Ripening Behavior Of Durian Applied With Different Levels Of Ethephon

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Abstract
The study investigated the effects of different levels of ethephon on duration to ripening and some physico-chemical characteristics of durian using mature and immature fruits. The experiment was composed of 8 treatment combinations with 3 replications in a Completely Randomized Design (CRD). The treatments composed of 1, 3, and 5 percent of ethephon with tap water for the control. Specifically, data were gathered using sensory evaluation on color and texture of fruits, weight loss was computed at day of ripening including the chemical composition of the edible portion of the fruit such as total soluble solids (TSS), titratable acidity (TA), and pulp pH. The study revealed the use of ethephon at 1%as a ripening agent in durian at right stage of maturity (120 DAFI) given
the generally significant difference in duration of ripening, color, texture and taste consistent with TSS while a comparable result was found in 2 terms of weight loss, fruit acidity and pulp pH. The fruits harvested 120 DAFI obtained the shortest waiting time to ripening as exhibited by all treatments using ethephon except the control comparable with fruits harvested 110 DAFI. This result tends to explain further that the application of ethephon in fruits harvested 110 DAFI fits the purpose of ripening induction but failed to exhibit comparable color patterns, taste and texture of the fruit at the ideal stage of maturity. Thus, the application of ethephon works good with fruits at maturity level ideal
for harvesting at 120 DAFI.

Keyword: Durian, Ethephon, pH, Titrable acidity, Total Soluble Solid

Introduction

Durian *(Durio zibethinus)*, of the Bombacacaea family, is a seasonal tropical fruit that is widely cultivated in Southeast Asia, particularly in tropical countries such as Malaysia, Indonesia and Thailand. Dubbed the 'King of Fruits', durian is well-known due to its unique aroma and taste. Moreover, durian is reported to have many health benefits, such as containing many bioactive and antioxidative compounds (Arancibia-Avila et al., 2008), and being a good source of protein (Gorinstein *et al.,* 2011). The uniqueness of durian draws the interest of both Asian and non-Asians, and this led to the increasing demand for durian in both the local and international markets in the past decade (Ho and Bhat, 2015). During high season, there would be an abundance of durian in the market. This results in an oversupply of durian which would eventually reduce the high price of durian significantly (Wasnin *et al.,* 2014). Generally, durian is harvested when it is matured, and consumed fresh. Durian is reported to have a limited shelf life of 34 days (Pauziah *et al.,* 1992). Furthermore, consumers nowadays are being more selective and look beyond the aroma, taste and overall appearance of a fruit. In addition to the aforementioned sensorial qualities, consumers are also looking for the freshest fruits with the highest nutritional values. Therefore, a better alternative technology is required to preserve fruits efficiently in order to deliver good quality products to ultimate users and industrial consumer. The traditional practice of harvesting durian becomes a constraint in maximizing profit of the farmers nowadays. The fruit is allowed to attain ripeness while attached to the tree and most cases when some of the fruits abscise or fall which affect the taste and overall quality. The practice also includes harvesting all the fruit after 2-3 fruit have already fallen to the ground. This kind of practice which is common among farmers had been observed that fruits begin to ripen 2-
3 days after harvest. Considering this span of time from harvest to ripening mean a shorter time also to dispose the product to consumers at distant places, resulting to damage of the fruit due to exhibit off-flavors beyond the full-ripening phase.

The production of durian is common to countries in Southeast Asia, more particularly to the tropical climates of Indonesia, Malaysia, Thailand and the Philippines. It is considered as a major fruit in these countries, except for the Philippines since its value and export potential has been recognized just recently. One of the reasons for having this export potential is derived from the difference in the environmental characteristics between the four countries which led to the different fruiting schedule of durian between countries. As an emerging export winner, durian can take advantage of the lower tariff in the world market and trade liberalization under the General Agreement on Tariffs and Trade (GATT). Global land, particularly Asia, offers bright opportunity for the industry (PCARRD, 2003).

Considering the great economic contributions and potentials of durian, a lot of government and private initiatives had been undertaken to promote and develop the industry. One of the most significant of which is the formulation and availability of the National Road Map for fruit crops in the Philippines by the Department of Agriculture (DA). The objectives are to increase off-season production, reduce post-harvest losses, expand market, and produce globally competitive processed products. It envisions Southern Philippines durian industry to be globally competitive, expanding markets, and environmentally sustainable (Garcia and Pamplona 2009). Other developments include the laying down of good agricultural practices (GAP) for durian production, the formulation and approval of the Philippine National Standards as well as the ASEAN standards for the commodity.

