2 14-17 % showed better retention of flesh color. Thus, for air tranport was possible to ship rambutan to Europe and packing in EMAP after arrival..

Keywords: rambutan, EMAP, CAS, postharvest, storage life, air transportatiton

ABSTRAK

Setyadjit, Jeroen Knol, Maxe Paillard, Sri Yuliani, Sulusi Prabawati, Wisnu Broto and Yessy Rosalina. 2017. Umur Simpan Rambutan yang dikemas dengan Menggunakan Teknik EMAP Mikroferforasi dan CAS Microperforated untuk Transportasi Jarak Jauh.

Ada banyak teknologi untuk meningkatkan umur simpan rambutan, yang merupakan buah non klimakterik, antara lain teknik EMAP (*Equillibrium Modified Atmosphere Packaging*) dan teknik CA (*Controlled Atmosphere*). Percobaan laboratorium menggunakan teknik EMAP pada rambutan cv. Binjai dan Lebak Bulus dilakukan dengan menggunakan 4 tingkat jumlah lubang pada LDPE film dengan perforasi mikro: 0, 5, 10, 30 lubang (100 µm) dan stretch film (kontrol supermarket); dikombinasikan dengan suhu penyimpanan (kamar vs 10^{o}C). Sebelum menempatkan buah di ruang penyimpanan 10^{o}C, rambutan telah diadaptasi dengan suhu 15^{o}C selama 24 jam. EMAP 10 perforasi mikro lebih unggul untuk menjaga kesegaran buah hingga 21 hari pada suhu 10^{o}C untuk 'Binjai' dan 'Lebak Bulus'. Perforasi mikro EMAP 10 yang diterapkan di kontainer yang diangkut udara dari Jakarta ke Belanda (Amsterdam, 40 jam, jarak 11350.64 km) menunjukkan penyimpanan selama 18 hari untuk Binjai dan Lebak Bulus, tetapi hanya 14 hari untuk Rapiah. Penyimpanan lanjutan dengan menggunakan CA, tidak bisa mencapai 30 hari. Oksigen rendah (3 % O_2) ditambah CO_2 14-17% menunjukkan retensi warna daging yang lebih baik. Dengan demikian, agar tranport udara memungkinkan untuk mengirim rambutan ke Eropa, direkomendasikan menggunakan liner plastic dalam karton dan perlu dikemas dengan EMAP setelah tiba di tujuan.

Kata kunci: rambutan, kemasan atmosfer termodifikasi kesetimbangan, penyimpanan atmosfer terkendali, pascapanen, umur simpan, transportasi udara

INTRODUCTION

Many varieties of rambutan have been cultivated around the world[1], the most widely grown varieties in Indonesia are Lebak Bulus, Rapiah, and Binjai, and still many more varieties existed in the field. Rambutan have to be harvested when color and taste reached eating quality i.e. 16 and 28 days after color break[1,2] or 112 days after full bloom of rambutan flower[1,3].

During development on the tree there are change in sugar, total soluble solids, vitamin C[2] towards the full color ready for harvesting. In fact during storage of various color skin of See-compo showing different pattern of glucose, fructose during storage where sucrose tend to increase at green yellow and yellow fruit, with the compensation of decrease of glucose and fructose[2].

Rambutan is typical of non-climateric fruit since there is not any upsurge respiration rate during storage, they produced only low level of ethylene (<0.04 µl kg-1 h-1) and insensitive to ethylene at low temperature [2,4,5]. Rambutans have plenty spintern on the skin, and on the surface of splintern there are many opened stomatas, thus they have very short storage life due to high transpiration rate [2,3,6].

Rambutan fruit has only short storage life at ambient temperature, with appearance of browning spintern then dried spintern there after within 3–4 days[3,6]. The cause of browning on the skin was proven by[3,6] was the excessive water loss of the spintern, then take out the water in the peel, thus also cause browning on the skin. Result of study by[6] confirm there was higher increase activity of PPL (Phenylalanine Ammonia Lyase), POD (Phenol oxidase), PO (Peroxidase) on the spintern than on the skin when rambutan stored at low level of relative humidity.

A lot of effort has been done by researchers such as application of suspension of microbes in postharvest treatment preventing pericarp browning [8], application of Trichoderma harzianum combined with chelated calcium as pre-harvest spray successfully increased shelf life by disease control[9]. Trichoderma hazianum combined with calcium salt applied as postharvest treatment was also successfully extend storage life of rambutan[10]. In fact the disease of rambutan such as beardsly mealy bug can be control by gamma irradiation of minimum dosage of 166 Gy with a maximum dose of 900 Gy for Rongrien Rambutan[11].

Other postharvest efforts have been used to increase the storage life of rambutan and its family such as low temperature storage[7], chemical treatments, control atmosphere storage and modified atmosphere packaging [3,4]. Best low temperature storage is 7-10^{o}C if not suffered chilling injury in which the susceptibility vary among cultivars. By low temperature storage fruit last for 10-12 days.

Controlled atmosphere storage of rambutan[5] using R162, 'Jit Lee', and R 156 can prolong storage life reach 15 days at 7.5^{o}C, 11-13 days at 10 ^{o}C and 19-20 days at 10 ^{o}C in 9-12 % CO_2. In a special plastic film the storage life of rambutan can reach 21 days at 10 ^{o}C[4]; Latifah[3] packed 'Rong-Rien' rambutan with cling and wrap plastic is the best at ambient can store up to 6 days, compared wrap in banana leaves with control at ambient temperature can only store for 3 days.,

The objective of this research was to find out (1) the number of microperforation in EMAP techniques which gave the maximum storage life. (2) To measure the real storage life of various variety of rambutan during air-transport-export trial when applied the EMAP (Equillibrium Modified Atmosphere Packaging) and CAS (Controlled Atmosphere Storage) technique.

