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Fruit Quality of Guava (*Psidium guajava* 'Kristal') under Different Fruit Bagging Treatments and Altitudes of Growing Location

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Abstract

Fruit quality is an important aspect that requires attention and more study when it comes to commercializing tropical fruits, including guava 'Kristal'. This study aimed to evaluate the effect of bagging treatment and altitude of growing orchard on fruit quality of guava (*Psidium guajava* var. 'Kristal'). This study was conducted at two local orchards managed by small scale farmers, at Gunung Batu (1000 meter above sea level, m asl) and Brajaselebah (25 m asl), Lampung Province, Indonesia. Nested design was applied to test 5 types of bagging treatments and 2 levels of land altitude. Fruit quality was assessed by measuring both physical and chemical characteristics. Fruit size indicated by fruit weight and diameter was significantly larger in lowland compared to highland. The total soluble solid (TSS) was significantly higher in lowland compared to highland, while titratable acid (TA) showed an opposite result. Vitamin C of the fruits varied from 140 to 146 mg per 100 g. Different types of fruit bagging and land altitudes did not affect the physical and chemical characteristics of "Kristal" guava fruits. Fruit scar intensity was higher in lowland, especially in fruit without bagging. Fruit bagging is highly recommended for farmer due to the success of this treatment to reduce fruit scar intensity, thus resulting in good fruit quality, irrespective of the growing locations.

Keywords: land altitude, fruit quality, total soluble solid, titratable acid, vitamin C

Introduction

Guava (*Psidium guajava*) is one of the popular tropical fruits worldwide due to its delicious taste and

nutritious content. Earlier studies reported that guava is rich in vitamin C, comparable to citrus and pomelo (Kalsum et al., 2015; Romalasari et al., 2017). One of the popular guava varieties in Indonesia is 'Kristal'; it was introduced from Vietnam and recently widely cultivated due to the suitability to agroclimatic factors in Indonesia. Several studies have been conducted to improve guava tree growth and to increase the production by applying biofertilizer (Widyastuti et al., 2021a), organic fertilizer (Widyastuti et al., 2021b), artificial shading (Budiarto et al., 2019), and canopy manipulation (Widyastuti et al., 2019a; Budiarto et al., 2018). More efforts should be made to improve fruit quality in guavas, in addition to increasing fruit production (Musyarofah et al., 2020).

Fruit quality is an important issue, especially for products that are consumed in raw and fresh, such as guavas. Guava fruit quality derived from conventional farming may be subjected to pesticide residue and inappropriate pesticide dosage. In order to achieve profitable agribusiness and minimize the negative impact on the environment, sustainable agriculture practices are recommended (Listiana et al., 2021). In a sustainable agriculture, there is a need to replace chemical pesticide with more environmental-friendly substances such as biopesticide. In addition to biopesticide, physical treatments to minimize the deterioration of fruit quality, such as fruit bagging, are needed.

Fruit bagging is suitable in guava organic systems (Neto et al., 2020). Fruit bagging can improve fruit coloration (Kim et al., 2008) and reduce the damage from pest, disease, sunburn, mechanical injuries and agrochemical residues (Jing et al., 2008; Sharma et al., 2014; Xu et al., 2018; Campbell et al., 2021). Fruit bagging has been widely used in numerous fruit

commodity, such as apple (Frank 2018; Teixeira et al., 2011), pomegranate (Bagle, 2011), mango (Sarker et al., 2009), litchi (Debnath and Mitra 2008), loquat (Ko et al., 2010), pear (Wang et al., 2011) and guava (Sharma et al., 2020; Parameswara and Susanto, 2019; Morera-Montoya et al., 2010). More studies should be conducted to improve the success of fruit bagging in maintaining fruit quality (Ali et al., 2021). To achieve the optimum fruit bagging treatment, it is necessary to evaluate this technique on both low and high altitude areas, where guavas are grown. The difference of altitude of the growing location may cause variation of agroclimatic, yield, growth and plant metabolite content (Efendi et al., 2021; Widyastuti et al., 2019b). Earlier study has implied that metabolite content is an important variable related to ground cherry fruit quality (Mubarok et al., 2021). Unfortunately, there is still limited study reporting the effect of guava fruit bagging in different growing location. Therefore, this study aimed to evaluate the fruit quality of 'Kristal' guava in response to different fruit bagging treatment and altitude of growing location in Indonesia.