This is the challenge for this proposed study to test the benefit of using hormones to realize the potential economic returns in horticultural crop production particularly in durian.
Hence, in this study the use of ethephon was considered in order to document the response of the fruit particularly the post-harvest attributes related to ripening behaviour which are observable through some physico-chemical tests. The result of this study may help determine the specific level of ethephon that could enhance the best results in ripening of durian fruit which will serve as guide for farmers and traders to shorten the waiting time for ripening and reduce the cost of harvesting.
Furthermore, from the result of the study the morphological characteristics of durian during ripening was documented and served as additional information to support the works of early scientists who characterized durian a plant bearing edible fruit of commercial value and nutritional content good for human consumption.

Objectives of the Study

Generally, this study aimed to test the effect of ethephon on the ripening behaviour of durian fruits at different stages of maturity. Specifically, the following were the objectives of the study:

1. To determine the number of days to ripening of durian harvested at two stages of maturity and applied with different levels of ethephon; and
2. To determine the postharvest characteristics of durian harvested at two stages of maturity applied with different levels of ethephon in terms of weight loss, change in color, texture, and the chemical composition such as sugar content, titratable acidity, and pulp pH.

Review Of Related Literature

Biology of Durian

Durian *(Durio zibethinus)*, of the Bombacacaea family, is a seasonal tropical fruit that is widely cultivated in Southeast Asia, particularly in tropical countries such as Malaysia, Indonesia and Thailand. Dubbed the 'King of Fruits', durian is well-known due to its unique aroma and taste. Moreover, durian is reported to have many health benefits, such as containing many bioactive and antioxidative compounds (Arancibia-Avila *et al.*, 2008), and being a good source of protein (Gorinstein *et al.*, 2011). The uniqueness of durian draws the interest of both Asian and non-Asians, and this led to the increasing demand for durian in both the local and international markets in the past decade (Ho and Bhat, 2015). During high season, there would be an abundance of durian in the market. This results in an oversupply of durian which would eventually reduce the high price of durian significantly (Wasnin *et al.*, 2014). Generally, durian is harvested when it is matured, and consumed fresh. Durian is reported to have a limited shelf life of 3- 4 days (Pauziah *et al*., 1992). Furthermore, consumers nowadays are being more selective and look beyond the aroma, taste and overall appearance of a fruit. In addition to the aforementioned sensorial qualities, consumers are also looking for the freshest fruits with the highest nutritional values. Therefore, a better alternative technology is required to preserve fruits efficiently in order to deliver good quality products to consumers.

Biological Importance of Plant Hormones

Plant hormones play a great role in plant growth and development (Weaver, 1972). A knowledge about these substances is indeed a necessity for those desiring to apply this in agriculture.
The word "hormone" was first coined by animal physiologists Bayliss and starling (1904). The term "hormone" is restricted to naturally occurring plant products. Growth hormones are hormones that regulate growth while flowering hormones, if they exist, are hormones that initialize the information of primordia or promote their development (Weaver, 1972).

Ethylene and Ripening Mechanics

Ethylene is naturally occurring plant hormones, primarily responsible for the ripening of climacteric fruit and several processes associated with ripening. Ethylene is a simple gaseous hydrocarbon with molecular formula C_2h_4. It can easily diffuse in and out of the plant tissue from exogenous sources (Watkins, 2006).
Ethylene is routinely reported as a major regulator of the ripening of climacteric fruit. However, other hormonal and/or developmental factors are also involved, but the nature of these factors remains largely unknown. The availability of ethylene-inhibited transgenic tomatoes (Murray *et al.,* 1993; Picton *et al.,* 1993; Theologis *et al.,* 1993) and melons (Ayub *et al.,* 1996; Guis *et al.,* 1997) has allowed researchers to determine among the ripening events those that could proceed in the absence of the hormone. Colour changes can be either ethylene dependent or independent according to the type of pigments involved and the fruit species. In ethylene-suppressed tomatoes, the accumulation of lycopene is strongly impaired (Oeller et al., 1991; Murray et al., 1993) while the synthesis of cartenoids is ethylene-independent in the melon (Guis et al., 1997). Chlorophyll degradation is totally prevented in ethylene-suppressed fruit, consistent with the stimulation by ethylene of chlorophyllase gene expression (Jacob-Wilk *et al.,* 1999). Sugar and acids accumulation is unaffected by ethylene suppression. Some other ripening events appear to depend partially on ethylene. For instance, softening and membrane deterioration comprise both ethylene-dependent and –independent components. This observation is consistent with the involvement of a complex set of differentially regulated genes. Among the polygalacturonase gene family of melon, some members are ethylene regulated others not (Guis *et al.,* 1999). Aroma volatiles also exhibit great dependence upon ethylene in the tomato and the melon (Baldwin *et al.,* 2000; Bauchot *et al.,* 1998) although some biosynthetic pathways seem to escape ethylene regulation (Flores *et al.,* 2001a). Because the upsurge of ACC syntheses activity occurs simultaneously in ethylene-suppressed and wild type fruit, it was concluded that the onset of autocatlytic ethylene production is ethylene-independent. These data support the concept that although ethylene plays a major role in

