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Postharvest and Storage Quality of F200 Pineapple *Ananas Comosus* (L.) Merr as Influenced by Gibberellic Acid Application and Calcium Supplements

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ABSTRACT

The study was conducted to determine the optimum rate of GA_3, calcium, and its combination for postharvest quality improvement of F200 pineapple fruits and by determining also the effect on the pineapple fruit chemistry such as brix, acidity, pH, and vitamin C contents. Pineapple fruits applied with GA_3 at 100 to 300 ppm resulted in a lesser degree of translucency. The degree of translucency of fruits on calcium-applied plants with or without a combination of GA_3, was the same. This explains the role of calcium in cell wall stability. and plant structural strength is predicated on the formation of Ca-pectate. compounds, which stabilize the cellulitic matrix of the middle lamella and "cement" adjacent plant cells to one another that control the translucency of pineapple fruits. The brix of F200 pineapple fruits significantly increased by the application of GA_3, at 250-300 ppm than the 100 ppm and untreated control. Significant results were observed on the TA of fruits from plants sprayed with calcium. Higher TA on fruits was observed from plants sprayed with calcium at 10 and 20 ml/l compared to a lower rate of calcium at 5 ml/l. A significant result was observed on the vitamin C. content of the fruit on plants applied with calcium at a higher rate of 20 ml/l. The visual quality of pineapple fruits decreased with storage. On ambient stored pineapple fruit for 7 days, a significant effect was observed only on GA_3, application. All pineapple fruits were treated with GA_3, at different rates. remained with a better visual quality than untreated fruits. Application of GA_3,, particularly at higher rates, maintained a better fruit quality of pineapple than plants without GA_3, application. A significant result was also found on the flesh condition of the fruit on GA_3,, and calcium application at 1 week after ambient temperature. Future research to validate the result of the present study is highly recommended on the possible performance of different pineapple varieties.

INTRODUCTION

Pineapple (Ananas comosus) is a tropical fruit valued for its sensory and nutritional attributes. However, it is highly perishable due to internal browning and physicochemical changes during storage. Postharvest treatments using calcium and plant growth regulators like gibberellic acid (GA_3) have shown potential to enhance the shelf life and maintain the quality of various fruits. This study focuses on the combined effects of calcium and GA_3 dipping applications to mitigate internal browning and preserve the physicochemical characteristics of pineapple during storage.

The translucency problem in pineapples, also known as "water core," is a significant postharvest issue that negatively impacts fruit quality. It is characterized by the accumulation of water in the intercellular spaces of the fruit tissue, leading to a translucent and soggy appearance. Research has shown that the application of calcium and gibberellic acid (GA_3) can mitigate translucency and enhance postharvest quality. By delaying cell wall degradation, GA_3 ensures that the fruit's structural integrity remains intact, which can prevent the onset of translucency.

Calcium, being one of the elements with the key role in several plant structures, like cell wall stability and plant structural strength, can help the fruits to strengthen and avoid some physiological problems that affect the quality of fruits during the postharvest stage. Because of its role in binding cell wall substances (particularly pectin chains) and maintaining cell wall integrity in fruits, pre-harvest calcium nutrition has received considerable grower and researcher attention. Liquid calcium fertilizers and gypsum improve the firmness and storability of some fruits. The response to additional calcium is understandably more evident in acid soils, as cited by Midmore (2015). Calcium inhibits enzymes like polygalacturonase and pectin methylesterase that degrade pectin, thereby preventing tissue softening and translucency.

When used together, GA_3 and calcium provide complementary benefits. GA_3 delays ripening and senescence, while calcium strengthens the fruit's structural framework, creating a dual mechanism to combat translucency. Research has shown that GA_3 and calcium treatments significantly enhance the storage life of pineapples, with reduced incidence of translucency, better firmness, and improved visual appeal during extended storage periods. The application of GA_3 and calcium together increased the fruit size, delayed fruit maturity, and strengthened the fruit tissue in resistance to bruises and quality problems in postharvest. There is

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the possibility that when fruits are applied with GA_3, they become weakened and more susceptible to bruises and quality deterioration. Calcium's primary function is to provide a stronger cell wall and stronger tissues to become more resistant to any quality deterioration and improve postharvest life. The objectives were to determine the influence of different levels of GA_3 applied alone or in combination with calcium application on postharvest and storage quality of F200 pineapple.

LITERATURE REVIEW

GA_3 application has been proven in some research findings of several crops cited by Li, *et al.* (2010) such as larger-sized fruit and improved fruit quality (Jackson 2003; Sharma and Singh 2009), maintaining cell expansion (Davis 2004; De Jong *et al.,* 2009; Ozga and Dennis 2003), to enhance fruit growth in a wide variety of species such as Japanese pear (Zhang *et al.,* 2005, 2007), litchi (Chang and Lin 2006) and grape (Casanova *et al.,* 2009), improve the grape size and quality (Harrell & Williams, 1987; Dimovska *et al.*, 2014; Nampila *et al.*, 2010; Kapłan *et al.*, 2017); to obtain fruits of better quality (Gonzalez-Rossia *et al.,* 2006; Sharma and Singh 2009), in blueberry (Vaccinium ashei) and some other fruits (Cano-Medrano and Darnell 1997).

Effect of GA_3 on Growth, Yield and Postharvest Quality in Some Crops. Gibberellins are a group of growth substances known to retard ripening and senescence of fruits. The effect of GA_3 seems to be mainly on colour development, although other aspects of ripening processes are also affected. (Ladaniya, 1997) noted the effect of pre-harvest application of GA_3 (10, 15 and 20 ppm) on physico-chemical characteristics of Nagpur mandarin during holding of fruit on the tree as well as on losses during postharvest storage at ambient and refrigerated conditions. GA_3 treatments (10, 15, 20 ppm) delayed rind colour development and fruit softening and minimized fruit drop and puffiness during on tree storage without adverse effect on T.S.S./acid ratio and fruit productivity in subsequent years.

GA_3 Studies in Pineapple. There are several studies conducted in the effects of GA in pineapple. (Suwandi, et, al., 2016) for instance reported that the application of gibberellin alone 100 or 200 ppm increased the fruit weight, harvest index and fruit crown length, a positive effect on the quality of this planting material, and delayed fruit maturity by 5days in 'Smooth Cayenne' pineapple. However, it has been observed that GA_3 had little effect on the total soluble solids and fruit juice pH but it increased the vitamin C content. In terms of flow cytometric analysis they showed that 50 mg l-1 GA_3 treatment had only a slight impact on the number of S phase cells.

In GA application did not control flowering time in 'Smooth Cayenne' but resulted in the reduction of fresh fruit weight when pineapple seedlings were treated with GAs (Gowing and Leeper, 1961). No studies have been conducted to evaluate the complete profile of fruit quality in response to GA application in 'Comte de Paris' pineapple. Flow cytometric analysis and histological observation led to a more profound understanding of the mechanisms of GA_3's effect on pineapple fruit weight.

(Li and Sun, 2010) reported that the different concentrations of GA_3 increased the fruit weight significantly, in which the best treatment, i.e. 50 mg/L GA3 increased the fresh weight of pineapple fruits by 20.3% compared with the control. Histological observation showed that GA_3 caused fruit cells enlargement, which resulted in the increase of fruit fresh weight.

Calcium Nutrition in Pineapple. Postharvest application of potassium sulphate, 2-chloroethyl phosphonic acid, and calcium hydroxide followed by wax sprays and exposure to light also reduced Internal Browning (IB) in pineapple (Nanayakkara et, al., 2005).

(Silva et, al., (2005) conducting the study on lime , gypsum and basaltic dust effect on the calcium nutrition and fruit quality of pineapple, their result showed that the fruit translucency index decreased as the amount of applied total calcium increased.

Further, fertilization with calcium increased fruit calcium levels and improved fruit storage life by reducing the incidence of internal browning associated with refrigerated storage (Herath et, al., 2000). High fruit translucency caused by cell sap leakage into the apoplast is a problem in fresh fruit production in some months of the year in Hawaii. High translucency causes losses because it is associated with increased bruising injury, fruit leakage and potential carton rejection due to the perception of disease.

