INHIBITION OF *DUKU* (*Lansium domesticum*) SPOILAGE USING OZONE

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ABSTRACT

Two dominant spoilages on post harvested *duku* are skin browning and fungal growth. Two types of three-day post harvested duku, i.e. those detached from its raceme and those still attached on its raceme, were exposed to ozone *or* UV-C irradiation for 40 seconds, prior to storage at 29±2°C. The percentage *of duku* with skin browning based on a fixed scale, fungal growth, aril damage, composition changes were examined after 9 days of storage. There was no skin browning, fungal growth and aril datnage on the attached *duku* treated by ozone on the 9th days of post-harvest or the 6th days of storage. The level of total soluble solids and skin thickness of the attached duku were significantly higher than those of detached *duku.* The level of total soluble solids of untreated and UV treated detarhed *duku* were significantly lesser among others. Ozonated *duku* had higher titratable acidity than the UV treated and untreated *duku.* Ozone can be used as an effective, simple and rapid method to prolong the shelf life of *duku* without adversely affecting the quality attributes.

Keywords: duku (Lansium domesticum), ozone, UV-C, spoilage, storage

INTRODUCTION

Duku is one *of* exotic tropical fruit which *is* potential to be promoted as an export commodity. The central production areas of *duku* are spread all over Indonesia. However, the market areas of duku are still limited. Duku must arrive to the market within 1-2 nights as the yellow skin colour will become blackish brown after 2-3 days postharvest. This colour change results in an unattractive

appearance which limits the **market** area, **decreases** the economical values and **increases the percentage** of postharvest loss.

Most farmers **harvest** ***duku*** by grasping the fruit to make it detached from its raceme. Detached duku will have damages on the base of each fruit. The damage promote the respiration rate, production and activity of ethylene which result in overripening, senescence and decay. Senescence stimulated the enzymatic browning ***of*** the skin. In addition, detaching the fruit from its raceme triggers microbial growth, especially fungi. Keeping the fruit attached on its raceme retards the spoilage and lengthens the storage life. However, at day 4-5 postharvest, **mycelia** will be found on the fruit skin, which dictates that browning and **microbial** contamination **must** be handled as soon as possible after duku are harvested (Yanuriati, 2005; Yanuriati **and** Tanzerina, 2007; Yanuriati and Mursidi, 2008; Yanuriati *et* al., 2009).

Ozone exposure and UV-C irradiation can preserve and lengthen the shelf life of some fruits. Ozone has been **used** for decades in many **countries** and recently, the US Food and Drug Administration (FDA) has categorized ozone as a Generally Recognized as Safe (GRAS) substance. Relatively tow concentrations of ozone and short contact time **are** sufficient to inactivate bacteria, moulds, yeast, spores, parasites **and viruses** [Kim *et al.*, 1999; Restaino ***et*** *al.*, 1995). Ozone maintains **quality** and reduces microbial populations in whole and sliced **tomatoes (Aguayo** *et al.*, 2006) **and** blackberries (Barth ***et*** *al.*, 1995). **Ozone is** also **very** effective in scrubbing ethylene through chemical reaction to prolong the storage life of many fruits and vegetables (Rice *et* ***al.,*** 1982; **Xu, 1999).**

Low doses of UV-C irradiation onto fruit **can** act as antifungi and delays the ripening process (Shama and Alderson, 2004). Softening process on UV-C exposed peach for 3,5 **or** 10 minutes is slower than control (Gonzales-Aguilar et *al.*, 2004). The similar phenomenon also found in mangoes [Gonzales-Aguilar, 2001). In addition, endogenous putrescine, spermidine and spermine levels of some fruits increase after UV-C exposure. These polyamines can rise the resistance of fruit from decay (Gonzales-Aguilar, 2004; Gonzales-Aguilar, 2001). **UV-C** treatment can also lessen the incidence of chilling injury (Vicente et al., 2004).

UV-C irradiation and Ozone treatment are safe methods for replacing the use of pesticides and fungicides. Exposure ozone or UV-C irradiation to attached duku may reduce the postharvest damages and can increase the shelf life. These advantages can develop market and competitiveness of the fruit.