Material and Methods

Study Site

This study was conducted between March to June 2021 at two local guava orchards managed by small scale farmers, at Gunung Batu (1000 meter above sea level, m asl) and Brajaselebah (25 m asl), Lampung Province, Indonesia.

The orchards grow three-year-old guava trees (*Psidium guajava* var. Kristal) that were being managed under intensive cultures, as indicated by triannual pruning, monthly weed control, precisely determined fertilizer doses, i.e., 40 kg of organic fertilizer and 250 g NPK per tree. This study was arranged in a nested design, with two factors, i.e., bagging treatment and altitude of growing location. Measured fruits were collected from 5 bagging treatments: (1) white plastic bag, (2) black plastic bag, (3) blue plastic bag, (4) transparent plastic bag and (5) no plastic bag/control. The guava trees in this study were grown at low altitude (100 m asl) or high altitude orchard (800 m asl). Fruits with no fruit scar were bagged when the fruit diameter reached 2 cm. The bagging treatment was maintained until the day of harvesting. The bagging was done on the same day, during a sunny morning. There were 10 combination treatments and were replicated 10 times, so that there were a total of 100 fruits from 20 individual trees prepared for observation.

At harvest, fruits were manually picked and stored in

a close container during the transfer to the laboratory. The fruits were measured for diameter, weight, softness, scar intensity, vitamin C content, titratable acid content, total soluble solid, and ratio of total soluble solid to titratable acid. Fruit diameter (cm) was measured using digital caliper on the widest part of the fruit, i.e., the middle. Fruit weight (g) was measured using digital analytical balance and expressed in wet basis. Fruit softness was measured using penetrometer and expressed in mm per 50 g per second. This measurement was conducted in three spots within a fruit, i.e., upper, middle and lower parts. Fruit scar intensity (%) was measured based on the ratio of the scar area to the total peel area. The entire fruit peel was detached from the fruit and then scanned using ImageJ software for area calculation. Vitamin C (mg per 100 g⁻¹) content was measured in guava juice by following standard Iodine titration method (Rahman et al., 2015). Titratable acid (%) was measured by using 0.1 N NaOH titration method and indicator of phenolphthalein following Sadler and Murphy (2010). Total soluble solid (°Brix) was measured by subjecting the guava juice on refractometer lens (PAL-1 Atago).

Data Analysis

All measurements were subjected to analysis of variance (ANOVA) and Duncan post hoc test at $\alpha = 5\%$, if any significant differences were found. Statistical analysis was done using the program STAR version 2.0.1.

Result and Discussion

The altitude of growing location significantly affected all fruit quality variables, except fruit softness and vitamin C. Additionally, fruit bagging significantly affected both fruit scar intensity and total soluble solids of 'Kristal' guava. Guava fruit quality with different bagging treatments is similar, both at low and high altitudes (Table 1).

The difference of bagging treatment showed slight variation in fruit diameter, i.e., ranging from 7.88-7.85 cm (Figure 1A). In contrast, the fruit diameter was significantly higher in fruit harvested from lowland (8.03 cm) than fruit from highland (7.65 cm) (Figure 1A). The greater diameter observed in lowland-originated 'Kristal' guava fruit was supported by greater fruit weight obtained. The fruit weight of lowland fruit was 259 g and it was significantly higher than the highland ones, i.e., 217 g (Figure 1B). There was approximately 19% weight improvement among lowland compared to highland fruits. This finding was supported by results from previous studies (e.g.

Table 1. The result of analysis of variance of 'Kristal' guava fruit quality in response to different fruit bagging treatments and altitudes

Treatment	FW	FD	FS	FSI	TSS	TA	TSS/TA	VC
Fruit Bagging (F)	ns	ns	ns	**	**	ns	ns	ns
Land altitude (L)	**	**	ns	**	**	**	**	ns
Interaction F x L	ns	ns	ns	ns	ns	ns	ns	ns

Note: FW- fruit weight, FD- fruit diameter, FS- fruit softness, FSI- fruit scar intensity, TSS- total soluble solid, TA- titratable acid, TSS/TA- ratio of TSS to TA, VC- vitamin C, ns – not significantly different, * * significantly different.

Musyarofah et al., 2020; Widyastuti et al., 2019a). Fruit weight is an important attribute of 'Kristal' guava. Most consumers prefer the 'Kristal' guava fruit with a weight of more than 250 g than the small/light one (Unpublished data). Thus, the production of heavier fruit (>250 g) could potentially improve the income and profit of fruit farmers.