MATERIALS AND METHODS

The field experiment was conducted in Brgy. Kablon, Tupi, South Cotabato. The site is slightly slope and within the highland agro environment located at the foot of Mt. Matutum with a topographical elevation of 870 above sea level. An established F200 variety of pineapple plots at maturity age ready for forcing at twelve (12) months from planting was used in this study. The Split-Plot Design was used in this experiment with four replications. The GA_3 levels serve as the main plot, while levels of calcium are the subplot, and the treatments are as follows: The main plot is the GA_3 levels of 0ppm, 100ppm, 250, and 300ppm. The levels of calcium are 0 calcium, 5 ml/li, 10 ml/li, and 20 ml/li.

Fruit Quality Reading

The three (3) sample fruits per replicate were graded for blemish, and translucency.

Blemish

Denotes a "discoloration" or "hardening" in the fruit cylinder or in any portion thereof. This condition materially affects its appearance and includes, but is not limited to, any fruit eye that on the exposed portion exceeds 1/16" in its longest dimension.

Fruit Translucency

Check for fruit transparency to light. During ripening, the gas (microscopic air pocket between fruit cells) is normally displaced by juice, making the tissue translucent.

Fruit Porosity

Openings or vacuoles in the fruit surface after peeling. The porosity of the fruit was assessed using the severity scale rating used in pineapple fruit in the commercial industry (Dull, 1971; Gortner et, al., 1967).

Total Soluble Solid, Acidity, and Vitamin C Reading

Two samples from each replicate were comminuted for analysis of the following parameters: Total soluble solid, acidity, pH, and Vitamin C.

Total Acidity

This was taken through titration method. The NaOH was standardized first into 0.1N to be used for titration process. The 30 ml pineapple juice was put on the flask and put it into the installed burette and start to dropped slowly the standardized 0.1N NaOH into the extracted juice and the color changes into the pinkish color inside the flask and the amount of standardized 0.1N NaOH was recorded where the juice stable changes in color.

pH

This was determined by dipping the tip of handheld or benchtop pH meter on the extracted juice of pineapple fruit.

Vitamin C

This was determined by using titration method (redox titration using iodine solution). The prepared iodine solution was used as titrant as the iodine is added during the titration, the 20ml pineapple juice were put on the flask with 150ml distilled water and 1ml prepared starch indicator and put it on the burette containing iodine solution and start to drop until the juice was change into the blue black color.

Initial Test

Prior to the storage test, the two (2) fruits with the color index of 4 to 5 per treatment and replication were collected and harvested from the field for initial data analysis of brix, acidity, pH, and Vitamin C. This was determined using the procedure of extracting the pineapple juice by titration process to get the brix, total acidity, pH and Vitamin C.

Storage Test

Four (4) fruits per replicate on each treatment with shell color 2-3 were taken for postharvest quality check and weighed individually before and after the ambient and cold storage. The two fruits were placed under the ambient temperature for one (1) week period and the other two (2) fruits were stored inside the chiller unit with maintained temperature of 7.2 0C for 21 days cooling. After 21 days of storage, the fruits were pulled out from the chiller and transfered under the ambient condition for another 7 days of observation.

Weight Loss

The initial weight of the fruits and after storage was measured. Weight loss was computed and expressed in percentage of the initial weight.

Visual Quality Rating

This was determined by using the following visual quality rating scale.

The Shell Appearance, Shell Mold Incidence, Chilling Injury, Crown Quality Changes, and Flesh Condition of the Fruit were determined using the modified procedure modified from (Dull, 1971).

Shell Appearance

The shell appearance of the fruit was also determined using the rating scale scale use in reading the shell appearance on pineapple fruit.

Shell Mold Incidence

The Mold Incidence was also characterized by brown or black blotches present on the shell of the pineapple fruit and this was determined using the Rating scale used in reading the shell mold incidence on pineapple fruit.

Chilling Injury

The days to symptom manifestation, all fruits inside the refrigerated chiller container were monitored the number of days to appearance of chilling injury symptom and this was noted using the rating scale used in reading the chilling injury on pineapple fruit.

Crown Quality Changes

All fruits after cold storage were observed the changes in appearance of the crown and this were evaluated. Degree of yellowing, wilting, and/or water soaking were determined using a scale of 1 (none) and 4 (severe).

Flesh Condition of the Fruit

The flesh condition of the fruit was determined following the rating scale used in reading the fruit condition on the pineapple fruit.

Statistical Analysis

Data were subjected to analyses of variance using Tukey's analysis.

RESULTS AND DISCUSSION

Postharvest Fruit Quality Responses

Blemish and Porosity

Blemish denotes a "discoloration" or "hardening" in the fruit cylinder. No blemish on fruits was found in all fruit samples taken in all plots treated with GA_3 levels and calcium. Also, no porosity incidence has been observed on the fruit surface after peeling in all fruit sampled of F200 pineapple applied with different GA_3 levels and calcium supplement application.

Fruit Translucency

Translucency on fruits at harvestable age is presented in Table 1. The application of GA_3 in pineapple fruit was significantly found to have an influence with the opaque reading, which is equivalent to no translucency level. As observed, the highest rate of GA_3 at 300 ppm was found to have an influence on eliminating the translucency on pineapple fruits, which is significantly comparable to the 250 ppm rate of application. However, even the 100 ppm rate of GA_3 was also effective in reducing the translucency on fruits with opaque reading or no translucency found comparable to fruits applied with 250 ppm compared with the untreated control fruits with semi-translucent reading.

No significant difference in the degree of translucency in fruits was found on calcium application, and all treatments were found to have no translucency reading, including the control or untreated one. On the interaction effect between GA_3 and calcium application on fruits, no significant difference was also found. No degree of translucency on fruits with the highest rate of GA_3 application with calcium levels compared to all other treatment combinations of GA_3 and calcium application. This implied that the GA_3 application on pineapple fruits has a significant influence in controlling the translucency incidence on fruits at harvestable age.

Translucency is when the flesh has a water-soaked appearance during the ripening process of fruits, and this might be the result of the rapid maturity and ripening of GA_3-untreated pineapple fruits, resulting in the faster accumulation of water sap on the fruit tissue, resulting in the translucent appearance. Senescence-related loss of membrane integrity leads to water-soaked, translucent flesh, which tends to be softer than non-translucent fruit, as cited by Chen and Paull (1995). In some reports, this typically happens when the plants are exposed to a long drought and exposed to the rainy season during the fruit bloom to mature. Fruits untreated with GA_3 illustrate early maturing and faster ripening, and senescence has been observed to have weakened flesh compared to those fruits treated with levels of GA_3 application; this remarkable result points out that more fruit translucency occurred on fruits without GA_3 application than the treated ones.

Table 1: Fruit quality of F200 pineapple as applied with varying ppm levels of GA_3 and calcium during field production

GA_3 level (ppm) main plot	**Fruit Quality**		
	Blemish	**Fruit Translucency**	**Porosity**
GA_3 (untreated)	0.00	2.02[a]	0.00
GA_3 (100 ppm)	0.00	1.44[b]	0.00
GA_3 (250 ppm)	0.00	1.29[bc]	0.00
GA_3 (300 ppm)	0.00	1.00[c]	0.00
Calcium level (ml/Ii) sub plot			
Calcium (untreated)	0.00	1.50	0.00
Calcium (5ml/li)	0.00	1.65	0.00
Calcium (10ml/li)	0.00	1.38	0.00
Calcium (20ml/li)	0.00	1.23	0.00
GA_3 with Calcium Interaction			
GA_3 (untreated) + Calcium (untreated)	0.00	1.75	0.00
GA_3 (untreated) + Calcium (5ml/li}	0.00	2.58	0.00
GA_3 (untreated) + Calcium (10ml/li)	0.00	2.25	0.00
GA_3 (untreated) + Calcium (20ml/li)	0.00	1.50	0.00
GA_3 (100ppm) + Calcium (untreated)	0.00	2.00	0.00
GA_3 (100ppm) + Calcium (5ml/li)	0.00	1.75	0.00
GA_3 (100ppm) + Calcium (10ml/li)	0.00	1.00	0.00
GA_3 (100ppm) + Calcium (20ml/li)	0.00	1.00	0.00
GA_3 (250 ppm) + Calcium (untreated)	0.00	1.25	0.00
GA_3 (250 ppm) + Calcium (5ml/li)	0.00	1.25	0.00
GA_3 (250 ppm) + Calcium (10ml/li)	0.00	1.25	0.00
GA_3 (250 ppm) + Calcium (20ml/fi)	0.00	1.42	0.00
GA_3 (300 ppm) + Calcium (untreated)	0.00	1.00	0.00
GA_3 (300 ppm) + Calcium (5ml/li)	0.00	1.00	0.00

GA_3 (300 ppm) + Calcium (10ml/li)	0.00	1.00	0.00
GA_3 (300 ppm) + Calcium (20ml/fi)	0.00	1.00	0.00
CV (%) main plot		35	
CV (%) interaction		35.8	

Total Soluble Solid, Total Acidity, Fruit pH and Vitamin C

Sugar content plays an important role in the flavor characteristics and commercial assessment of pineapple fruit quality (Py *et al.*, 1987). TSS, mainly sugars, are often used as an indicator of fruit maturity and quality (Paull, 1993). Fruits TSS at one week after ambient storage from harvest was significantly different on GA_3-applied plants. As observed, pineapple fruits on plants with 250-300 ppm GA_3 application had higher brix than the 100 ppm application and with no GA_3 application. No significant result was found on calcium application and with the interaction between GA_3 and calcium on the brix level of the fruit.