MATERIALS AND METHODS

Duku were harvested from farmer's plantation at Serapek, Ogan Komering Ilir South Sumatra. Harvesting was conducted by cutting the *duku*'s **stick** in order to make it remain **attached** to its raceme. The fruit were sorted, packed and sent to Palembang. The 3-day harvested duku were classified into two groups. First, duku that were kept attaching on its raceme, and the second that were detached from its raceme. The detached ***duku*** were exposed to UV-C irradiation or gas ozone for 40 seconds or without exposing. The attached *duku* were exposed to UV-C irradiation for 0, 20, 30, or 40 seconds. Afterwards, the fruits were packed in ventilated corrugated cartoon and stored at 29±2°C for 6 days. Weight loss, percentage of browning *duku*, fungus growth, aril's damage, soluble solids, titratable acidity and vitamin C were analyzed on **the** initial and on the sixth day of storage [or **ninth** day after harvest).

The weight loss was measured gravimetrically. The initial weight is substracted with the 6th day storage weight, and then divided by initial weight and multiplied by 100%.

The percentage of ***duku*** browning were **counted** by drawing the surface area and the browning **area** of **the *duku*** skin on plastic. The percentage of surface area of *duku* skin was analyzed by leaf area meter and the browning area were measured using mm block paper. The percentage of duku browning were classified into 5 categories, i.e.no skin browning areas, 1-10% browning areas. 10-25% browning areas, and >25% browning areas on the **skin,** and spoiled.

The fungal growth and aril **damage** were analyzed macroscopically. The existence of **fungi was** analyzed visually. The arils is considered damaged when one ***or*** more aril epidermis **decayed.**

Titratable acidity, total soluble solids and vitamin C content were analyzed by using the same juice sample. **Seven** *dukus* were

peeled, the arils were then blended and approximately 10 mL of juice **was** used for analyses. The **juice was** titrated with 0.1 NaOH and phenolphthalein indicator. Total soluble solids **were** analyzed by using **digital hand** refractometer which had been calibrated to zero value with distilled water. Vitamin C was analysed **using** 2,6-D (dichloro indophenols) after HPO3-acetic acid addition.

Percentage **of** fungal growth and aril damage was transformed to the arcsine. **An** analysis of variant was used to the transformed data as **a** quantitative variable, weight loss, total soluble solids, titratable **acidity** and vitamin C. The LSD test was used to determine differences at $\alpha = 0.05$.

RESULTS AND DISCUSSION

Results

Percentage of Browning

The skin browning of duku could be inhibited by exposing the **fruit** to UV-C irradiation or ozone for **40** seconds **(Table 1)**. For the attached *duku,* the browning inhibition levels were higher at ***duku*** exposed to ozone for 40 second than at duku with **UV-C expossure** for 40 seconds. After 6 day of storage or 9 day postharvest, the attached duku with ozone exposure showed no browning on the skin, whereas the attached duku with UV-C irradiation exposure had browning on the skin. The percentage of attaced ***duku*** with UV-C exposure without browning on the skin (Table 1) was 47.15%. Ozone exposure onto detached duku did nor effectively inhibit skin browning since the inhibition **was** only about 15%.

Table 1. Percentage of browning *duku* based on scale of browning

Treatment		Percentage of browning on skin of *duku*				
The conditions of *duku*	Treatment	No browning	< 10	>10-25	>25	Spoil
Attached	Control	0	5	15	60	20
	UV-C	47.82	4.34	21.73	4.32	21.73
	Ozone	100	0	0	0	0
Detached	Control	0	4.55	0	50	45.45
	UV-C	0	19.04	*9.52*	38.09	33.33
	Ozon	15	25	15	25	*20*

Percentage of duku with fungal growth and aril damage

The **percentage** of *duku* attacked **by fungi** and aril damage in attached and **detached** *duku* was similar. **There** was **higher level** of fungal growth and aril damage on detached *duku* than those attached, although there **was** no significant difference. On day **9** of postharvest or **day** *6* of storage, the attached *duku* with ozone **exposure for** 40 seconds did not **have** fungal growth or aril **damage.** On the other hand, the fungal growth or aril damage on UV-C **exposure on** both **duku types** could not be **inhibited. Fungal growth** and aril damage in the attached *duku* was effectively **inhibited** until 9 day postharvest or 6 **day** after exposing by ozone (Tabel 2).