MATERIALS AND METHOD

Materials and Equipments

Rambutan cv Lebak Bulus and Binjai for EMAP Laboratory Scale were harvested from orchard in Sukabumi, West Java. Material for EMAP packaging air Export Trial, EMAPCA rambutan cvs Lebak Bulus and Binjai from an orchard ini Subang, West Java. Rambutan cv Rapiah from an orchard in Cirebon, West Java. Rambutan harvested at optimum ripening, very carefully not dropped from tree. and put in HDPE packaging for harvest, and transported to ICAPRD in Bogor using refrigerated truck. On arrival in laboratory, fruit were detached from Prancis, sorted, and ready for the treatments.

Equipment uses were controlled atmosphere storage-laboratory scale equipment belong to Waginengan University, laser machine for making microholes (100 µm), and i-button temperature and relative humidity logger by maxim.

Methods

EMAP Laboratory scale

Rambutan cv. Binjai were from Sukabumi, West Java whilst for second experiment was from Blitar, East Java. Rambutan cv. Lebak Bulus for both experiment came from rambutan orchard in Subang, West Java. Fruit were directly harvested from the tree at optimum maturity such dark red for Binjai and yellowish red for Lebak Bulus. Fruit were then transported to Laboratory of Indonesian Centre for Agriculture Postharvest Research and Development (ICAPRD) in Bogor, Indonesia in air conditioned vehicle (15 ^{o}C) for further treatments. Stalk of the fruit were cut using scissor left for 2 mm, sorted for physical, pest and disease damage, and even color. Fruit then washed with tap water left dry in air at room temperature. After 2 h pre-cooling at 15 ^oC, fruit were subjected to various temperatures. Packed fruit were stored at 15^oC before they were moved to 10 ^oC for 21 days of storage. Other treatments were packed and direct placement in room temperature (27-30^oC).

EMAP Packaging

Commercial LDPE plastic film 0.04 mm (measurement using micrometer) with anti-fog layer were supplied by Agrotechnology and Food Centre, Wageningen University the Netherland. Size of bags was 25 x 30 cm before closing and 25 x 25 cm after closing with anti-fog inside. The package were previously then put a 100 µm laser holes for 0, 5, 10 and 30 micro-holes. Each bags contained 15 fruits (550 g), then sealed with hot sealer temperature 130 ^oC. Punnet reatment was also made with stretch film mimic the supermarket packaging. Fruit were sampled at 7, 14 and 21 days of storage. Parameter observed were spintern color (scoring), skin color Scoring), texture (scoring), off flavor (scoring), Total Soluble Solids (Refractometer Atago, % ^oBrix), Vit C Content (Titration, mg/100 g), Total Acidity (Titration, %. Color score (see Analyses).

Air-Export Trial

Rambutan was harvested from Orchads in Subang, West Java in 1 hour. Three cultivars were used i.e. Lebak Bulus, Binjai and Rapiah. Rambutan then transported to ICAPRD Laboratory in Bogor in refrigerated car (15 ^oC) (126+115.9 Km distance). At the Laboratory fruit were Cleaned, graded, packed and refrigerated at ICAPRD (14 hours) at 10 ^oC. Fruit were transported from Bogor to Airport (115.9 km distance). Exportation to the Netherland (40 hours) (11.350.64 km distance). Evaluated and further processed in the Netherlands (21 days). Two types of cartboard boxes (7 x 13 x 13cm) waxed inside used. First using fruit were arranged in the box with LDPE plastic liner. Second was using plastic EMAP bag, 6 plastic bag, each 550 g rambutan. Both type of cartboard were transported for exportation.

EMAP-CA

Rambutan packed without EMAP were divided into two lots. Arrived in the Netherland the first lot were packed and non packed in EMAP packaging as outline above. The second lots were stored in Controlled Atmposphere Storage with combination of CO_2(%):O_2(%)=0:21, 5:3, 10:3, 14:3, 17:3, 20:3, at 10 ^oC for 4 weeks by using air flow gas .

Analyses

Sensorial evaluation, and chemical analyses. Color of the rambutan spintern extremities, color of the rambutan in general, rot development, texture and taste of the rambutan were evaluated. Following the criteria and marks used for the sensory evaluation: Color of rambutan spintern: 0= 15 -40% of spintern is green (fresh light green), 1= 10-39% of spintern is green (darker green), 2= <9% of spintern is green, red is the main color, 3= spintern has dark red color (auburn), 4= spintern is completely brown. Color of rambutan in general: fruit surface browning:0= none browning, rambutan color red, 1= 1-20% of total surface is brown, 2= 21-50%, 3= 51-80%, 4= 81-100%. Texture evaluation (open the fruit before evaluating the texture): 1 =soft and watery, 2= soft, 3= crisp, 4= very crisp. Off-flavor evaluation (of the eatable part of rambutan fruit): 1= no off-flavor, 2= mild off-flavor, 3= moderately off-flavor, 4= strong off-flavor, 5= extremely strong off-flavor. Color score was 0: 75%-40% of spintern still green. 1: 10-39% of spintern green. 2: <9% of spintern green. 3: Spintern has dark red colour. 4: Spintern completely brown. Color of the rambutan skin: 1: 100% still red. 2: >50% still red. 3:25% still red. 4: 10% still red. 5: Brown. 6: Black.

The experimental design of EMAP laboratory scale was completely randomised design with 3 replicates. The data were analysed using SAS program.