Gibberellin (GA) plays a role in increasing the source-sink relation or sink strength by activating enzymes involved in sugar metabolism (Zhang *et al.*, 2007; Iqbal *et al.*, 2011). The present study of Suwandi *et al.* (2016) showed that 100 ppm of GA increased the sucrose/hexose ratio, while 200 ppm of GA showed the opposite results. This may be related to a mechanism of GA to regulate sucrose and hexose balance in a fruit (Brenner & Cheikh, 1995). Li *et al.* (2011) stated on their result on GA study in pineapple, with the increase of GA_3 concentrations, the content of total soluble sugar decreased.

Total acidity, fruit pH, and vitamin C content of pineapple fruit as influenced by GA_3 and calcium application is presented in Table 2. Comparable TA of the fruits were observed among GA_3-treated and untreated plants. However, significant results were observed on the TA of fruits from plants sprayed with calcium. Higher TA on fruits from plants sprayed with calcium at 10 and 20 ml/l compared to lower rate of calcium at 5 ml/li.

The higher TA on fruits coming from plants sprayed with a higher rate of calcium implied that the more calcium applied on fruits can affect the total acidity to increase. This implied that when the fruit had not yet fully ripened, the acidity was higher, and this will decrease to a lower level if the fruit was more ripened. As observed in the early chapter on maturity spread, there is a trend on maturity spread of the pineapple fruits in the early weeks from the start of 29 to 30 WAF. The calcium applied between 5 to 20 ml/li was found to have the higher percentage of fruit to mature compared with the untreated one. This might affect the TA on those fruits applied with a higher rate of calcium. due to the effect of fruit maturity factor.

Boe *et al.* (1967) observed that the acid content was found to be lower in immature fruit. and it was highest at the stages when color appeared with a rapid decrease as The fruit ripened at ambient conditions. They also reported that citric acid was the major constituent of total acid and malic acid occurred in small concentration and decrease at the fruit ripened. The decreasing trend of titratable acidity during the storage period was reported also by Upadhyay *et al.* (1994). According to them, acidity was reduced during storage growth on attainment of maturity and ripening.

On the other hand, no significant differences were observed in TA of the fruits among treatments combination of GA and calcium.

pH

pH played an important role as an indicator in the determination of acidity and alkalinity condition. Statistical analysis on pH in fruit juice revealed also that no significant difference in GA_3 and calcium rate of application and even in the interaction of the two factors mentioned. The pH is higher on the fruits at 1 week after ambient temperature compared with those fruits in the initial data collected. Even the effect between treatments has no trend, but the comparison between the initial fruit analysis on pH and the 1-week ambient storage has the difference of increasing the pH status on fruits. This indicates that when the pineapple Fruits are going to ripen more; the acidity is also going to lower down. This result correlates the TA on fruits on the previous discussion of result. The initial fruit was collected from the field and immediately processed for the pH analysis on juice while the ambient storage was stayed for 1 week after the analysis. This implied that the pH was also much lower when the fruits were not fully ripened compared to the 1-week ambient temperature in which it is more ripened, and the pH has increased. This result correlate on the TA result in the previous discussion where the higher the pH indicates the less acidity occurs and the lower the pH was, the more acidity happened on fruit.

Pineapple juice pH declines from 3.9 to 3.7 as the fruit approaches the full-yellow stage (Teisson & Pineau, 1982) and increases as the fruit senesces, with titratable acidity showing the opposite trend (Gortner & Singleton, 1965; Teisson & Pineau, 1982; Chen & Paull, 1995).

Vitamin C

Vitamin C on F200 pineapple fruit juice applied with GA_3 and calcium level supplements at 1 week of ambient storage is presented in Table 19. No significant result on vitamin C in fruits was found on GA_3 levels of application on vitamin C in fruits among plants with GA_3 application and with the control.

Significant result was observed on the vitamin C content of the fruit on plants as applied with calcium at a higher rate of 20 ml/li. Lower rate of 10 and 5 ml/li calcium did not improve the vitamin C content of the fruit. Vitamin C is easily destroyed by heat, but is more heat stable under acidic conditions such as in the heat pasteurization in orange juice (Morris *et al.*, 2004), and it has been noted that the pineapple fruits were exposed under the drought condition period since the fruit maturity in the field was on the development of this experiment. The higher acidity result on a higher rate of calcium at 20 ml/li implicate the higher vitamin C result in pineapple fruit juice even on the drought period.

No significant interaction between GA_3 and calcium supplement application on vitamin C in fruits of F200 pineapple.

Table 2: Total Soluble Solid, Total acidity, pH and Vitamin C on fruits of F200 pineapple fruit after application with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**Initial Data**					**One (1) week ambient temperature**				
	Shell Color	**Total Soluble Solid**	**Total Acidity**	**pH**	**Vitamin c**	**Shell Color**	**Total Soluble Solid**	**Total Acidity**	**pH**	**Vitamin c**
GA_3 (untreated}	4	13.13	0.28	3.85	61.47	5.50	11.66[b]	0.29	4.29	63.75
GA_3 (100 ppm)	4	13.50	0.29	3.95	60.66	5.00	12.22[b]	0.31	4.28	67.16
GA_3 (250 ppm)	4	13.50	0.28	3.90	60.66	4.75	13.13[a]	0.25	4.28	66.48
GA_3 (300 ppm)	4	12.75	0.28	3.83	69.81	4.88	12.34[ab]	0.28	4.30	71.82
Calcium level (ml/li) sub plot										
Calcium (untreated)	4	14.00	0.28	3.93	64.68	5.19	12.22	0.26[ab]	4.29	64.68[b]
Calcium (5ml/li)	4	13.00	0.21	3.88	64.52	4.75	12.56	0.23[b]	4.33	62.87[b]
Calcium (10ml/li)	4	13.63	0.31	3.83	64.68	5.19	11.81	0.32[a]	4.29	64.68[b]
Calcium (20ml/li)	4	12.25	0.33	3.90	58.74	5.00	12.75	0.32[a]	4.24	76.99[a]
GA_3 with Calcium Interaction										
GA_3 (untreated) + Calcium (untreated)	4	14.00	0.48	3.70	51.36	5.75	12.38	0.30	4.33	50.07
GA_3 (untreated) + Calcium (5ml/li)	4	14.00	0.26	3.80	64.84	5.50	11.50	0.30	4.35	61.31
GA_3 (untreated} + Calcium (10ml/li)	4	13.50	0.25	3.80	71.90	5.50	11.13	0.28	4.25	63.71
GA_3 (untreated) + Calcium (20ml/li)	4	11.00	0.13	4.10	57.78	5.25	11.63	0.27	4.23	79.92
GA_3 (100 ppm) + Calcium (untreated)	4	14.00	0.25	4.00	64.84	5.25	11.88	0.21	4.30	61.79
GA_3 (100 ppm) + Calcium (5ml/li)	4	11.00	0.21	4.00	57.78	4.50	13.13	0.21	4.35	63.55
GA_3 (100 ppm) + Calcium (10ml/li)	4	15.00	0.29	3.90	63.55	4.75	12.13	0.41	4.30	65.00
GA_3 (100 ppm) + Calcium (20ml/li)	4	14.00	0.40	3.90	56.49	5.50	11.75	0.41	4.18	78.32
GA_3 (250 ppm) + Calcium (untreated)	4	14.00	0.24	4.00	64.20	5.00	13.00	0.23	4.28	75.11
GA_3 (250 ppm) + Calcium (5ml/li)	4	14.00	0.20	3.80	57.13	4.25	12.75	0.19	4.33	55.37
GA_3 (250 ppm) + Calcium (10ml/li)	4	15.00	0.33	3.80	64.20	5.25	12.50	0.30	4.33	63.71
GA_3 (250 ppm) + Calcium (20ml/li)	4	11.00	0.34	4.00	57.13	4.50	14.25	0.30	4.20	71.74
GA_3 (300 ppm) + Calcium (untreated)	4	14.00	0.15	4.00	78.32	4.75	11.63	0.31	4.28	71.74
GA_3 (300 ppm) + Calcium (5ml/li)	4	13.00	0.19	3.90	78.32	4.75	12.88	0.22	4.28	71.26