Weight Lass

The weight loss of *duku* **was** not affected by duku condition, **kinds** of treatment, **and** the interaction between condition and kinds of treatment, although **UV-C** exposure on the attached *duku* had the lowest weight loss (Table **3).**

Table 2. Percentage of duku with fungal growth and aril damage

Treatment	Fungus growth		Aril damage	
	Average	Arcsin average	Average	Arcsin Average
***Duku* conditions (A)**		ns		Ns
Attached	13.612	19.346a	13.612	19.346a
Detached	31.388	31.748a	31.388	31.748a
Treatment		ns		Ns
Control	30.416	31.665	30.416	31.665
UV-C	27.084	28.719	27,084	28.719
Ozone	10	16.228	10	16.228
Interaction A x B		*		*
detached	40.833	38.04a	40.833	38.04a
detached, UV-C	33.333	33.37ab	33.333	33.37ab
Attached	20	25.29ab	20	25.29ab
Attached, UV-C	25.6	24.13ab	25.6	24.13ab
detached, Ozone	20	23.84ab	20	23.84ab
Attached, ozone	0	8.62 b	0	8.62 b

Skin Thickness

During senescence, the skin of duku became thinner. The skin thickness of duku was not significantly affected either by kinds of treatment or the interaction between condition and kinds of treatment, although UV-C and ozone exposure duku tend to have a thicker skin than control. Skin thickness of duku was significantly affected only by conditions of duku. Keeping the *duku* attached to its raceme could significantly inhibit the loss of thickness (Table 3).

Total Soluble Solids *(TPT)*

Total soluble solids were significantly influenced by the conditions of duku and the interaction between conditions and kinds treatment of duku. A significant greater level of total soluble solids was found on attached duku than detached *duku.* On day 9 postharvest, attached *duku* exposed by UV-C had the highest levels of total soluble solids, followed by attached duku with ozone exposure, detached duku with ozone exposure and attached *duku* without exposure. Total soluble solids of these treatments were not significantly different. However detached duku without exposure and

detached ***duku*** with **UV-C exposure** significantly had the least total soluble solids content. Exposure to UV-C could significantly inhibit the reduction of total soluble solids only at attached duku, but ozone exposure could significantly inhibit the decrease in total souble solids both on attached and **detached *duku*** (Tabel 3).

Table 3. Changes of weight loss, TPT, KAT and vitamin C of *duku*

Treatment	Weight lass (%)	Skin thickness (mm)	TPT (°Brix)	KAT (%)	Vitamin C (mg/100 mL)
***Duku* conditions (A)**	ns	**	**	ns	Ns
Attached	14.836	0.93a	19.233a	0.275	10.967
Detached	16.051	0.80b	18.579b	0.267	10.507
Treatment (B)	ns	ns	ns	*	Ns
Ozone	15.659	0.88	19.175	0.293a	9.818
UV	15.642	0.92	18.781	0.258b	10.852
Control	15.030	0.80	18.763	0.263b	11.541
Interaction A x B	ns	ns	*	ns	Ns
UV-C, attached	14.405a	0.97	19.475a	0.259	10.680
Ozone, attached	15.337a	0.96	19.175a	0.288	9.991
Ozone, detached	15.981a	0.80	19.175a	0.298	9.646
Attached	14.767a	0.88	19.050ab	0.279	12.230
Detached	15.293a	0.72	18.475bc	0.247	10.852
UV-C, detached	16.879a	0.87	18.088c	0.256	11.024

Note: average followed by different alphabet means significant different (p>0,05)

Titratable Acidity

The titratable acidity of duku was not significantly affected either by conditions of duku, or by the interaction between conditions and kinds of treatment. Titratable acidity of duku **were** only influenced significantly by **kinds** of exposure. Titratable acidity of *duku* oxposed by ozone were significantly higher and differrent than the others. This **fact explains that treatment** using ozone would inhibit the use of substrate for respiration.