The fruit softness of 'Kristal' guava varied from 0.42-0.46 mm.g⁻¹.s⁻¹ (Figure 1C). The fruit softness is related to the composition of the cell wall, such as

cellulose, hemicellulose, lignin, and pectin; where the decline of these variables lead to the softer fruit texture (Jain et al., 2003). In contrast to fruit softness, the fruit scar intensity was significantly affected either by land altitude and fruit bagging treatment (Table 1). The intensity of fruit scar was significantly higher in the control fruits compared to bagged fruit, irrespective of color variation of the bags. The control fruit had fruit scar intensity of about 7.7%, while transparent bagged fruit had 0.88%, followed by black, white and blue bagging treatment of 1.75%, 1.85%, and 2.5%,

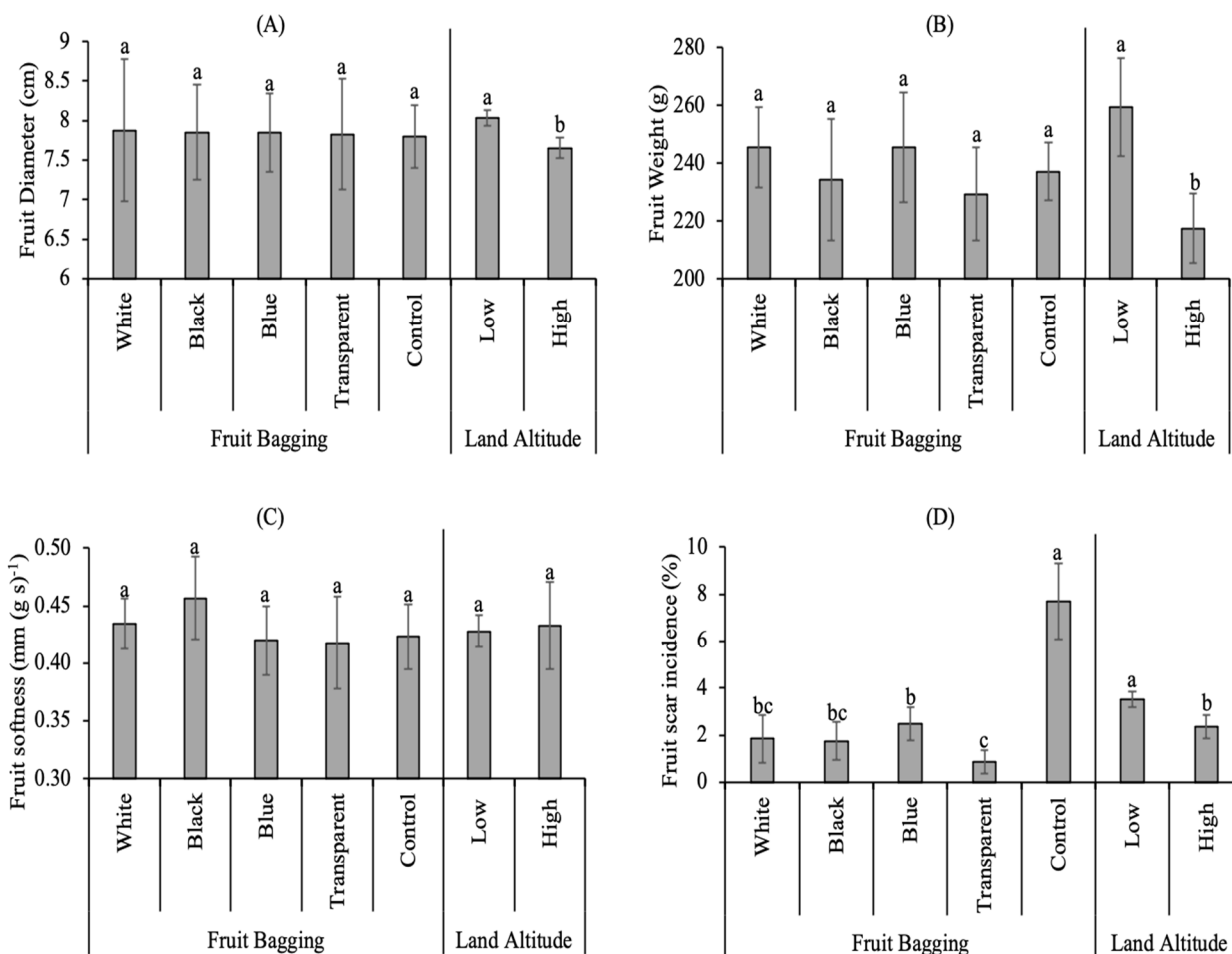


Figure 1. Physical quality of 'Kristal' guava fruit in response to two factors, i.e., fruit bagging treatment and land altitude. Note: 1A – fruit diameter, 1B – fruit weight, 1C- fruit softness, 1D- fruit scar incidence. The different alphabet above the rectangular bar is significantly different among the same factor based on the Duncan's multiple range test at $\alpha = 0.05$; the error bar represents the standard deviation.

respectively (Figure 1D). The higher scar intensity in control fruits could be attributed to natural scarring pest infections in the orchards. The bagging practice was proven to reduce the damage of scarring pest on fruit appearance quality. This finding was in agreement with previous studies in Taiwanese guava (Morera-Montoya et al., 2010), apple (Frank, 2018; Teixeira et al., 2011), pomegranate (Bagle 2011), mango (Sarker et al., 2009), litchi (Debnath and Mitra, 2008), loquat (Ko et al., 2010) and pear (Wang et al., 2011).