RESULTS AND DISCUSSION

Results

Effect of microperforation on EMAP technique

Spintern color for 'Binjai' happened at day 7 at room temperature whilst at 10^oC happened at day 14 (Figure 3), and there was not any changes between 14 and 21 days of storage. The stretch showed a little change at day 7 compared to pack of EMAP. Spintern colour, in 'Lebak Bulus' at day 7th, the lowest score was at 30 micro-perforations (Table 1.). At 10 ^oC, the spintern colour started to increase score at day 7, the highest at strech film. At day 21st, the lowest score were at 5 and 10 micro-perforations.

Skin colour score of rambutan cv. 'Binjai' stored at room temperature for 7 days in 10 microperforations was lowest score 3 (Table 1.), compare to the other treatment. At 10^oC up to 14 days of storage, there was not any significant change. At day 21st, it is clear that 10 microperforation is the lowset score whilst no perforations was highest score.

For 'Lebak Bulus' at room teperature the difference happened at day 7, and at day 14 there was any different among treatments (Table 1.). Package with 30 perforations showed lowest score. At 10°C similar to 'Binjai' but it happened very slowly even at day 21 almost all scores still low particularly for 5 and 10 micro-perforations (score 1.5 and 1.2 respectively). It is clear when the skin of rambutan other treatment start browning; the 5 and 10 microperforations not browning yet.

Texture of rambutan cv. 'Binjai' at room temperature of strech film the texture was soft whilst MAP can slightly retard the texture (Table 1.). At 10 °C, after 21th days, texture score of rambutan at 5, 10 and 30 micro-perforations are superior compared to no perforation and strecth film. Texture of 'Lebak Bulus' at room temperature differ to 'Binjai' since, 'Lebak Bulus' at day 7 all the texture score already reach 4 (Table 1.). Texture at day 21th, however, the fruit are all still at 1.0 whilst score for stretch film already reach 2.

Off flavor at room temperature, for 'Binjai' can only been detected at day 7, and the biggest are at strecth film and without micro-perforation (Table 1.). At 10 °C, for 5 and 10 perforations, there is not any off flavor detected, whilst at stretch film there was off flavor; and at 30 micro-perforations and no perforations, there was increased score even though off flavor have not started yet.

'Lebak Bulus' at room temperature showed off flavor very strong at strech film and non-perforated at day 7, whist the other MAP showed midle strength off flavour (Table 1.). At 10 °C, at 21th day, there was not any off flavour on all MAP package except the strech film start having increase score.

Table. 1. Quality parameters of various treatment of Rambutan during storage
Tabel 1. Parameter kualitas dari berbagai perlakuan pada rambutan selama penyimpanan

Cv. Binjai							
Treatments/ *Perlakuan*	Spintern *Color* 7;14;21 d	Skin Color/ *Warna Kulit* 7;14;21 d	Texture/ *Tekstur* 7;14;21 d	Off Flavor /*Rasa Aneh* 7;14;21 d	TSS (° Brix)/ *TPT* (° Brix) 7;14;21 d	Vit C (mg/100 g)/ *Vit C* (mg/100 g) 7;14;21 d	Total Acid (%)/ *Total Asam*(%) 7;14;21 d
Ambient/ *Kamar*							
Strecth film /*Strecth Films*	3.6;4.0;-	3.5;4.0; -	2.4;3.9; -	2.4;3.0; -	18.4a;09.7a;-	52.8a;17.6a;-	0.3a;0.3a;-
0	3.6;4.0;-	3.5;4.0; -	2.4;3.9; -	2.4;3.0; -	16.8a;15.0a;-	66.0a;13.2a;-	0.3a;0.4a;-
5 holes/ *lubang*	3,6;4.0; -	3.6;4.0; -	2.3;4.0; -	2.3;3.0; -	16.0a;13.3a;-	57.1a;13.2a;-	0.5a;0.3a;-
10 holes/ *lubang*	3.5;4.0; -	3.6; 4.0; -	2.3; 4.0; -	2.3; 4.0; -	15.6a;13.9a;-	70.3a;17.6a;-	0.4a;0.5a;-
30 holes	3.4; 4.0; -	3.6; 4.0; -	2.7; 4.0; -	2.5;3.0; -	15.6a;10.7a;-	57.1a;17.6a;-	0.3a;0.5a;-
10°C							
Strech film/ *Strecth Films*	0.0;3.8;4.0	0.0;0.3;2.7	0.0;0.0;1.0	0.0;0.0;0.0	19.2a;19.2a;18.3a	26.4a;43.9a;35.1a	0.3a;0.2a;0.3a
0	0.0;2.9;4.0	0.0;0.6;3.7	0.0;0.0;1.0	0.0;0.0;0.0	18.8a;18.8a;18.8a	36.2a;35.2a;35.1a	0.3a;0.3a;0.3a
5 holes/ *lubang*	0.0;3.3;3.5	0.0;0.1;1.1	0.0;0.0;1.0	0.0;0.0;0.0	18.8a;18.8a;17.8a	40.0a;40.0a;43.7a	0.3a;0.3a;0.4a
10 holes/ *lubang*	0.0;3.3;3.7	0.0;0.0;0.3	0.0;0.0;1.0	0.0;0.0;0.0	19.3a;19.3a;18.8a	36.0a;35.2a;35.0a	0.2a;0.3a;0.3a
30 holes/ *lubang*	0.0;3.1;3.5	0.0;0.0;1.3	0.0;0.0;1.0	0.0;0.0;0.0	19.8a;18.4a;18.8a	36.2a;35.2a;43.8a	0.2a;0.2a;0.3a