Vitamin C

Vitamin C were not significantly affectedeither by the condition of duku, kinds of treatment or interaction betwen them [Table 3).

Discussions

Exposure to ozone for 40 seconds could retard over ripening and spoilage. No browning, visual fungal growth and aril damage were detected on attached duku on day 9 postharvest or 6 day storage, while 47.12% browning, and 25.6 % fungus growth and aril damage were found in UV-C exposed *duku.* The other treaments have browning, fungal growth and aril damage at a greater levels compared to these 2 treaments.

Exposure to ozone for 40 seconds delayed over ripening or senescence. The ethylene was chemically removed from fruit surface and storage atmosphere, and the formation was prevented. Ethylene was known could enhance the over ripening, senescence, cell ion leakage and oxidative enzimatic browning. In addition, mycelia and sporulation damaging the aril of duku could be stopped by ozone exposure for 40 seconds. Baratharaj (1995) reported that ozone could also promote the healing of wounds and enhance resistance to further infection. This study correlate with the founding in this research that in detached duku treated by ozone, there was about 15% of no browning and 80% of no fungal growth and no aril damage.

Exposure of UV-C irradiation for 40 seconds inhibited browning, fungal growth and aril damage of *duku.* The 3-day harvested *duku* might have a greater initial fungi load contamination from field, and during harvesting. The duration of UV-C exposure on the fruits was too fast, therefore incapable to kill fungi. Further researches were required to find out the optimal exposure time and post harvest handling to reduce spoilage and lengthen the shelf life of the fruit. Attached duku with UV-C exposure had thicker skin and higher TPT levels than ozone exposure. The slower physicochemical changes could contribute the results (Gonzailes-Aguilar, 2004, Gonzales-Aguilar, 2001, Ponappa *et al.*, 1993). It was showed that UV-C exposure can stimulate the increase on putrescine, sperrnidine and spermine. These polyamines can maintain the integrity of cell membrane and inhibit senescence, In addition, Yanuriati *et al.*,

(2009) also found that UV-C exposure for 40 seconds could be used as an effective method to lessen the spoilages and lengthen the shelf life of fresh attached *duku* for 9 days at 29±2°C. After 9 days storage, no fungus growth and aril damages were detected on the fruit. The fruits had significantly higher level of vitamin C and no significantly higher levels of total soluble solids and titratable acidity. However, about 67.74% of the fruit had no skin browning and 22.58% of the fruit had skin browning less than 10%.

The ozone exposure was not effective to be applied on detached *duku*. It can be depicted from Tabel 3 that attached *duku* significantly have a thicker skin and higher levels of TPT than detached *duku*. Detaching *duku* would cause wounds at the stem end. The would trigger the respiration, ethylene production and activity rates. As a consequence these could accelerate senescence. During senescence, integrity of cell membrane decreased which resulted in ion leakage and oxidation of polyphenol by polyphenolase. The wounds also provides nutritions for fungal growth (Yanuriati, Yanuriati, 2007). Ozone inactivated microorganisms rapidly by reacting with intercellular enzymes, nucleic material, and components on their cell's envelope, spore coats, or viral (Khadre *et al.*, 2001). Furthermore, ozone controled *Rhixopus stolonifer* and induced resveratrol and prostilbene phytoalexins in table grapes and these made the berries were more resistant to subsequent infection (Sarig *et al.*, 1996).

CONCLUSIONS

Exposure to ozone for 40 seconds was an effective method to reduce skin browning, fungus growth and aril damage with higher levels on total soluble solids.

The self life of *duku* exposed to ozone for 40 seconds was days.

of UV-C for 40 seconds to *duku* was ineffective to reduce spoilages, although it tended to maintain the chemical of postharvest *duku*. Extending UV-C irradiation time may be required to effectively lessen the spoilage of *duku*.

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