the ripening of climacteric fruit, both ethylene-dependent and -independent pathways co-exist in climacteric fruit. On the other hand, non-climacteric fruit comprise ethylene-dependent events (Goldsmith, 1997).
Ethylene has insightful and significant effects on various environment responses and development events of plants (Yang and Hoffman, 1984). Endogenous production of ethylene increases during certain stages of growth and development, such as seed germination, fruit ripening, and leaf and flower senescence and abscission, and in response to drought, flooding, physical wounding, chilling injury, pathogen infection, and chemical inducers (Yang and Hoffman, 1984; Theologis,1992).
In banana ripening demonstrates several changes in the physiologists and biochemical attributes of the fruit (Kesari *et al.,* 2007). Substantial researchers have been conducted into the effects of ethylene on the ripening process of bananas. During ripening, bananas release small amounts of ethylene, volatile esters and carbon dioxide. It is important that these gases be confined to the ripening room particularly during the early stages of the process. The amount of gases present has a direct bearing on the rate of ripening at a given temperature. To speed up ripening, it is essential to apply ethylene artificially. The binding mechanism of ethylene to these receptors to stimulate chemical reactions towards ripening process. Ethylene receptors are embedded in the cells of fruits. Ethylene molecules in the air bind to the receptor sites and perform like a "key" to unravel them. The receptor sites eventually send a chemical signal to the cells of the fruit to perform a series of chemical reactions (Blankenship, 2001; Choi and Huber, 2018).
For the horticulturist, the ripening of fleshy fruit involves a series of organoleptic changes that make the fruit attractive to the consumer. For the physiologist, the ripening process corresponds to a developmental stage during which biochemical and physiological events are initiated that lead to changes in texture, aroma, color, etc. With the development of molecular biology, fruit ripening is viewed as a genetically programmed event involving the regulated expression of specific genes. Although these processes vary from one type of fruit to the next, fruit can be divided into two broad groups, known as climacteric and non-climacteric. The classification into one group or the other depends on whether or not a fruit exhibits a peak in respiration and ethylene production during ripening. Autocatalytic ethylene production is a major feature of climacteric fruit (McMurchie *et al.,* 1972).

Methodology

Scope and Research Locale

The study was conducted in Matti, Digos City on February 2020. The study was limited only on the determination of postharvest characteristics of durian fruits harvested at two stages of maturity and affected by the application of different levels of ethephon. The study used synthetic ethylene hormone particularly the commercial grade of ethephon which was procured from Agrivet Store in Davao City.
Durian fruits were procured from San Miguel Corporation's Durian Farm in Davao Occidental. The fruits were free from diseases and other defects when harvested. The fruits were harvested manually early in the morning using sharp knife. Only fruits which attained stage of maturity that fall within 110 and 120 days after fruitlet initiation (DAFI) were used in this study. Fruitlet initiation in this study refers to the fruitlet development after the accessory organs like the petals and stamen already dehisced.

Experimental Design and Treatment

This experiment was laid out in Completely Randomized Design (CRD) composed of 8 treatment combinations and replicated three times with three replications. Factor A comprised the two stages of fruit maturity in days, while Factor B the levels of ethephon in millilitres (ml).

Factor A- Stages of Maturity	Factor B- Levels of Ethephon
110 - Days	Control
120 - Days	1%
	3%
	5%

Data Gathered

Number of Days to Ripening

The fruits treated with different levels of ethephon were monitored daily to distinguish which exhibit ripening among the treatment samples. The hollow sound produced by tapping a stick at the fruit wall was among the indicators used to detect ripening on top of the odor as secondary indicator and twisting of the peduncle that creates a crack at the abscission zone.

Weight Loss

The treated fruits were weighed daily to monitor change in weight until ripening and compared with the initial weight and the difference was recorded representing weight loss.

Texture of the Fruit

During ripening the fruit was subjected to manual method of texture evaluation . Rating sheet using visual quality rating using a Likert Scale of 1-5 with corresponding descriptive characteristics to serve as guide to panel of evaluators.

Score	Description
1	No indication of ripening when tapped using stick very slight in terms of hollow sound.
2	Very slight hollow sound difficult to detect when tapped using stick.

3	Slightly hollow sound produced when tapped using stick
4	Moderate hollow sound produced when tapped using stick.
5	Strong hollow sound produced when tapped using stick and the peduncle cracked when twisted secondary to aroma/odor.

Fruit Wall Color

The fruit at ripening phase was evaluated based on the external fruit color. Rating sheet using visual quality rating using Likert Scale of 1-5 with corresponding descriptive characteristics which served as guide to panel of evaluators.