Cv. Lebak Bulus							
Ambient/ *Kamar*							
Strech film	3.9;4.0;-	3.9;4.0;-	3.0;4.0;-	3.9;4.0;-	15.9a;-;-	44.0a;-;-	0.5a;-;-
0	3.9;4.0;-	3.9;4.0;-	3.9;4.0;-	3.0;4.0;-	15,4a;11.3a;-	52.1a;19.7a;-	0.4a;0.7a;-
5 holes/ *lubang*	3.8;4.0;-	3.6;4.0;-	3.8;4.0;-	2.6;4.0;-	15.0a;11.9a;-	42,2a;21.2a;-	0.4a;0.7a;-
10 holes/ *lubang*	4.0; 4.0;-	3.8; 4.0;-	3.8; 4.0;-	2.9; 4.0;-	15.3a;11.0a;-	40.0a;22.8a;-	0.5a;0.9a;-
30 holes/ *lubang*	3.5; 4.0;-	3.0; 4.0;-	3.9; 4.0;-	2.5; 4.0;-	15.3a;10.5a;-	66.0a;20.1a;-	0.4a;1.0a;-
10 ^{o}C							
Strech film	1.0;1.9;4.0	0.0;0.0;2.3	0.0;0.0;1.0	0.0;0.0;1.0	18.6a;18.8a;18.5a	26.3a;26.3a;44.0a	0.5a;0.5a;0.3a
0	1.0; 1.9;3.3	0.0; 0.0;3.7	0.0; 0.0;1.0	0.0; 0.0;0.0	18.0a;18.6a;17.4a	30.7a;26.1a;35.1a	0.5a;0.5a;0.4a
5 holes/ *lubang*	1.1;2.8;2.8	0.0;0.5;2.2	0.0;0.0;1.0	0.0;0.0;0.0	18.8a;18.8a;17.7a	30.8a;35.1a;44.0a	0.5a;0.4a;0.5a
10 holes/ *lubang*	1.5;2.7;3.6	0.0;1.2;1.3	0.0;0.0;1.0	0.0;0.0;0.0	18.8a;18.7a;17.2a	30.7a;35.1a;52.7a	0.4a;0.4a;0.4a
30 holes/ lubang	1.3;2.9;3.1	0.0;1.3;2.7	0.0;0.0;1.0	0.0;0.0;0.0	18.8a;18.2a;17.9a	39.5a;26.4a;48.3a	0.4a;0.4a;0.4a

Total soluble solids for 'Binjai' stored at low temperature was higher compared at 10^{o}C (Table 1). Among treatments there is not any trend. Similarly in 'Lebak Bulus', 10^{o}C showed higher values compared room temperature storage (Table 1.). Between 'Binjai' and 'Lebak Bulus' there is a tend of higher in TSS of 'Binjai'.

Binjai at room temperature showed a decline in Vit. C after the fruit alredy rotten at day 14th (Table 1). After 21th storage at 10 ^{o}C, all the treatments tend to increase but among the treatments there is not any significant difference. Similar trend was also observed in Lebak Bulus (Table 1).

Total acid content of Binjai at room temperature when fruit rotten some steady some are increase and one is fallen (Table 1). At end of storage of 10^{o}C, the value are all similar. At Lebak Bulus at room temperature, the acid content at all treatments showed increase when fruit are rotten (Table 1). 'Lebak Bulus' tend to have higher acid content compared to 'Binjai'.

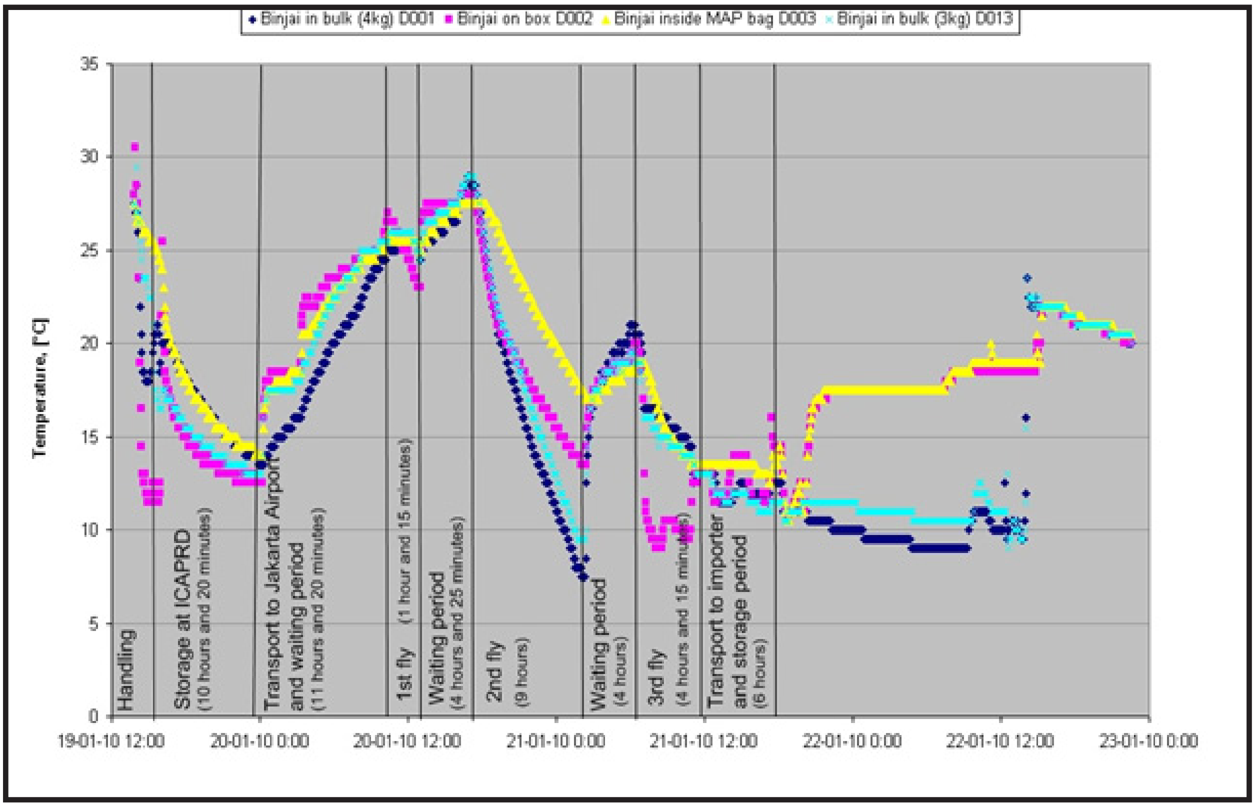
Temperature inside the rambutan E-MAP bags and other packaging was recorded during the air export transport. Temperature profile presents a really high amplitude (21^{o}C) (Fig. 1.). This data indicate that no temperature control during the complete export chain (main problem: during the transit and loading period: product are not stored under cold conditions). Temperature increase particularly during waiting period. This would affect the subsequent storage and display on arrival on destination.