GA_3 (300 ppm) + Calcium (10ml/li)	4	11.00	0.36	3.80	59.06	5.25	11.50	0.29	4.30	66.28
GA_3 (300 ppm) + Calcium (20ml/li)	4	13.00	0.43	3.60	63.55	4.75	13.38	0.29	4.35	78.00
CV (%) main plot						13.6	8.8	26.8	11.3	12.7
CV (%) interaction						12.7	8.2	31.9	10.1	17.2

Percent Fruit Weight Loss

Results revealed that no significant difference in percent weight loss on pineapple fruit influenced by GA_3 and calcium supplements on both 1 week after ambient storage and 3 weeks after storage temperature at 7.2°C (Table 3). On the interaction between the GA_3 and calcium level weight loss of the fruit varied differently. Fruits applied with GA_3 with calcium at 20 ml/li combination was significantly affecting the weight loss of pineapple fruit, which is significantly comparable to those fruits applied with 100 ppm GA_3 with untreated and 10 ml/li rate of calcium and the 250 ppm of GA_3 + untreated & 5 ml/L of calcium.

Generally, It was found that higher percent weight loss was observed on fruits after exposure. to storage temperature with 7.2°C fruits compared with the lower fruit weight loss in 1 week after ambient temperature F200 pineapple fruits.

No report yet has been found. related to support calcium causing fruit weight loss in postharvest commodity. However, as stated by studies of bitter pit development, revealed that calcium may have a secondary role in disease development (Saure, 1996). The elevated GA may have increased the permeability of cell membranes in the fruit adjacent to vascular bundles, thereby resulting in increased sensitivity of the fruit cells to postharvest water stress, which after harvest may have triggered a calcium deficiency, enhancing fruit susceptibility. This report might be related to more fruit. weight loss when applying GA_3 due to the antagonizing effect to calcium causing the More water stress on fruits, resulting in losing weight.

Shell Mold

Shell mold of the fruits was not observed at 1 week after storage in ambient condition. At 3 weeks after the cold storage at 7.2°C, the shell mold of the fruits ranged from 3.5 to 4, which were comparable among treatments in Table 3. As observed, all fruits treated with GA_3 and calcium or in a combination of the two have a shell mold incidence rating of 4, which is equivalent to 76 to 100% of fruits having shell mold.

Table 3: Percent weight loss and shell mold both in 1 week ambient condition and 7.2oC storage temperature on fruits of F200 pineapple fruit after application with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**% Weight loss (gm)**		**Shell mold**	
	Ambient temperature (1 week)	**Storage at 7.2 C in 21 days**	**Ambient temperature (1 week)**	**Storage at 7.2 C in 21 days**
GA_3 (untreated)	0.91	0.92	0.00	3.88
GA_3 (100 ppm)	0.81	1.41	0.00	4.00
GA_3 (250 ppm)	0.95	2.19	0.00	4.00
GA_3 (300 ppm)	1.30	1.94	0.00	4.00
Calcium level (ml/li) sub plot				
Calcium (untreated)	1.02	1.74	0.00	3.88
Calcium (5ml/li)	1.09	1.30	0.00	4.00
Calcium (10ml/li)	1.02	1.75	0.00	4.00
Calcium (20ml/ li)	0.83	1.67	0.00	4.00
GA_3 with Calcium Interaction				
GA_3 (untreated) + Calcium (untreated)	0.92	0.41^{d}	0.00	3.50
GA_3 (untreated) + Calcium (5ml/li)	1.14	0.84^{cd}	0.00	4.00
GA_3 (untreated) + Calcium (10ml/ li)	1.08	1.63^{bcd}	0.00	4.00
GA_3 (untreated) + Calcium (20ml/ li)	0.51	0.80^{cd}	0.00	4.00
GA_3 (100 ppm) + Calcium (untreated)	0.67	2.12^{abcd}	0.00	4.00
GA_3 (100 ppm) + Calcium (5ml/li)	0.78	0.88^{cd}	0.00	4.00
GA_3 (100 ppm) + Calcium (10ml/li)	0.85	2.26^{abc}	0.00	4.00
GA_3 (100 ppm) + Calcium (20ml/ li)	0.93	0.37^{d}	0.00	4.00
GA_3 (250 ppm) + Calcium (untreated)	0.87	2.81^{ab}	0.00	4.00

GA_3 (250 ppm) + Calcium (5ml/li)	1.23	2.41^{abc}	0.00	4.00
GA_3 (250 ppm) + Calcium (10ml/li)	1.18	1.73^{bcd}	0.00	4.00
GA_3 (250 ppm) + Calcium (20ml/ li)	0.51	1.80^{bcd}	0.00	4.00
GA_3 (300 ppm) + Calcium (untreated)	1.62	1.61^{bcd}	0.00	4.00
GA_3 (300 ppm) + Calcium (5ml/li)	1.22	1.07^{bcd}	0.00	4.00
GA_3 (300 ppm) + Calcium (10ml/li)	0.99	1.38^{bcd}	0.00	4.00
GA_3 (300 ppm) + Calcium (20ml/ li)	1.37	3.69^{a}	0.00	4.00
CV (%) main plot	105.7	68.5		6.3
CV (%) interaction	79	78.3		6.3

Visual Quality Rating (VQR)

Visual quality of pineapple fruits decreased with storage. On ambient stored pineapple fruit for 7 days, a significant effect was observed only on GA_3 application. All pineapple fruits treated with GA_3 at different rates remained with a better visual quality than untreated fruits. However, calcium application of fertilizer to pineapple plants did not improve fruit quality of pineapple after storage (Table 4).

For fruits stored at refrigerated condition, visual quality changes were observed after 15 days of storage. A significant effect on fruit visual quality was observed only on GA_3. treated pineapple plants. Application of GA_3, particularly at the higher rates, maintained a better fruit quality of pineapple than plants without GA_3 application. This result implied the role of GA in improving the quality of some horticultural crops. Gibberellic acid has been proven in some studies on its effect to delay peel maturity and delayed senescence in fruits and improve fruit quality in the end. Such study reported by Davies *et al.* (1997) in citrus to extend the freshness on fruits. To obtain fruits of better quality (Gonzalez-Rossia *et al.,* 2006; Sharma & Singh 2009).