Besides physical quality, there was also the assessment of chemical fruit quality, as indicated by total soluble solid (TSS), titratable acid (TA) and vitamin C content. The highest TSS of 8.86 °Brix was recorded in 'Kristal' guava fruits that were covered by white plastic, whereas the lowest TSS was from the control fruit, i.e., 8.55 °Brix (Figure 2A). However, the variation of TSS among four bag colors was not significant and ranged from 8.74-8.86%. In response to different growing altitude, the fruit from lowland had significantly higher TSS (8.90 °Brix) compared to

those from the highland (8.57 °Brix). This finding was similar to the result of previous studies (Musyarofah et al., 2020). In contrast, high-altitude fruits had a significantly higher TA (Figure 2B). This finding was in agreement with an earlier study (Solarte et al., 2014), however it was in contrast with another study (Parra-Coronado et al., 2018). Present findings implied that Kristal guava fruit had more acid and taste more sour compared to the fruit from lowland. Fruit maturation stage highly influenced the level of TSS and TA in fruit, where the TA decreased and TSS increased as fruit ripening occurred (Dolkar et al., 2017).

Chemical quality of 'Kristal' guava fruit in response to fruit bagging treatments and land altitude. Note: 1A- total soluble solid, 1B- titratable acid, 1C- ratio of total soluble solid to titratable acid, 1D- vitamin C. The different alphabets above the rectangular bars show significantly different among the same factor based on the Duncan's multiple range test at $\alpha = 0.05$; the error bar represents the standard deviation.