Rapia variety is not appreciated by European consumers (importer and expert of Wageningen University). They were thinking that the fruit is in adequatelyripe (still green). European consumer accepts rambutan with red hair and dark red colour of the skin. This data are obtain by prelimanry comment on the fruit after arrival in the importer and after arrival in the Wageningen University Laboratory.

Taking account into this data, it is not recommended to transport the rambutan without cool box (reducing the influence of external environment on the product temperature) and packed inside E-MAP bag.

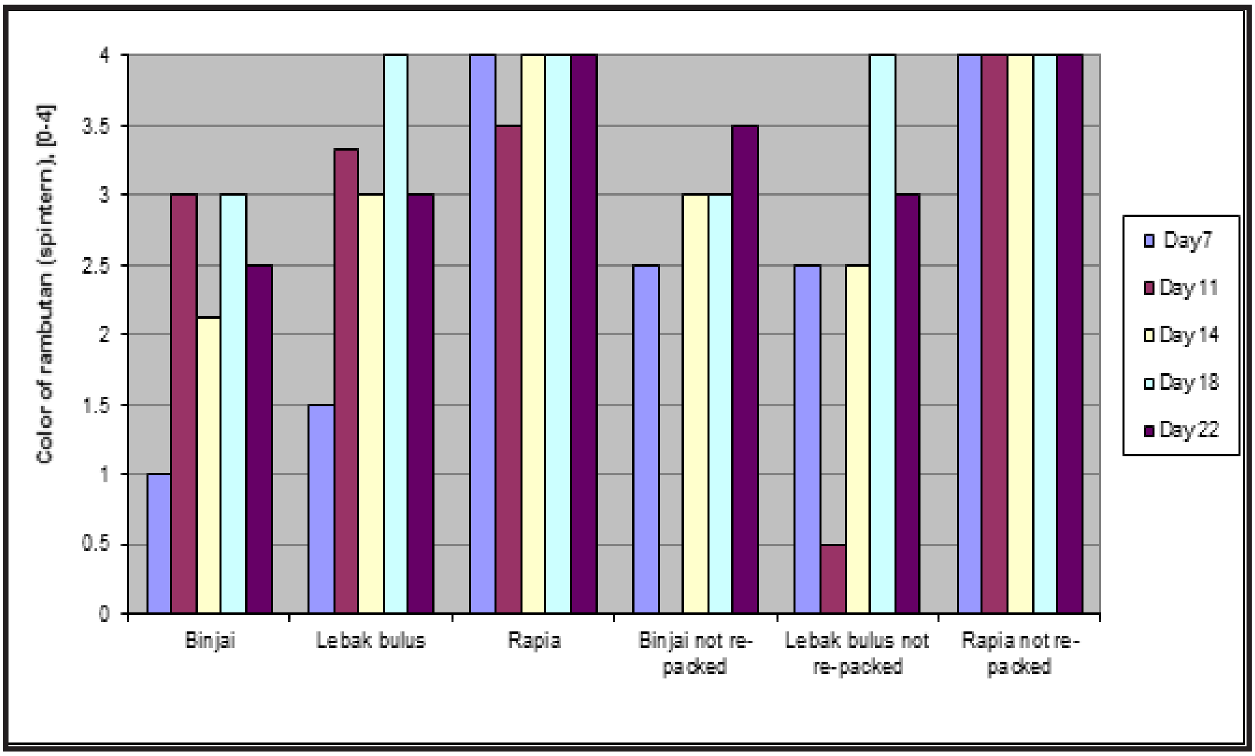
EMAPAir-Transport-

Result of transporation in EMAP bags with transport trial are shown in Graph 2 (Rambutan spintern) and 3 (color of rambutan in general).