Table 4: Visual Quality Rating (VQR) at one (1) week ambient condition and after 21 days under 7.2oC storage temperature on fruits of F200 pineapple fruit after applied with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**visual quality rating(VQR)**							
	7 days Ambient	**3 days storage**	**6 days storage**	**9 days storage**	**12 days storage**	**15 days storage**	**18 days storage**	**21 days storage**
GA_3 (untreated)	4.13^{b}	9.00	9.00	9.00	9.00	7.75^{b}	5.44^{c}	4.50^{b}
GA_3 (100 ppm)	7.56^{a}	9.00	9.00	9.00	9.00	7.88^{b}	7.19^{b}	6.943^{a}
GA_3 (250 ppm)	7.693^{a}	9.00	9.00	9.00	9.00	8.50^{a}	8.25^{a}	7.56^{a}
GA_3 (300 ppm)	8.313^{a}	9.00	9.00	9.00	9.00	8.383^{a}	8.06^{a}	7.633^{a}
Calcium level (ml/li) sub plot								
Calcium (untreated)	6.56	9.00	9.00	9.00	9.00	8.13	7.38	6.75
Calcium (5ml/li)	7.19	9.00	9.00	9.00	9.00	8.06	7.13	6.88
Calcium (10ml/li)	6.63	9.00	9.00	9.00	9.00	8.19	7.31	6.75
Calcium (20ml/li)	7.31	9.00	9.00	9.00	9.00	8.13	7.13	6.25
GA_3 with Calcium Interaction								
GA_3 (untreated) + Calcium (untreated)	3.50	9.00	9.00	9.00	9.00	7.75	5.50	3.75
GA_3 (untreated) + Calcium (5ml/li)	4.75	9.00	9.00	9.00	9.00	7.25	5.00	4.50
GA_3 (untreated) + Calcium (10ml/li)	3.50	9.00	9.00	9.00	9.00	8.00	5.75	5.75
GA_3 (untreated) + Calcium (20ml/li)	4.75	9.00	9.00	9.00	9.00	8.00	5.50	4.00
GA_3 (100 ppm) + Calcium (untreated)	7.00	9.00	9.00	9.00	9.00	8.00	7.75	7.75
GA_3 (100 ppm) + Calcium (5ml/li)	7.75	9.00	9.00	9.00	9.00	8.00	7.25	7.25
GA_3 (100 ppm) + Calcium (10ml/li)	8.00	9.00	9.00	9.00	9.00	8.00	7.25	7.25
GA_3 (100 ppm) + Calcium (20ml/li)	7.50	9.00	9.00	9.00	9.00	7.50	6.50	5.50
GA_3 (250 ppm) + Calcium (untreated)	7.50	9.00	9.00	9.00	9.00	8.50	8.75	8.50
GA_3 (250 ppm) + Calcium (5ml/li)	7.75	9.00	9.00	9.00	9.00	8.50	8.00	7.00
GA_3 (250 ppm) + Calcium (10ml/li)	7.25	9.00	9.00	9.00	9.00	8.50	8.25	7.25

GA_3 (250 ppm) + Calcium (20ml/li)	8.25	9.00	9.00	9.00	9.00	8.50	8.00	7.50
GA_3 (300 ppm) + Calcium (untreated)	8.25	9.00	9.00	9.00	9.00	8.25	7.50	7.00
GA_3 (300 ppm) + Calcium (5ml/li	8.50	9.00	9.00	9.00	9.00	8.50	8.25	8.75
GA_3 (300 ppm) + Calcium (l0ml/li)	7.75	9.00	9.00	9.00	9.00	8.25	8.00	6.75
GA_3 (300 ppm) + Calcium (20ml/li)	8.75	9.00	9.00	9.00	9.00	8.50	8.50	8.00
CV (%) main plot	17.1	0.00	0.00	0.00	0.00	5.2	11.6	18.8
CV (%) interaction	18.3	0.00	0.00	0.00	0.00	5.8	14	23.1

Shell Appearance on Fruits

Shell appearance on fruits at ambient and storage conditions was presented in Table 5. Shell appearance of pineapple fruits decreased with storage temperature at 15 days after. At 7 days ambient temperature, even the untreated control fruits showed a more beautiful shell appearance, but according to the scale rating; all treatments with GA_3 are within the shiny appearance rating of shell color.

Calcium application on the other hand, have also not influenced the shell appearance of fruits in pineapple including the interaction between the GA and calcium. However, the application of GA_3 and calcium combination on pineapple fruit was found to influence the rating of 1, which is equivalent to the shiny surface appearance of fruit compared with the fruits treated with GA_3 and calcium at ambient conditions for 1 week.

The shell appearance of pineapple fruit stored in refrigerated conditions. It was observed that the shell appearance changes on fruits starts at 15 days after. Significant effect on shell appearance was observed in GA_3-treated pineapple plants. GA_3 applied at 250 to 300ppm was influence the shell appearance on fruit and this remain consistent until 18 days of storage condition. Calcium applications have no significant influence on shell appearance at 15 days after storage and even in 18 days after but as observe, higher rate of calcium was influenced the better shell color of within shiny surface rating description on fruit, and this was remained until 18 days of storage. The significant interaction between the GA_3 and calcium was observed at 18 days after storage. Fruits applied with GA_3 at 100 ppm + calcium untreated and 20 ml/li still have better shell appearance rating comparable to untreated GA3 with 10 and 20ml/li, GA_3 300ppm with untreated calcium and 10 ml/L compared with the untreated GA_3 and calcium fruits which has a poorer shell rating appearance of 3 that has equivalent to dried up surface shell appearance.

Table 5: Shell Appearance at one (1) week after ambient condition and after 21 days under 7.2oC storage temperature on fruits of F200 pineapple fruit after applied with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**Shell appearance**							
	7 days Ambient	**3 days storage**	**6 days storage**	**9 days storage**	**12 days storage**	**15 days storage**	**18 days storage**	**21 days storage**
GA_3 (untreated)	1.13[a]	1.00	1.00	1.00	1.00	1.44[c]	2.31	2.56
GA_3 (100 ppm)	1.63[b]	1.00	1.00	1.00	1.00	1.44[c]	1.69	2.00
GA_3 (250 ppm)	1.25[b]	1.00	1.00	1.00	1.00	1.94[a]	2.00	2.50
GA_3 (300 ppm)	1.25v	1.00	1.00	1.00	1.00	1.69[b]	1.81	2.25
Calcium level (ml/li) sub plot								
Calcium (untreated)	1.38	1.00	1.00	1.00	1.00	1.63	2.00	2.13
Calcium (5ml/li)	1.31	1.00	1.00	1.00	1.00	1.75	2.25	2.69
Ca leiu m (10ml/li)	1.19	1.00	1.00	1.00	1.00	1.56	1.81	2.19
Ca leiu m (20ml/li)	1.38	1.00	1.00	1.00	1.00	1.56	1.75	2.31
GA_3 with Calcium Interaction								
GA_3 (untreated) + Calcium (untreated)	1.00	1.00	1.00	1.00	1.00	1.75	3.00[a]	3.00
GA_3 (untreated) + Calcium (5ml/li)	1.25	1.00	1.00	1.00	1.00	1.00	2. 75[ab]	2.75
GA_3 (untreated) + Calcium (l0ml/li)	1.25	1.00	1.00	1.00	1.00	1.50	l.75[cde]	2.00
GA_3 (untreated) + Calcium (20ml/li)	1.00	1.00	1.00	1.00	1.00	1.50	l.75[cde]	2.50
GA_3 (100 ppm) + Calcium (untreated)	2.00	1.00	1.00	1.00	1.00	1.25	1.25[e]	1.25
GA_3 (100 ppm) + Calcium (5ml/li)	1.25	1.00	1.00	1.00	1.00	2.00	2.25[bc]	2.75
GA_3 (100 ppm) + Ca leiu m (10ml/li)	1.25	1.00	1.00	1.00	1.00	1.25	2.00[cd]	2.00

GA_3 (100 ppm) + Calcium (20ml/li)	2.00	1.00	1.00	1.00	1.00	1.25	1.25^{e}	2.00
GA_3 (250 ppm) + Calcium (untreated)	1.00	1.00	1.00	1.00	1.00	1.75	2.00^{cd}	2.00
GA_3 (250 ppm) + Calcium (5ml/li)	1.25	1.00	1.00	1.00	1.00	2.00	2.00^{cd}	2.50
GA_3 (250 ppm) + Calcium (10ml/li)	1.25	1.00	1.00	1.00	1.00	2.00	2.00^{cd}	2.75
GA_3 (250 ppm) + Calcium (20m/li)	1.50	1.00	1.00	1.00	1.00	2.00	2.00^{cd}	2.75
GA_3 (300 ppm) + Calcium (untreated)	1.50	1.00	1.00	1.00	1.00	1.75	1.75^{cde}	2.25
GA_3 (300 ppm) + Calcium (5m/li)	1.50	1.00	1.00	1.00	1.00	2.00	2.00^{cd}	2.75
GA_3 (300 ppm) + Calcium (10m/li)	1.00	1.00	1.00	1.00	1.00	1.50	1.50^{de}	2.00
GA_3 (300 ppm) + Ca leiu m (20m/li)	1.00	1.00	1.00	1.00	1.00	1.50	2.00^{cd}	2.00
CV (%) main plot	33.7	0.00	0.00	0.00	0.00	19.2	27.1	31.3
CV (%) interaction	43.2	0.00	0.00	0.00	0.00	27.6	26.6	30.8

Chilling Injury

Chilling injury of the fruit was evident on the 18th day of storage (Table 6). However, comparable degree of chilling injury on pineapple fruits was observed either GA3, calcium sprayed plants and plants without application. The chilling injury is the result of low temperature conditions below optimum causes chilling damage on fruit like pineapple.