Score	Description
1	No observable color change in the fruit is visible.
2	10-15% observable color change of the fruit is visible.
3	16-25% observable color change of the fruit is visible.
4	26-50% observable color change of the fruit is visible.
5	51-75% observable color change of the fruit is visible.

Fr-igure 1. Fruit Wall Color of Durian

Fruit Pulp Taste Evaluation

The fruits at ripening phase were subjected to taste test using the edible portion. Rating sheet using likert scale of 1-5 was used with corresponding descriptive characteristics to serve as guide to panel of evaluators.

Score	Description
1	Dislike Extremely
2	Dislike Slig
3	Neither like dislike
4	Moderate like.
5	Like Extremely

Chemical Analysis for TSS, TA and pH

The fruits during ripening were subjected to chemical evaluation using the edible portion in terms of total soluble solids (TSS) by using a refractometer, tiratable acidity (TA) and pulp pH.

Statistical Analysis

The data were analyzed using Analysis of Variance (ANOVA) in Completely Randomized Design (CRD). Treatment means with significant results were further analyzed using HSD.

Results And Discussion

Temperature and Relative Humidity of the Storage Area

The experimental fruits in the study were exposed to a temperature range of 27°C to 30°C under low (70%) and high (80%) relative humidity(Table 9) in an open and ventilated area protected from sunlight.

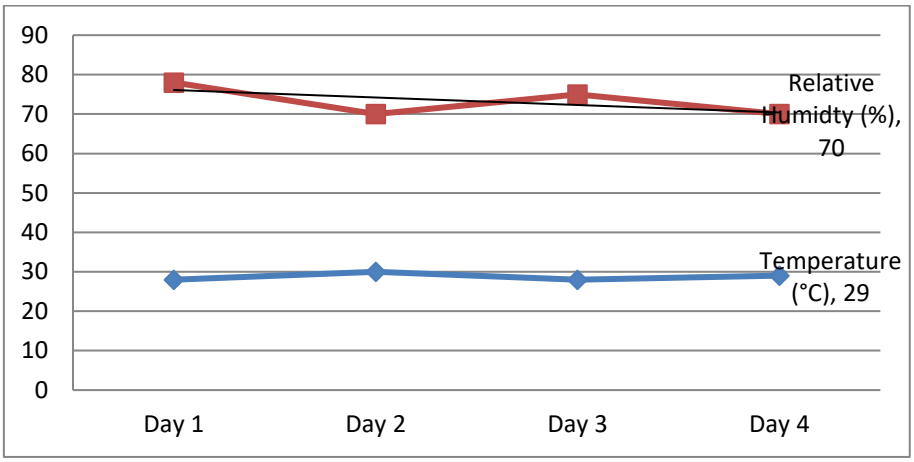

Figure 2 . Daily Record of averageTemperature (Celsius) and Relative Humidity (%) of the storage area throughout the duration of the study. Matti, Digos City. February 2020.

Duration to Ripening

The data in Table 1 revealed a highly significant difference among treatments across stages of fruit maturity and the control treatments having the longest time in days to ripening while all treatments applied with ethephon exhibits the shortest duration to ripening. This means the fruits harvested at two stages of maturity exhibited an effect in response to use of ethephon and this conforms with several studies in the past that climacteric fruits where durian is one among them ripening was induced to ripen earlier because of the triggering mechanism of ethylene present in the ethephon being used in the study.

Table 1. Number of hours to ripening of durian fruits at different maturity levels as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN****
Control		3.33	3.33	3.33	9.99	3.33 a
110 DAFI	1%	2.33	2.67	2.67	7.67	2.55 b
	3%	3.33	3.33	3.33	9.99	3.33 a
	5%	2.00	2.67	2.67	7.34	2.45 b
Control		2.33	2.33	2.33	6.99	2.33 b
120 DAFI	1%	2.33	2.00	2.00	6.33	2.11 b
	3%	2.00	2.33	2.00	6.33	2.11 b
	5%	2.3	2.00	2.00	6.33	2.11 b
CV: 7.75%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Sensory Evaluation of Fruit Texture

During ripening the fruits were subjected to manual method of texture evaluation. Rating sheet for visual quality rating using a Likert Scale of 1-5 with corresponding descriptive characteristics served as guide to panel of evaluators such as: (1) no indication of ripening when tapped using stick very slight in terms of hollow sound; (2)very slight hollow sound difficult to detect when tapped using stick; (3) slightly hollow sound produced when tapped using stick; (4) moderate hollow sound produced when tapped using stick; and (5) strong hollow sound produced when tapped using stick and the peduncle cracked when twisted secondary to aroma or odor. The data in Table 2 shows that there was a significant difference among treatments in terms of fruit texture as rated by panel of experts doing the sensory evaluation with only T_1 of the fruits from harvested 110 DAFI exhibit the mean value of 4 which was comparable to all mean values of the fruits harvested 120 DAFI and the rest recorded mean value within bracket 3. This indicates that when the fruits harvested at 110 DAFI treated with ethepon the fruit texture attain only the rating scale within the bracket of 3 with a descriptive rating of slightly hollow sound produced when tapped using a stick which means not a good indicator of ripening and affect the quality n terms of taste. While all the fruits in 120 DAFI shows the upper limit of bracket 4 and approaching rating scale 5 which means highly acceptable level of fruit ripening as rated by the panel of evaluators.