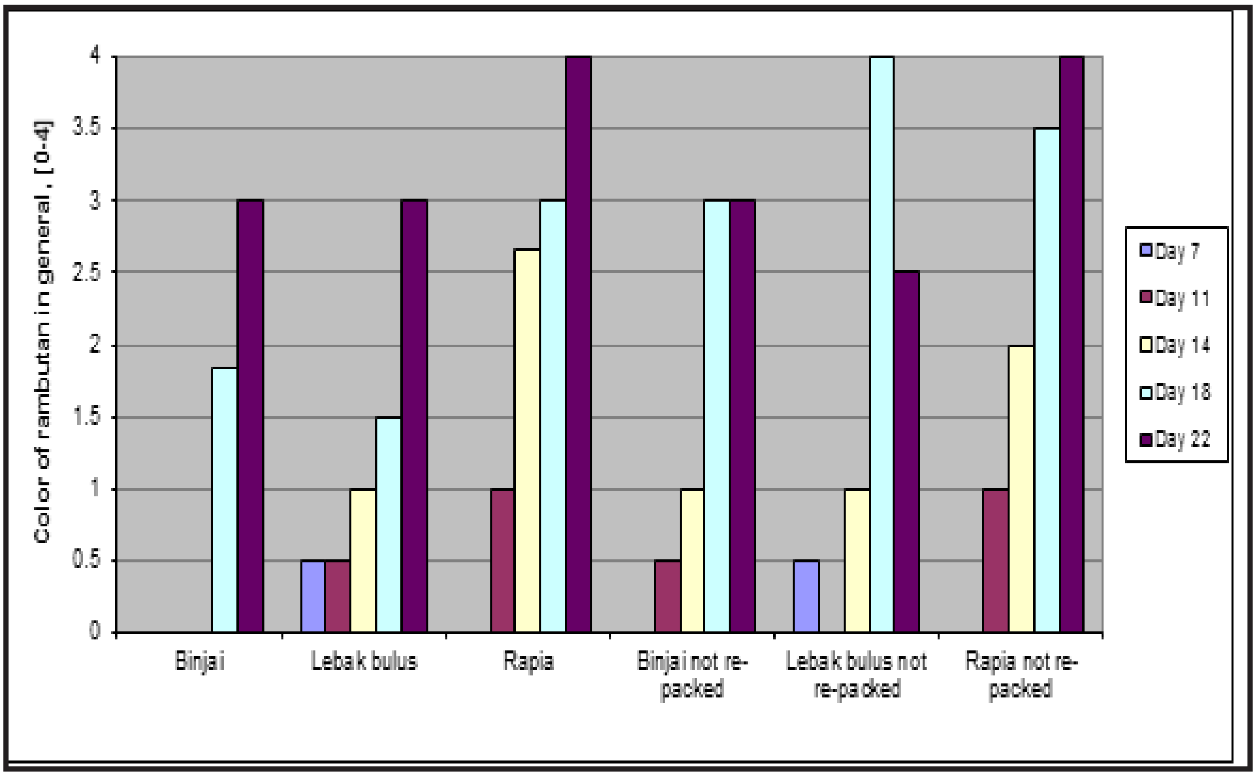
Graph 1. Temperature data from i-button logger

Grafik 1. Data suhu yang di ambil dengan logger i-button



Graph 2. Color of rambutan spintern

Grafik 2. Warna rambut



Graph 3. Color of rambutan in general
Grafik 3. Warna rambutan secara umum

Spintern color was maintained in the first week for Binjai and Lebak bulus but not Rapia. The bad score of Rapia is mainly due to the poor initial quality (lot of spinterns were black before the exportation process). CV. Binjai had better spintern color in both type of packaging can stored up to 22 days whilst Lebak Bulus can only had good color score up to 18 days. Unrepacked had better spintern color retention than repacked one.

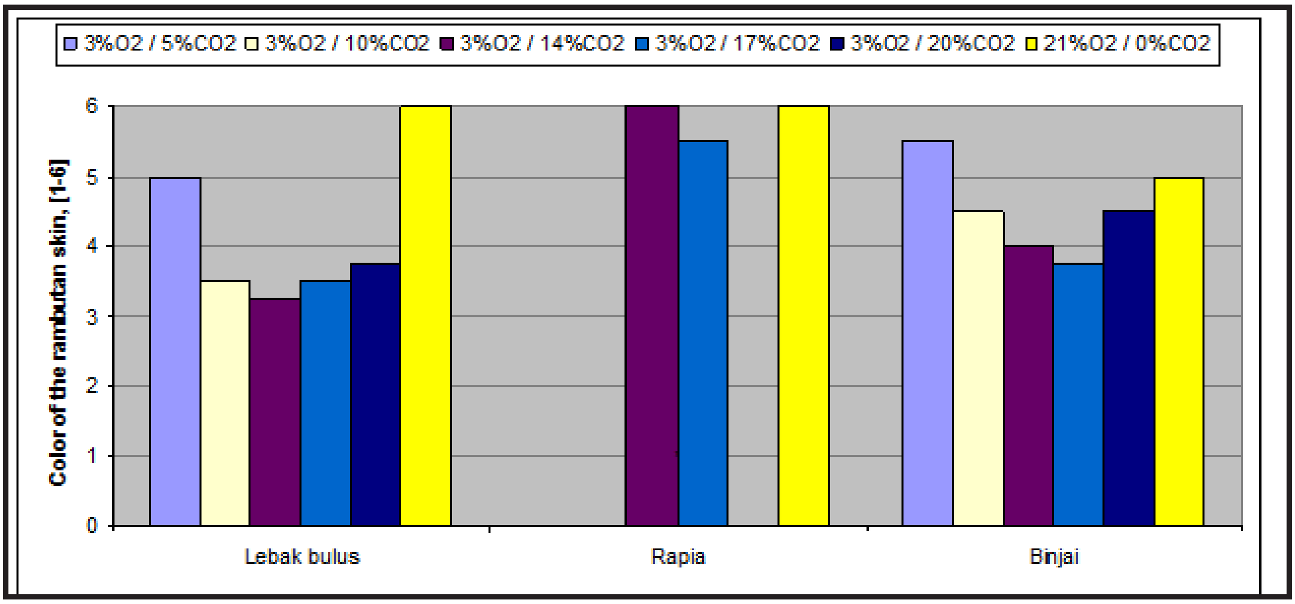
Color in general showed better color retention to all varieties up to 18^{th} days. After 22 days only Binjai of both types of packaging and Lebak Bulus with repacking had best color retention. Rapia at day 18^{th} also better in color retention when it was repacked. Marketable approach for general color (score 2), up to 18^{th} day of storage in Binjai and Lebak Bulus in repacked but not repacked for Rapiaup to day 14^{th}.