In Queen pineapple, chilling injury called endogenous brown spot or black heart was manifested as browning at the inner tissues near the core. It is associated with the decline in ascorbic acid to a very low level giving rise to anhydroascorbate that serves as substrate for browning reactions (Serrano, 2002).

Taking tropical fruit examples, the exposure to high temperature during production may reduce storability losses due to subsequent chilling injury (Kang *et al.*, 2001), Lower than optimal temperatures during growth can cause physiological damage. that expresses itself as chilling damage during storage (e.g., < 21°C in pineapple can lead to internal browning during storage and to lenticel damage— lenticel spotting—in mango). Primarily due to cell membrane damage and often measured as K+ leakage, chilling sets in motion a series of secondary reactions including ethylene production, increased respiration, and the increased presence of toxic chemicals such as ethanol and acetaldehyde. Flavour, texture, colour and storage life are all likely to be lessened by chilling damage.

Table 6: Chilling injury after exposure of 21 days under 7.2oC storage temperature on fruits of F200 pineapple fruit after applied with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**Chilling injury**						
	3 days storage	**6 days storage**	**9 days storage**	**12 days storage**	**15 days storage**	**18 days storage**	**21 days storage**
GA_3 (untreated)	0.00	0.00	0.00	0.00	0.00	2.19	5.63
GA_3 (100 ppm)	0.00	0.00	0.00	0.00	0.00	3.13	10.94
GA_3 (250 ppm)	0.00	0.00	0.00	0.00	0.00	6.25	16.25
GA_3 (300 ppm)	0.00	0.00	0.00	0.00	0.00	3.44	7.81
Calcium level (ml/li) sub plot							
Calcium (untreated)	0.00	0.00	0.00	0.00	0.00	2.50	8.13
Calcium (5ml/li)	0.00	0.00	0.00	0.00	0.00	3.13	9.38
Ca leiu m (10ml/li)	0.00	0.00	0.00	0.00	0.00	5.63	10.31
Ca leiu m (20ml/li)	0.00	0.00	0.00	0.00	0.00	3.75	12.81
GA_3 with Calcium Interaction							
GA_3 (untreated) + Calcium (untreated)	0.00	0.00	0.00	0.00	0.00	0.00	2.50
GA_3 (untreated) + Calcium (5ml/li)	0.00	0.00	0.00	0.00	0.00	8.75	18.75
GA_3 (untreated) + Calcium (l0ml/li)	0.00	0.00	0.00	0.00	0.00	0.00	1.25
GA_3 (untreated) + Calcium (20ml/li)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GA_3 (100 ppm) + Calcium (untreated)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GA_3 (100 ppm) + Calcium (5ml/li)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GA_3 (100 ppm) + Ca leiu m (10ml/li)	0.00	0.00	0.00	0.00	0.00	0.00	6.25
GA_3 (100 ppm) + Calcium (20ml/li)	0.00	0.00	0.00	0.00	0.00	12.50	37.50

GA_3 (250 ppm) + Calcium (untreated)	0.00	0.00	0.00	0.00	0.00	3.75	17.50
GA_3 (250 ppm) + Calcium (5ml/li)	0.00	0.00	0.00	0.00	0.00	3.75	18.75
GA_3 (250 ppm) + Calcium (10ml/li)	0.00	0.00	0.00	0.00	0.00	15.00	15.00
GA_3 (250 ppm) + Calcium (20m/li)	0.00	0.00	0.00	0.00	0.00	2.50	13.75
GA_3 (300 ppm) + Calcium (untreated)	0.00	0.00	0.00	0.00	0.00	6.25	12.50
GA_3 (300 ppm) + Calcium (5m/li)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GA_3 (300 ppm) + Calcium (10m/li)	0.00	0.00	0.00	0.00	0.00	7.50	18.75
GA_3 (300 ppm) + Ca leiu m (20m/li)	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CV (%) main plot	0.00	0.00	0.00	0.00	0.00	150.7	137.6
CV (%) interaction	0.00	0.00	0.00	0.00	0.00	234.5	180.8

Crown Quality Changes

Changes in the crown quality of pineapple fruit is an indicator of sensitivity to low temperatures and ethylene response. Hence, what has been reported for plant leaves may also occur with the crown leaves. At 10°C, stomatal opening and closing are slowed and CO_2 uptake is reduced, compared with 17°C (Kent, 1967). Ethylene increases leaf respiration, causes stomatal opening, and enhances dehydration (Dull & Staruszkiewicz, 1966). Opening of stomata requires illumination on the preceding day and ethylene negates this requirement (Kent, 1967). The crowns of fresh fruit soon lose their green, healthy look, and the leaves become dehydrated and necrotic, and this is possibly due to ethylene.

Crown quality of pineapple fruits among treatments stored at ambient storage remained the same. However, after 21 days at 7.2°C storage, crown quality of the fruits almost changed, but the degree was comparable. Result implied that application of GA_3 and calcium during the production period did not influence the crown quality at postharvest during the observation period at ambient and low temperature storage, which means treated or untreated if stored in the ambient and 7.2°C Storage in 21 days will perform the same.

Flesh Condition of the Fruit

Application of GA_3 and calcium on pineapple plants significantly improve the flesh condition of the fruit. Fruits of pineapple plant applied with a higher rate of GA_3 at 250 ppm and particularly at 300 ppm had a better flesh condition than untreated fruits. On GA_3, applied fruits at a lower rate of 100 ppm, flesh condition was comparable to untreated fruits.

Significant result was also found on fruits applied with a higher rate of calcium at a higher rate of 300 ml/li were also found to have a good rating equivalent to acceptable/opaque flesh comparable to 5 and 10 ml/li rate of application than the control untreated fruits at 1 week ambient storage condition. The result on translucency data from the previous discussion on the translucency of fruit implicates the effectiveness of GA_3 and calcium application in producing the good flesh condition. Pineapple fruit translucency increases with increasing fruit weight (Bowden, 1969), possibly due to a decrease in calcium concentration, since larger fruit may need more calcium to stabilize cell membranes. When fruit cannot acquire sufficient calcium, cell membranes may lose integrity and lead to leakage and translucency.

Pineapple fruit translucency has been suggested to be related to an increase in cell wall hydrolases (Soler, 1993) and membrane permeability (Soler, 1994a). High calcium concentration may decrease the secretion or activities of cell-wall hydrolases (Huber, 1983) and membrane permeability. Furthermore, there is no significant difference in the interaction between the GA_3 and calcium application to the flesh condition of the fruit.

Shell Color Changes

The data on shell color changes on fruits applied with GA_3 and calcium supplement is presented in Table 7.

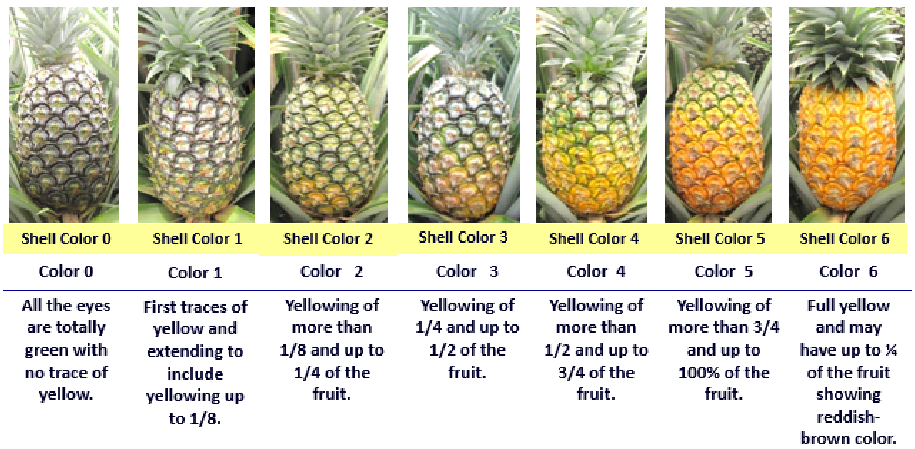

Figure 1: Shell color chart to determine the color index in F200 pineapple (Dull, 1971 Gortner *et al.*, 1967)

Statistical analysis revealed that no significant difference in the changes of shell color on fruits at 1 week after ambient temperature and the fruits at 21 days storage of 7.2°C. However, it was found that fruits applied with the higher rate of GA_3 at 250 to 300 ppm have influence to lower color index at around color 4 compared with the lower rate of GA_3 at 100 ppm and the untreated control, which is to have the higher color index of color 5.