Table 2. Texture of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN****
Control		4.0	4.5	4.0	12.5	4.16^{ab}
110 DAFI	1%	3.8	3.5	4.0	11.3	3.77^{ab}
	3%	3.5	4.0	3.5	11.0	3.67^{ab}
	5%	3.0	3.5	4.0	10.5	3.5^{0b}

Control		4.3	4.8	5.0	14.10	4.70[a]
120 DAFI	1%	4.0	4.8	4.5	13.3	4.43[ab]
	3%	4.0	4.5	5.0	13.5	4.50[ab]
	5%	4.2	4.8	4.5	13.5	4.50[ab]
CV: 8.98%						

Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant,
** denotes significant; ** denotes highly significant.*

Score	Description
1	No indication of ripening when tapped using stick very slight in terms of hollow sound.
2	Very slight hollow sound difficult to detect when tapped using stick.
3	Slightly hollow sound produced when tapped using stick
4	Moderate hollow sound produced when tapped using stick.
5	Strong hollow sound produced when tapped using stick and the peduncle cracked when twisted secondary to aroma/odor.

Sensory Evaluation of Fruit Taste

The fruits at ripening phase were subjected to taste test using the edible portion of the fruit after opening. Rating sheet using Likert Scale of 1-5 was used with corresponding descriptive characteristics which served as guide to panel of evaluators: (1) dislike extremely; (2) dislike slightly; (3) neither like nor dislike; (4) moderately like; and (5) like extremely.

The data in Table 3 presents the result that there was a highly significant difference on sensory evaluation in terms of fruit taste which resembles acceptability indicator in the usual trading interaction with customers and consumers of the fruit in the market. The same pattern of response was observed in fruit taste as observed in the data on fruit texture in Table 2 wherein fruits at 120 DAFI got the highest rating of 4.33- 4.67 which belong to the descriptive rating of moderately like to like extremely and are comparable to the control (T_1) in both 110-120 DAFI fruit maturity stages which were allowed to ripen normally without ethephon application. This means that the application of ethephon in this particular study fits the purpose of ripening induction but failed to exhibit comparable taste and even texture of the fruit at the ideal stage of maturity of 120 DAFI. Hence, the application of ethephon works good with fruits at maturity level ideal for harvesting in order to effect both ripening induction and taste as well as texture remains favourable as marked with rating scale belonging to the upper limit of 4 or approaching extreme score of 5 meaning the panel rated liked extremely.

Table 3. Taste of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN****
Control		4	4.2	4.3	12.5	4.16[abc]
110 DAFI	1%	4.0	3.5	3.0	10.5	3.50[cd]
	3%	3.5	3.0	3.0	9.5	3.17[d]
	5%	3.6	3.5	4.0	11.1	3.70[bcd]
Control		4.0	4.5	5.0	13.50	4.50[ab]
120 DAFI	1%	4.5	4.5	4.0	13.0	4.33[abc]
	3%	4.5	4.3	4.8	13.6	4.53[ab]
	5%	5.0	4.5	4.5	14.0	4,67[a]
CV: 8.27%						

Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant,
** denotes significant; ** denotes highly significant.*

Score	Description
1	Dislike Extremely
2	Dislike Slightly
3	Neither like nor dislike
4	Moderate like.
5	Like Extremely

Fruit Wall Color

The fruits at ripening phase were evaluated based on the external color which at harvesting exhibit full green with tip of thorns visibly green and sharp-pointed. The data in Table 4 presents the mean difference among treatments and indicates slight level of significance exists and the pattern of effect due the application of ethephon seemed consistent with the other sensory tests conducted like texture and taste of fruit edible portion where the fruits harvested 120 DAFI got the highest range of mean rating. Furthermore, the tips of the thorns surrounding the fruit wall started to show senescence or there was an observed destruction of making it not sharp-pointed in structure completely different from fruits not attaining ripening stage. This result tends to explain and support the findings in texture and taste that the application of ethephon fits the purpose of ripening induction but failed to

exhibit comparable change in color, taste and texture of the fruit at the ideal stage of maturity. Thus, the application of ethephon works good with fruits at maturity level ideal for harvesting(120 DAFI) in order to effect both ripening induction,color change, pulp taste as well as texture remains favourable as rated by panel of sensory evaluators.