It seems that rambutan EMAP packed in Indonesia present less green spintern after exportation particularly for Lebak Bulus. This is due to high temperature fluctuation during the exportation: rambutan packed under E-MAP during the transport are more sensible to temperature fluctuation that rambutan sent in bulk.

Air-Transport-CAS

After air transportation by using plastic liner in the carboard; fruit were stored in CAS (Controlled Atmosphere Storage). Result of the experiment are presented in Graph 4.

Best conditions: was low oxygen concentration (3%) and 14-17% CO_2 contents: Better color preservation of the rambutan, no off-taste development for these storage conditions. It seems that these storage conditions can assume a good quality preservation for a shorter storage period (maximum 2 weeks).



Graph 4. Results of color of various combination of low oxygen and CO_2

Grafik 4. Hasil pengamatan warna dari beberapa kombinasi oksigen rendah dan CO_2

Discussion

Rambutan has specific volatiles than provide unique flavor, mainly are (E)-2-nonenal, and nonanal[15], Rambutan is not only consumed for freshness, but it is contained many bioactive compounds[1], viz. phenolic compound[12], amino butyric acid (GABA) which give effect of anti-depressant[15]. This specific compound are changed accrording maturity stages[12]. Some researcher even study how the axtract the compound such as in GABA[16], and in phenolic compound[17]. Thus it is really useful to extend the shelf life rambutan since it is also to extend the availability of bioactive material naturally.

Rambutan 'Binjai' and 'Lebak Bulus' can be stored longer using equillibrium modified atmosphere packaging microholes (EMAP-microholes) 21 days at 10 °C, however, the only significant beneficial is only at the skin, texture and off flavor whilst the internal quality of flesh such as Vit C content, total soluble solid and total acid have not been improved by the treatments. For storage temperature of 10 °C, it is recommended the use of 10 micro-perforated holes for both varieties, and the storage life can reach 21 days. For rambutan cv. Lebak Bulus, by the tecnique could stored rambutan more than 21 days (see Table 1.) but the additional storage life could be less than one week. For storage at room temperature (30 °C), the 30 micro-holes the only treatment that have an effect and the observations should be done at less than 7 days e.g. 1, 2,4, 6 days of storage (experiment only observed 0 then 1 week).

Compare to other similar research, this micro-perforation-EMAP technique is significantly superior compared to other EMAP. O'Hare et al.5 reported an MAP technique which can kept rambutan 19-20 days at 10 °C , by using elevated CO_2 (9-12%). Yulianti et al. 2012[13] for rambutan cv. Binjai can reach only 20 days at 10 °C using special packaging 0.09 mm LDPE Tekpak.

In this experiment, it was also shown that stretch film packaging combined with gas composition CA storage at 3-5% O_2 and 12-15% CO_2 can kept rambutan up to 18.8 days at 10 °C, not calculated the air transportation from Indonesia to the Netherland. Make microholes up to 5 holes can increase the oxygen permeability from 18.80 ml/m2/mil/day at (37.8 °C) to 27.5 at (23 °C); CO_2 54.5 ml/m2/mil/day increase to un-detectable (too porous to detectable CO_2). Thus, the micro-perforation EMAP technique is superior compare to other usual EMAP technique is because the microholes EMAP techniques can control the amount of oxygen in the package even without giving control to carbon dioxides concentration. Thus, the EMAP microperforation which control concentration of oxygen could be better technique compared to usual EMAP which control carbon dioxides.

Suggestion that lower concentration of oxygen was less beneficial compared to higher concentration of CO_2 by [6] was not evidence in this experiment since the lower concentration of CO_2 and still some O_2 concentration in created in micro-perforated EMAP allow rambutan has longer storage life.

Additional extension of storage life for rambutan for further research can be achieved in two ways i.e. by improvement of EMAP system and improvement of rambutan capability to be stored longer. The most important in the EMAP system is the polymer being used. There are some commercial type of such as Tekpak Indonesia[13], also may be microperforated packaging develop by Wageningen University. Approaching to commercial type of plastic film readily available in Indonesia are polyethylene (PE), and polypropylene (PP). Internationally, there are choices of plastic film such as low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), EVOH as high barrier interlayer, high-density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polyester, i.e. polyethylene terephthalate (PET), polyvinylidene chloride (PVDC), polyamide (nylon) with each has strength and weakness. However, most MAP are still developed from polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP) and polyethylene (PE) for packaging of horticulture produce[18].

The transport by air from Jakarta to the Netherland still has weakness particularly the temperature increase during transport during waiting and transfer within airport. After the fruit in the plane the temperature is as expected and stable. This is why the controlled atmosphere storage is not effectively stored the rambutan even though the gas composition been used the high carbon dioxide as reported and recommended by[5] and also in rambutan family[14].

CONCLUSION

The best number of microholes in EMAP was 10 microholes that gave storage life 21 days for cv. Binjai; and more than 21 days but less than 28 days for cv. Lebak Bulus; at 10 ^{o}C. However, the application of microholes-EMAP technique in the commercial air-transportation system (Ca 11000 km) still cause shorter storage life of rambutan: 18 days for Binjai cv, 18 days for Lebak Bulus cv, and 14 days for cv. Rapiah at targeted 10 oC temperature during transportation and storage life. Real temperatures during transport from ICAPRD to Airport CGK climbing from 14 ^{o}C to 25 ^{o}C; first fly stay at 25 ^{o}C; transit for second fly climbing from 25 ^{o}C to 28 ^{o}C; Second fly fell down from 25 ^{o}C to ranging from 7.5^{o}C to 17,5^{o}C,; waiting for third fly climbing to 25 ^{o}C; during third fly fell down to 20 ^{o}C; transport to importer and storage average temperatures 12 ^{o}C.