This were closely related and indicators of the early maturity of those fruits without GA_3 application or less applied from the early chapter of the result which is the color changes also ahead to change than the fruits applied with GA_3. As mentioned in the early discussion of fruit maturity spread, the shell color as an indicator of maturity in fruits was observed delayed on those fruits with GA application plants.

Table 7: Crown quality changes, Flesh Condition and shell color changes at ambient condition and after exposure of 21 days under 7.2oC storage temperature on fruits of F200 pineapple fruit after applied with varying levels of GA_3 and calcium

GA_3 level (ppm) main plot	**Crown Quality Changes**		**Flesh Condition of the Fruit**		**Shell color changes**	
	Ambient	**21 days storaae (7.2C)**	**Ambient**	**21days storaae (7.2C)**	**Ambient**	**Storage**
GA_3 (untreated)	1.00	1.56	2.19[a]	-	5.50	4.94
GA_3 (100 ppm)	1.00	2.50	1.69[b]	-	5.00	4.88
GA_3 (250 ppm)	1.00	2.31	1.44[bc]	-	4.75	4.56
GA_3 (300 ppm)	1.00	2.69	1.13[c]	-	4.88	4.44
Calcium level (ml/li) sub plot						
Calcium (untreated)	1.00	2.31	1.63[a]	-	5.19	4.63
Calcium (5ml/li)	1.00	2.13	1.94[ab]	-	4.75	4.75
Ca leiu m (10ml/li)	1.00	2.50	1.63[ab]	-	5.19	4.50
Ca leiu m (20ml/li)	1.00	2.13	1.25[b]	-	5.00	4.94
GA_3 with Calcium Interaction						
GA_3 (untreated) + Calcium (untreated)	1.00	1.75	1.75	-	5.75	4.75
GA_3 (untreated) + Calcium (5ml/li)	1.00	1.00	2.75	-	5.50	5.00
GA_3 (untreated) + Calcium (10ml/li)	1.00	1.75	2.25	-	5.50	5.00
GA_3 (untreated) + Calcium (20ml/li)	1.00	1.75	2.00	-	5.25	5.00
GA_3 (100 ppm) + Calcium (untreated)	1.00	1.75	2.00	-	5.25	5.00
GA_3 (100 ppm) + Calcium (5ml/li)	1.00	2.50	2.50	-	4.50	4.75
GA_3 (100 ppm) + Ca leiu m (10ml/li)	1.00	2.50	1.25	-	4.75	4.50
GA_3 (100 ppm) + Calcium (20ml/li)	1.00	3.25	1.00	-	5.50	5.25
GA_3 (250 ppm) + Calcium (untreated)	1.00	2.50	1.50	-	5.00	4.50
GA_3 (250 ppm) + Calcium (5ml/li)	1.00	1.75	1.25	-	4.25	4.75
GA_3 (250 ppm) + Calcium (10ml/li)	1.00	3.25	2.00	-	5.25	4.25
GA_3 (250 ppm) + Calcium (20m/li)	1.00	1.75	1.00	-	4.50	4.75
GA_3 (300 ppm) + Calcium (untreated)	1.00	3.25	1.25	-	4.75	4.25
GA_3 (300 ppm) + Calcium (5m/li)	1.00	3.25	1.25	-	4.75	4.50
GA_3 (300 ppm) + Calcium (10m/li)	1.00	2.50	1.00	-	5.25	4.25
GA_3 (300 ppm) + Ca leiu m (20m/li)	1.00	1.75	1.00	-	4.75	4.75
CV (%) main plot	0.00	78.9	33.7		13.6	13.8
CV (%) interaction	0.00	49.8	38		12.7	13

Discussions

GA_3 application eliminated fruit translucency on pineapple. Degree of translucency of fruits on calcium-applied plants with or without combination were the same. No blemishes and porosity were observed on all fruits under studied. The Brix of F200 pineapple fruits significantly increased by the application of GA_3 at 250-300 ppm than the 100 ppm and untreated control. Brix, total acidity, pH, and vitamin C in fruit juice after 1 week of ambient temperatures were comparable among treatments. Significant results were observed. on the TA of fruits from plants sprayed with calcium. Higher TA on fruits from plants sprayed with calcium at 10 and 20 ml/l compared to lower rates of calcium at 5 ml/li. The pH in fruit juice was the same on plants sprayed with GA_3. calcium and those from untreated plants. However, a significant result was observed on the vitamin C content of the fruit on plants applied with calcium at a higher rate of 20 ml/li. Lower rates of 10 and 5 ml/li calcium did not improve the vitamin C content of the fruit. Weight loss of fruits with sole application of GA_3 or calcium was comparable to that of the control. Shell mold was found at 3 weeks after from the cold temperature of 7.2°C but no significant result on treatments of GA_3 and calcium and even on combinations.

Visual The quality of pineapple fruits decreased with storage. On ambient stored pineapple fruit for 7 days, a significant effect was observed only on GA_3 application. All pineapple fruits treated with GA_3 at different rates remained with a better visual quality than untreated fruits. However, calcium application to pineapple plants did not improve fruit quality of pineapple after storage. For fruits stored at refrigerated conditions, visual quality changes were observed after 15 days of storage. Significant effect on fruit visual quality was observed only on GA_3-treated pineapple plants but no significant on calcium and combination. Application of GA_3, particularly at the higher rates, maintained a better fruit quality of pineapple than plants without GA_3 application.

The significant result on shell appearance on the interaction of GA_3 and calcium application was found at 18 days of storage temperature. Fruits applied with GA_3 alone at 100 ppm and GA_3 with calcium at 20 ml/li remained with better shell appearance ratings comparable to untreated GA_3 plants with 10 and 20 ml/li calcium and GA_3 300 ppm without and with calcium at 10 ml/li.

No chilling injury was found on fruit at 3 to 15 days of storage, it started to appear at 18 to 21 days. No significant result was found on crown quality changes, shell color changes on fruit applied with GA_3, calcium and the interaction of GA_3 and calcium treatment both ambient and storage temperature but significant result was found on the flesh condition of the fruit on GA_3 and calcium application at 1 week after ambient temperature.

CONCLUSION

Less translucency incidence was observed in F200 pineapple fruits applied with GA_3 at 100 to 300 ppm. While the Brix of F200 pineapple fruits significantly increased at 250-300 ppm. The higher TA on fruits was observed from plants sprayed with calcium at 10 and 20 ml/l. There was higher weight loss in fruits applied with a combination of GA_3 and calcium stored in refrigerated conditions. The visual quality rating of fruits was fair to excellent if applied with GA_3 and better shell appearance with a calcium supplement. Pineapple flesh obtained from plants applied with GA_3 and calcium was still in acceptable condition after 1 week of storage at ambient conditions. The significant result on shell appearance on the interaction of GA_3 and calcium application was found at 18 days of storage temperature.

Application of GA_3 at 100 to 300 ppm increased the TSS and Vitamin C content of fruit after 1-week storage at ambient conditions, while calcium application alone at 20 ml/L increased the Vitamin C content of fruit. Moreover, a significant result was also found on the flesh condition of the fruit on GA_3 and calcium application at 1 week after ambient temperature.

REFERENCES

Bartholomew, D. P., Paull, R. E., & Rohrbach, K. G. (2003). *The pineapple: Botany, production, and uses.* CABI Publishing.

Bethke, P. C., & Jones, R. L. (1998). Gibberellin signalling. *Current Opinion in Plant Biology, 1*(5), 440-446.

Cano-Medrano, R., & Darnell, R. I. (1997). Cell number and cell size in parthenocarpic vs. pollinated blueberry (Vaccinium ashei). *Fruits, 80*(5), 419–425.

Casanova, L., Casanova, R., Moret, A., & Agusti, M. (2009). The application of gibberellic acid increases berry size of 'Emperatriz' seedless grape. *Spanish Journal of Agricultural Research, 7*(4), 919–927.

Chang, J. C., & Lin, T. S. (2006). GA3 increases fruit weight in 'Yu Her Pau' litchi. *Scientia Horticulturae, 108*(5), 442–443.