Table 4. Sensory rating on color of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN****
Control		4.0	4.3	4.0	12.3	4.10^{ab}
110 DAFI	1%	3.5	3.8	4.0	11.3	3.77^{ab}
	3%	4.0	3.5	3.5	11.0	3.67^{b}
	5%	3.5	3.8	3.5	10.8	3.60^{b}
Control		4.0	4.5	4.2	12.7	4.23^{ab}
120 DAFI	1%	4.8	4.5	4.5	13.8	4.6^{a}
	3%	5.0	4.0	4.0	13.0	4.33^{ab}
	5%	4.3	4.5	4.0	12.8	4.27^{ab}
CV: 7.25%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Score	Description
1	No observable color change in the fruit is visible.
2	10-15% observable color change of the fruit is visible.
3	16-25% observable color change of the fruit is visible.
4	26-50% observable color change of the fruit is visible.
5	51-75% observable color change of the fruit is visible.

Weight Loss of Fruit

The treated fruits were weighed daily to monitor change in weight until ripening and compared with the initial weight and the difference was recorded representing weight loss. The data presented in Table 5 summarizes the mean weight loss of the fruits used in the study.The result shows that there was no significant difference in weight loss among treatments using different levels of ethephon from two stages of maturity (110 DAFI and 120 DAFI) with a range of 470 grams - 650 grams. This findings would mean even the fruits harvested 110 DAFI could be applied with ethephon and induced to ripen with no distinguishable values of difference particularly in weight loss when compared with fruits harvested 120 DAFI. This weight loss could be attributed to moisture loss of the fruit peel as physical change of the color was highly observable and the tip of the thorns begin to manifest deterioration while in storage from the treatment of ethephon to ripening stage.

Table 5. Mean difference in weight loss (grams) of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN^{ns}**
Control		0.55	0.75	0.65	1.95	0.65
110 DAFI	1%	0.65	0.50	0.45	1.60	0.53
	3%	0.55	0.65	0.50	1.70	0.57
	5%	0.57	0.60	0.55	1.72	0.58
Control		0.55	0.55	0.60	1.70	0.57
120 DAFI	1%	0.50	0.45	0.45	1.40	0.47
	3%	0.50	0.65	0.55	1.70	0.57
	5%	0.50	0.60	0.45	1.55	0.52
CV: 12.84%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Total Soluble Solids (TSS)

The TSS in control treatments and applied with ethephon in Table 6 exhibits highly significant difference. The noted effect of high concentration of ethephon when applied to fruits at 120 DAFI are comparable to the previous reported TSS values of 19.4-25% (Ketsa and Pangkool, 1994; Pascua and Cantila, 1992; Wasnin et al., 2014). This finding suggests that the TSS in durian were affected by the different levels of ethephon and could be attributed to the accelerated breakdown of starch to sugar in the durian samples as ethephon level was increased. The TSS of durian as with other fruits is an important chemical indicator of taste as it dictates the overall sweetness and acceptability for consumption.

Table 6. TSS (degree Brix) of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN****
Control		17	20	17	54	18.00[b]
110 DAFI	1%	20	22	20	62	20.67[ab]
	3%	20	18	18	56	18.67[ab]
	5%	21	18	18	57	19.00[ab]
Control		22	20	22	60	21.33[ab]
120 DAFI	1%	23	22	20	65	21.67[ab]
	3%	22	20	20	62	20.67[ab]
	5%	23	22	22	67	22.33[a]
CV: 6.52%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Titratable Acidity (TA)

The titratable acidity of fruits in the study is presented in Table 7 which showed no significant difference among treatments in both maturity stages of 110 -120 DAFI. The result showed that the treated durian samples generally had comparable titratable acidity (TA) with the untreated control. This means that titratable acidity of the fruits is not affected by the application of ethephon considering the comparable values of the different treatments and this result further supports the claim that ripening could be triggered by ethephon application with no significant change in titratable acidity perhaps the noted effect was induction of pulp softening and sugar breakdown as well as some physically observable parameters only.

Table 7. Titratable Acidity (%) of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		REPLICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN[ns]**
Control		1.030	1.030	1.020	3.08	1.027
110 DAFI	1%	1.020	1.020	1.030	3.07	1.023
	3%	1.030	1.020	1.020	3.07	1.023
	5%	1.030	1.010	1.020	3.06	1.020
Control		1.020	1.020	1.020	3.06	1.020
120 DAFI	1%	1.020	1.030	1.030	3.08	1.027
	3%	1.030	1.020	1.020	3.07	1.023
	5%	1.020	1.030	1.020	3.07	1.023
CV: 0.60%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Durian Pulp pH

The measurement of pH in durian pulp was carried according to the method of Voon *et al.,* (2006). Briefly, the durian pulp were homogenised with distilled water (1:10 w/ v) for 1 min and subjected to pH measurement by a pH meter (Sartorius, Göttingen, Germany). The pH of durian pulp is shown in Table 8. It could be observed that the pH of the durian pulp showed no significant difference with a pH value having a range of 7.03 -7.4 across two maturity levels (110–120 DAFI). There were no significant fluctuations in the pH of durian pulp for both stages of maturity applied with ethephon. The pH is one of the measurements that could be used to determine the quality and freshness of durian. Durian with a low pH might be too acidic and would not be suitable for consumption, whereas a high pH might increase the possibility of microbial spoilage. However, in this study, the treated and the untreated durian showed a stable pH near 7 suggesting neutral values throughout the different levels. This finding potentially suggests that durian pulp pH is not affected even subjected to ripening induction using ethephon.