Controlled atmosphere storage 14-17 % CO_2: 3% O_2 on the rambutan on air-transport trial gave benefit on brown coloration prevention of rambutan skin but could not reach 4 weeks storage at 10^{o}C.

Thus, it is recommend for long distance exportation such as Europe destination it is used air transport with plastic liner in cardboard box, on arrival Emap can be applied for longer shelf life.

ACKNOWLEDGEMENT

Author thanks to Hortin Centre, The Netherland and Waginengan University for financial support for this project.

REFERENCES

1. Rohman A. Physico-chemical properties and biological activities of rambutan (*Nephelium lappaceum* L.) fruit. Research J. Phytochemistry. 2017;11(2):66-73
2. Tongtao S, Srilaong V, Kanlayanarat S, Noichinda S, Bodhipadma K, Khumjareon S. Leung DWM. Sugar status at harvest and during postharvest storage of *Nephelium lappaceum* cv. 'Sri-Chompoo' fruit from different maturity stages. Int Food Res J. 2015; 22(1):190-195
3. Latifah MN, Abdullah H, Aziz I, Fauziah O and Talib Y. Quality changes of rambutan fruit in different packaging system. J. Trop. Agric. Food Sci. 2009; 37(2):145-151
4. Julianti E, Ridwansyah, Yusraini E, Suhaidi I. Effect of modified atmosphere packaging on postharvest quality of rambutan cv. Binjai. J. Food Sci. Eng, David Publishing. 2012; 2:111-117
5. O'Hare TJ, Prasad A, Coke AW. Low temperature and controlled atmosphere storage of rambutan. Postharvest Biol Technol. 1994; 4: 147-157
6. Yingsanga P, Srilaong V, Kanlayanarat S, Noichinda S, McGlasson WB. Relationship between browning and related enzymes (PAL, PPO and POD) inrambutan fruit (*Nephelium lappaceum* Linn.) cvs. Rongrien and See-Chompoo. Postharvest Biol Technol. 2008; 50: 164–168
7. Noichinda S, Bhodipadma K, Tusvil P, Sathitwiangthong U, Sanngudonm T, Ketsa S. The physiology of chilling injured longan fruit. J. Applied Sci. 2015; 14(1):1-8
8. Martínez-Catellanos G, Shirai K, Pelayo-Zaldívar C, Pérez_Florez LJ, Sepúlveda-Sánchez JV. Effect of *Lactobacillus plantarum* and chitosan in the reduction of browning of pericarp rambutan (*Nephellium lappaceum*). Food Microbiol. 2009; 26: 444-449
9. Chiradej C, Punnawitch Y, and Warrin I. Fungal disease control and postharvest quality during storage of rambutan (*Nephelium lappaceum* L. cv. Rong-Rien) fruits treated with preharvest application of *Trichoderma harzianum*

and chelated calcium. Phillipp Agriculture Scientist. 2012;95(3):312-316

10. Marikar FMMT, Sivakumar D and Wijerathnam RSW. Biological control of rambutan post-harvest anthracnose (*Colleotrichum gloeosporioides*) by combined treatment of *Trichoderma harzianum*-TrH40 culture filtrates and calcium salts. Food Biotechnol. 2008;22:326-337
11. Zhan G, Shao Y, Yu Q, Xu L, Liu B, Wang Y, and Wang Q. Phytasanitary irradiation on beardsly mealy bug (*Hemiptera:Pseudococcidae*) females on rambutan (*Sapindales:Sapindacease*) fruits. Fla. Entomol. 2016;99(spec 2):114-120
12. Thitilertdecha and Rahkariyatam N. Phenolic content and free radical scavenging activities in rambutan during fruit maturation. Sci Hortic. 2011; 129:247-252
13. Sirichote A, Jongpanyalert B, Srisuwan L, Chantacum S, Pisuchpen S, and Ooraikul B. Effect of minimal process on the respiration rate and quality of rambutan cv. 'Rong-Rien'Songkanaklarin J. Sci. Technol. 2008;30 (Suppl 1):57-63
14. Duan X, Su X, Shi J, Yi C, Sun J, Li Y, and Jiang Y. Effect of low and high oxygen-controlled atmosphere on enzymatic browning of litchi fruit. J. Food Biochem. 2009; 33:572-586
15. Ong PKC, Acree TE, and Lavin EH. Characterization of volatiles in rambutan fruit (*Nephelium lappaceum* L.). J. Agric. Food Chem. 1998;46:611-615
16. Meeploy M and Deewatthanawong R. Determination of γ-aminobutyric acid (GABA) in rambutan fruit cv. Rongrian by HPLC-ELSD and separation of GABA from rambutan fruit using Dowex 50W-X8 column. J. Chromatographic Sci. 2016, 54(3):445-452
17. Yongliang Z, Qingyu M, Yang G, and Liping S. Purification and identification of rambutan (*Nephelium lappaceum*) peel phenolics with evaluation of antioxidant and antiglycation activities in vitro. Int. J. Food Sci. Technol. 2017;52:1810-1819
18. Goswami TK, Mangaraj S. Advances in polymeric materials for modified atmosphere packaging (MAP). Woodhead Publishing Limited, India. 2011