Castro, P. R. C. (1998). *Utilização de reguladores vegetais na fruticultura, na olericultura e em plantas ornamentais.* Série Produtor Rural, Ed. Especial, 81–84. ESALQ - Divisão de Biblioteca e Documentação.

Chang, J. C., & Lin, T. S. (2006). GA3 increases fruit weight in 'Yu Her Pau' litchi. *Scientia Horticulturae, 108*(5), 442–443.

Chapman, H. W. (2006). Tuberization in the potato plant. *Physiologia Plantarum, 11*(2), 215–224.

Chen, N. J., & Paull, R. E. (1995). Effect of waxing and storage on pineapple fruit quality. In *Proceedings of the International Symposium on Postharvest Science and Technology of Horticultural Crops.* Beijing, China.

Cleland, R. E., S. S. Virk, D. Taylor & Bjorkman, T. (1990). Calcium, cell walls and growth.

Collins, J. L. (1951). Notes on the origin, history, and genetic nature of the Cayenne pineapple. *Pacific Science, 5*(1), 3–17.

Collins, J. L. (1960). *The pineapple: Botany, cultivation, and utilization.* Interscience Publishers.

Colón, C. (1506). *Los cuatro viajes del Almirante y su testamento.* Espasa-Calpe.

Corden, M. E. (1965). Influence of calcium nutrition on fusarium wilt of tomato and polygalacturonase activity. *Phytopathology, 55*(2), 222–224.

Conway, W. S., & Sams, C. E. (1983). Calcium infiltration of Golden Delicious apples and its effect on decay. *Phytopathology, 73*(7), 1068–1071.

Damasco, O. P., Godwin, I. D., Smith, M. K., & Adkins, S. W. (1996). Gibberellic acid detection of dwarf off-type in micropropagated Cavendish bananas. *Australian Journal of Experimental Agriculture, 23*(2), 237–241.

Dar, T. A., Uddin, M., Masroor, M., Khan, A., Ali, A., Hashmi, N., & Idrees, M. (2015). Cumulative effect of gibberellic acid and phosphorus on crop productivity, biochemical activities, and trigonelline production in

Trigonella foenum-graecum L. Cogent Food & Agriculture, 1, 995950.

Davis, P. J. (2004). The plant hormones: Their nature, occurrence, and function. In P. J. Davies (Ed.), *Plant hormones: Biosynthesis, signal transduction, action* (3rd ed., pp. 1–15). Springer.

De Jong, M., Mariani, C., & Vriezen, W. H. (2009). The role of auxin and gibberellin in tomato fruit set. *Journal of Experimental Botany, 60*(7), 1523–1532.

Dhang, S. C., & Biswas, J. (2004). *Orissa Journal of Horticulture, 32*(2), 61–63.

Díaz, D. (2002). *Fisiología de árboles frutales* (1st ed.). AGT Editor, SA.

Dimovska, V., Petropulos, V. I., Salamovska, A., & Ilieva, F. (2014). Flame Seedless grape variety (Vitis vinifera L.) and different concentrations of gibberellic acid (GA3). *Bulgarian Journal of Agricultural Science, 20,* 137–142.

Dull, G. G., Young, R. E., & Biale, J. B. (1967). Respiratory patterns in fruit of pineapple, Ananas comosus, detached at different stages of development. *Physiologia Plantarum, 20,* 1059–1065.

Durner, E. F. (2013). *Principles of horticultural physiology.* CABI International.

Davis, P. J. (2004). The plant hormones: Their nature, occurrence, and function. In P. J. Davies (Ed.), *Plant hormones: Biosynthesis, signal transduction, action* (3rd ed., pp. 1–15). Springer.

Gonzalez-Rossia, D., Juan, M., Reig, C., & Agustí, M. (2006). The inhibition of flowering by means of gibberellic acid application reduces the cost of hand thinning in Japanese plums (Prunus salicina Lindl.). *Scientia Horticulturae, 110,* 319–323.

Gelmesa, D., Abebie, B., & Desalegn, L. (2010). Effects of gibberellic acid and 2,4-dichlorophenoxyacetic acid spray on fruit yield and quality of tomato (Lycopersicon esculentum Mill.). Ethiopian Institute of Agricultural Research-Melkassa Agricultural Research Center. P. O. Box 436, Nazreth, Ethiopia.

Graham, H. D., & Ballesteros, M. (2006). Effect of plant growth regulators on plant nutrients. *Journal of Food Science.* https://doi.org/10.1111/j.1365-2621.1980.tb04086.x

Harrell, D. C., & Williams, L. E. (1987). Net CO2 assimilation rate of grapevine leaves in response to trunk girdling and gibberellic acid application. *Plant Physiology, 83,* 457–459.

Herath, H. M. I., Bandara, D. C., & Banda, D. M. G. A. (2000). Effect of pre-harvest calcium application level on the post-harvest keeping quality of Mauritius pineapple. *Tropical Agricultural Research, 12,* 408–411.

Iqbal, N., Nazar, R., Khan, M. I. R., Masood, A., & Khan, N. A. (2011). Role of gibberellins in regulation of source-sink relations under optimal and limiting environmental conditions. *Current Science, 100,* 998–1007.

Jackson, J. (2003). *Biology of apples and pears.* Cambridge University Press.

Kapłan, M., Najda, A., Baryła, P., & Klimek, K. (2017). Effect of gibberellic acid dose and number of treatments on yield components of the "Einset Seedless" grapevine cultivar. *HortScience, 44*(4), 195–200.

Kumar, A., Tarun, K., Singh, B. N., & Lal, E. P. (2014). *Department of Biological Sciences Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, Uttar Pradesh. IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS), 1*(1), 28–30. e-ISSN: 2319-2380, p-ISSN: 2319-2372.

Lenahan, O. M., Whiting, M. D., & Elfving, D. C. (2006). Gibberellic acid inhibits floral bud induction and improves 'Bing' sweet cherry fruit quality. *HortScience, 41,* 654–659.

Li, Y. H., & Sun, G. M. (2010). Effect of gibberellic acid and N-(2-chloro-4-pyridyl)-N'-phenylurea treatments on fruit quality of pineapple. *Newsletter of the Pineapple Working Group, International Society for Horticultural Science, 17,* 18.

Matsuo, S., Kikuchi, K., Fukuda, M., Honda, I., & Imanishi, S. (2012). Roles and regulation of cytokinins in tomato fruit development. *Journal of Experimental Botany, 63*(10), 5569–5579.

Midmore, D. J. (2015). *Principles of tropical horticulture.* Central Queensland University, Australia; University of Reading, UK.

Nickell, L. G. (1982). *Plant growth regulators* (pp. 1–3). Springer-Verlag Berlin Heidelberg, New York.

Ozga, J., & Dennis, M. (2003). Hormonal interactions in fruit development. *Journal of Plant Growth Regulation, 22,* 73–81.

Sharma, R. R., & Singh, R. (2009). Gibberellic acid influences the production of malformed and button berries, and fruit yield and quality in strawberry (Fragaria 9 ananassa Duch). *Scientia Horticulturae, 119,* 430–433.

Suwandi, T., Dewi, K., & Cahyono, P. (2016). Pineapple harvest index and fruit quality improvement by application of gibberellin and cytokinin. *Fruits, 71*(4), 209–214.

Vargaz, A., & Lopez, J. A. (2011). Effect of dose rate, application method, and commercial formulations of GA3 in banana (*Musa AAA*) fruit green life. *Fresh Produce 2012.* Global Science Book.

Wilson Wijeratnam, R. S., Abeyesekere, M., Hewajulige, I. G. N., & Suganthini, R. (1996). Studies on the black heart disorder, electrolyte leakage, and endogenous calcium content in Kew and Mauritius variety pineapples grown in Sri Lanka. In S. Vijaysegaran, M. Pauziah, M. S. Mohamed, & S. Ahamad Tarmizi (Eds.), *Proceedings of the International Conference on Tropical Fruits,* (Vol. I, pp. 423–430). Malaysian Agricultural Research and Development Institute.

Zhang, C., Tanabe, K., Tamura, F., Matsumoto, K., & Yoshida, A. (2005). 13 C-photosynthate accumulation in Japanese pear fruit during the period of rapid fruit growth is limited by the sink strength of fruit rather than by the transport capacity of the pedicel. *Journal of Experimental Botany, 56,* 2713–2719.