Table 8. pH of durian fruits at different maturity stages as affected by application of ethephon. Matti, Digos City. February 2020.

TREATMENTS		I LICATION				
FACTOR A	**FACTOR B**	**I**	**II**	**III**	**TOTAL**	**MEAN[ns]**
Control		7.1	7.4	7.4	21.9	7.30
110 DAFI	1%	7	7.2	7.2	21.4	7.13
	3%	7	7.0	7.0	21.4	7.13
	5%	7.0	7.1	7.0	21.1	7.03
Control		7.5	7.4	7.3	22.2	7.40
120 DAFI	1%	7.3	7.0	7.0	21.3	7.10
	3%	7.4	7.3	7.3	22.0	7.33

	5%	7.5	7.3	7.3	22.1	7.37
CV: 1.94%						

*Means with the same letter do not differ significantly at 0.05 level, ns denotes not significant, * denotes significant; ** denotes highly significant.*

Summary, Conclusion And Recommendation

Summary

This study was conducted in Matti, Digos City on February 2020 and was limited only on the determination of postharvest characteristics of durian fruits harvested at two stages of maturity and affected by the application of different levels of ethephon. Specifically, the following were the objectives of the study: (1) to determine the time duration to ripening of durian harvested at two stages of maturity and applied with different levels of ethephon; and (2) to determine the postharvest characteristics of durian harvested at two stages of maturity applied with different levels of ethephon in terms of weight loss, change in color, texture, and the chemical composition such as sugar content, titratable acidity, and pulp pH. The experimental fruits in the study were exposed to a temperature range of 27°C to 30°C under low (70%) and high (80%) relative humidity in an open and ventilated area protected from sunlight.

The duration from fruit treatment with the hormone was monitored and recorded to compute the approximate time to ripening. The result shows the mean duration in hours for the different treatments posting a highly significant level of difference across stages of fruit maturity and within the 110 DAFI. However, for fruits within 120 DAFI the shortest possible time realized to attain ripening stage was exhibited by all treatments from $T_2 – T_4$ with mean values of 50.67 while T_1 (control) of mean value 56 hours or late of about 6 hours was comparable or did not show significant difference with other treatments in the same level of fruit maturity tested. The fruits in 110 DAFI having a range of mean values 61.33 – 80 hours where T_2 and T_4 (61.33 and 58.67 hours, respectively) are not showing comparable results but exhibit the shortest duration to ripening compared to T_1 and T_3 having the longest duration of 80 hours which did not differ significantly from each other to reach ripening stage. This means the fruits at 120 DAFI exhibit favourable responses to use of ethephon compared to fruits harvested 110 DAFI despite the fact that the latter successfully attained ripening on a later period which was significantly different from the former.

During ripening the fruits were subjected to manual method of texture evaluation. The data shows that there was a significant difference among treatments in terms of fruit texture as rated by panel of experts doing the sensory evaluation with only T1 of the fruits from harvested 110 DAFI exhibit the mean rating value of 4 which was comparable to all mean values of the fruits harvested 120 DAFI and the rest recorded mean rating value of 3. This indicates that when the fruits harvested at 110 DAFI treated with ethepon the fruit texture attain only the rating scale of 3 with a descriptive rating of slightly hollow sound produced when tapped using a stick which means not a good indicator of ripening and affect the quality in terms of taste. While all the fruits in 120 DAFI shows mean rating above 4 and approaching scale 5 which with descriptive rating highly acceptable level of fruit ripening as rated by the panel of evaluators.

At the time of ripening the fruits were subjected to taste test using the edible portion of the fruit after opening. The data presents a highly significant difference on sensory evaluation in terms of fruit taste which resembles acceptability indicator in the usual trading interaction with customers and consumers of the fruit in the market. The same pattern of response was observed in fruit taste as observed in the data on fruit texture wherein fruits at 120 DAFI got the highest rating of 4.33- 4.67 which belong to the descriptive rating of moderately like to like extremely and are comparable to the control (T_1) in both 110-120 DAFI fruit maturity stages which were allowed to ripen normally without ethephon application. This means that the application of ethephon in this particular study fits the purpose of ripening induction but failed to exhibit comparable taste and even texture of the fruit at the ideal stage of maturity of 120 DAFI. Hence, the application of ethephon works good with fruits at maturity level ideal for harvesting in order to effect both ripening induction and taste as well as texture remains favourable as marked with rating scale belonging to the upper limit of 4 or approaching extreme score of 5 meaning the panel rated liked extremely.