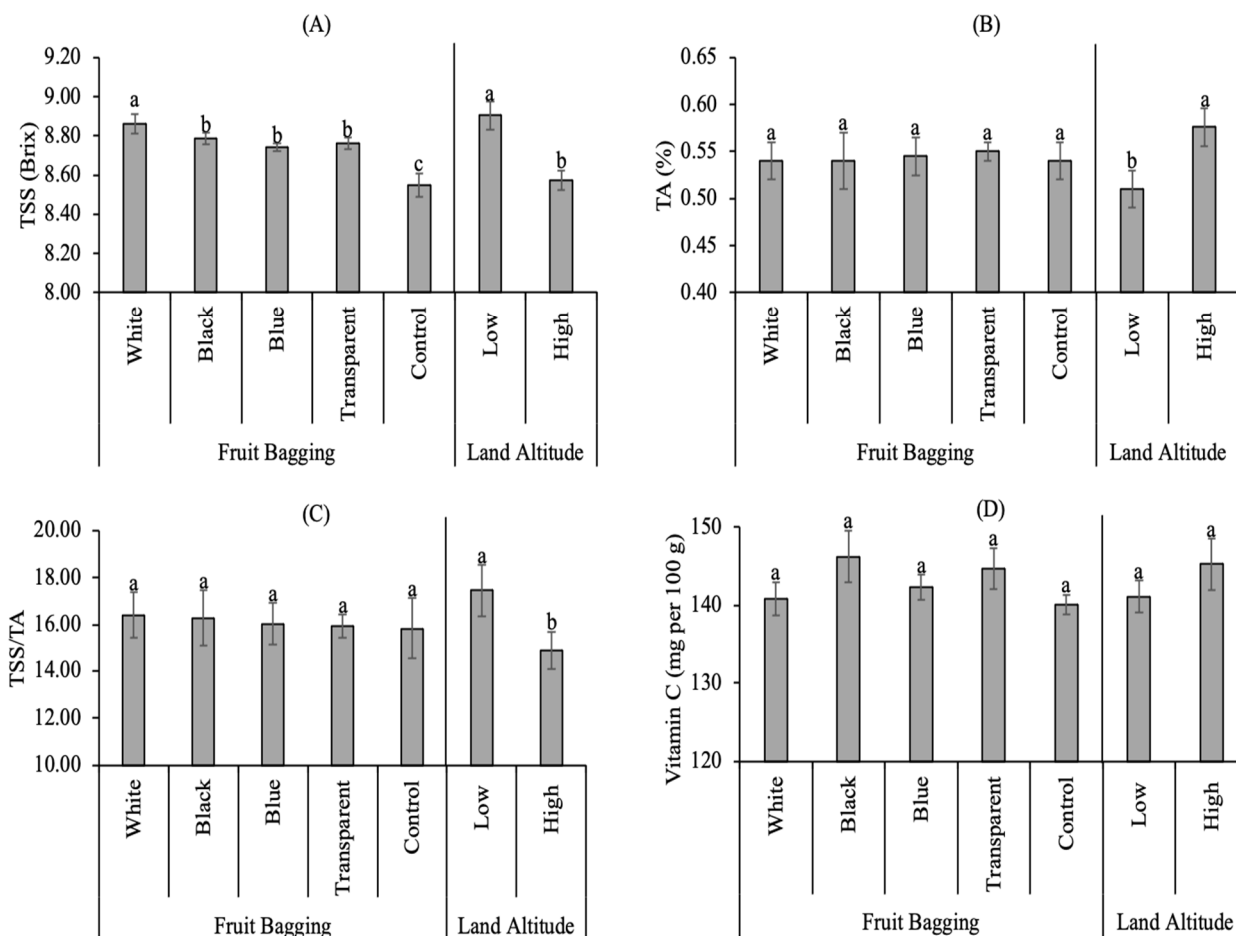


Figure 2. Chemical quality of 'Kristal' guava fruit in response to fruit bagging treatments and land altitude. Note: 1A- total soluble solid, 1B- titratable acid, 1C- ratio of total soluble solid to titratable acid, 1D- vitamin C. The different alphabets above the rectangular bar show significantly different among the same factor based on the Duncan's multiple range test at $\alpha = 0.05$; the error bar represents the standard deviation.

The fruit taste evaluated by consumers did not solely depend upon the TA or TSS of the fruit. Both TSS and TA simultaneously influenced the taste of 'Kristal' guava fruit (Susanto et al., 2019). This finding revealed that only the altitude of growing location that significantly influenced the ratio of TSS and TA (Table 1). The ratio of TSS/TA in fruit from lowland was 17.46 while fruit from highland was 14.89 (Figure 2C). The fruits from lowland have sweeter taste compared those from highland. Further studies are required to confirm the range of TSS/TA ratio that suit consumer preference.

The content of vitamin C with different fruit bagging systems and altitude was similar. The vitamin C content of guava fruit from different bagging treatment varied from 140 to 146 mg per 100 g, and from 141 to 145 mg per 100 g in different land altitude (Figure 2D). In contrast to the present finding, earlier studies reported the significant variation of vitamin C content in guava in during ripening and at different geographical sites (Gull et al., 2012) and cultural practice (Musyarofah et al., 2020). The high content of vitamin C in guava fruit is important for human health (Lee and Kader, 2000) and its role as a strong antioxidant (Macan et al., 2019).

Conclusion

Our study reported the fruit quality of "Kristal" guava that were grown on lowland and highland with different bagging treatments. Fruit weight and diameter was significantly higher when guava trees were grown on lowland compared to those grown on highland. The total soluble solid was significantly higher in lowland than highland, whereas titratable acid was lower. Vitamin C content was not significantly affected by fruit bagging treatments and altitude. Fruit scar intensity in both lowland and highland was reduced with fruit bagging. Fruit scar intensity was higher in lowland than in highland, especially without fruit bagging.

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