Furthermore, the fruits at ripening phase were also evaluated based on the external color which at harvesting exhibit full green with tip of thorns visibly green and sharp-pointed. The data presents the mean difference among treatments and indicates slight level of significance exists and the pattern of effect due the application of ethephon seemed consistent with the other sensory tests conducted like texture and taste of fruit edible portion where the fruits harvested 120 DAFI got the highest mean rating of 4.10- 4.60 which belong to the descriptive rating of 50% or more up to 75% observable color change of the fruit is visible which were comparable to the control (T_1) in both 110-120 DAFI fruit maturity stages which were allowed to ripen normally without ethephon application. It was also observed that the tips of the thorns surrounding the fruit wall started to show physical senescence features making it not sharp-pointed in structure completely different from fruits not attaining ripening stage. This result tends to explain that the application of ethephon in this study fits the purpose of ripening induction but failed to exhibit comparable color patterns, taste and texture of the fruit at the ideal stage of maturity of 120 DAFI. Thus, the application of ethephon works good with fruits at maturity level ideal for harvesting (120 DAFI) in order to effect both ripening induction, color change, pulp taste as well as texture remains favourable as rated by panel of sensory evaluators.

In terms of weight loss the fruits were weighed [illegible] tor change in weight until ripening and compared with the initial weight and the difference was rec[illegible]nting weight loss. The result shows that there was no significant difference in weight loss among treatments using different levels of ethephon from two stages of maturity (110 DAFI and 120 DAFI) with a range of 0.47 grams - 0.65 grams wherein T1 (control) of fruits harvested 110 DAFI got the highest weight loss of 0.65 grams while the lowest with T_2 of fruit samples from 120

DAFI. This findings would mean even the fruits harvested 110 DAFI could be applied with ethephon and induced to ripen with no distinguishable values of difference particularly in weight loss when compared with fruits harvested 120 DAFI. This weight loss could be attributed to moisture loss of the fruits while in storage from the treatment of ethephon to ripening stage.

The TSS in all untreated (control) and durian fruits applied with ethephon exhibits highly significant difference. The TSS for the untreated samples ranged from 18.00 – 21.33 degree Brix while the treated fruit samples had 18.67-22.33 degree Brix. The results are comparable to the previous reported TSS values of 19.4-25% (Ketsa and Pangkool, 1994; Pascua and Cantila, 1992; Wasnin *et al.,* 2014). This finding suggests that the TSS in durian were affected by the different levels of ethephon. These findings suggest that the dissociation or breakdown of starch to sugar in the durian samples treated with ethephon was high enough to justify highly significant difference among treatments. TSS of durian is an important chemical indicator of taste as it dictates the overall sweetness and acceptability for consumers.

The titratable acidity of fruits showed no significant variations throughout the different treatments using both maturity stages of 110 -120 DAFI. The result showed that the treated durian samples generally had comparable titratable acidity (TA) with the untreated sample (control). The titratable acidity in untreated samples and fruit samples applied with ethephon was in the range of 1.020- 1.027% for both stages of maturity (110-120 DAFI).

The measurement of pH in durian pulp was carried according to the method of Voon *et al.,* (2006). The pH of the durian pulp showed no significant difference with a pH value having a range of 7.03 -7.4 across two maturity levels (110 – 120 DAFI). There were no significant fluctuations in the pH of durian pulp for both stages of maturity applied with ethephon. The pH is one of the measurements that could be used to determine the quality and freshness of durian. Durian with a low pH might be too acidic and would not be suitable for consumption, whereas a high pH might increase the possibility of microbial spoilage. However, in this study, the treated and the untreated durian showed a stable pH near 7 suggesting neutral values throughout the different levels. This finding potentially suggests that durian pulp pH is not affected even subjected to ripening induction using ethephon.

Conclusion

Based on the data gathered in the study it is conclusive enough that the use of ethephon at different levels as a ripening agent in durian at 120 DAFI generally show favorable result in duration of ripening, color, texture and taste consistent with TSS while a comparable result was found in terms of weight loss, fruit acidity and pulp pH as exhibited by fruits harvested 110 DAFI. The fruits harvested 120 DAFI obtained the shortest waiting time to ripening compared to fruits harvested 110 DAFI.

Recommendation

The findings of the study on the favorable benefits of ethephon application at the lowest level as tested (1%) is highly recommended for fruits at 120 DAFI order to attain desired quality attributes comparable to its normal ripening traits and considering one cost.

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