

# Ripening Efficacy of Kamias Fruit (*Averroah Billimbi*) for Cavendish Banana (*Musa acuminata*)

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## Abstract

This paper aims determine the efficacy of Kamias (*Averrhoa bilimbi*) fruit as a ripening agent for Cavendish banana (*Musa acuminata*). A quantitative experimental research design was employed in the study. Unripe Cavendish bananas and Kamias fruits were procured from the local market and the fruits were extracted to three different concentrations. Calcium carbide was used as positive control. Six bunches of unripe bananas were allowed to ripe and labeled according to the type of treatment. Ripe bananas were then subjected to sensory evaluation, titratable acidity and Benedict's tests. Results showed that the use of Kamias fruit allowed ripening of banana for 76 hours while a 25-75% concentration of Kamias fruit extract allowed ripening for 76-96 hours. The bananas treated with Kamias Extract 75% had the highest level of acceptability and titratable acidity while the bananas treated with Kamias fruit had the highest level of reducing sugar. One-Way MANOVA reported that there is a significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with various ripening agents ( $p < 0.05$ ).

**Keywords:** Kamias (*Averrhoa bilimbi*), Ripening, Cavendish Banana (*Musa acuminata*), Experimental, Davao City

## Chapter 1

### INTRODUCTION

#### Background of the Study

The Philippines is known to be one of the top five exporters of bananas (*Musa acuminata*) in the world. According to the report of FAOSTAT (2018), the country traded 1.4 million tons of banana internationally, and the exports made up 98 percent of the Asian banana trade. In terms of hectarage, value and volume of production, the crop is the leading fruit species in the country. According to the Bureau of Agricultural Statistics or BAS (2018), the country produced nearly 9.2 billion tons of banana on 446,800 hectares of land, and these were valued at 147.6 billion pesos in 2017. The same statistics revealed that it is a consistent top dollar earner, with export revenues amounting to more than 1.1 billion US dollars annually. The crop significantly contributed to the 3.96 percent expansion in the gross value added in agriculture of the country.

In terms of cultivars grown for the market, Cavendish cultivars accounted for about 51.9 percent of national banana production followed by Saba with 27.6 percent while Lakatan together with other cultivars comprised the remaining share of 20.5 percent (PSA, 2018). Davao Region had the highest production of nine million tons or 37.3 percent of the total banana production.

However, to further boost the production of banana, adequate ripening technology needs great attention. Along with the improvement of technology, various artificial agents of fruit ripening have been used mostly to meet customers'

demand and other economic factors. For instance, Calcium carbide ( $\text{CaC}_2$ ) is a widely used commercial chemical agent for artificial ripening of climacteric fruits in different parts of the world. Once dissolved in water, this produces acetylene which acts as a ripening agent. Fruits treated with calcium carbide are soft and developed excellent peel color but poor flavor.

Despite the effort to increase the productivity of banana, treatment of crop with Calcium carbide has become questionable because of various health-related issues. For instance, acetylene produced from the chemical is responsible for the reduction of oxygen supply in the brain if it is consumed directly and can further because of prolonged hypoxia (Asif, 2012). Siddiqui and Dhua (2010) found out that the chemical contains trace concentrations of arsenic and phosphorus hydride. Furthermore, it may affect the neurological system by inducing dizziness, headache, sleepiness, mood disturbances, memory loss, mental confusion, seizures, and cerebral edema (Edenhofer, Joritz, Rink, & Voges, 2015). Calcium carbide belongs to the alkaline group, which exacerbates the mucosal tissue in the intestines. A distressed stomach after consumption of carbide-ripened mangoes has been reported recently in the study of Metsala, Schmidt, Skytta, Vaitinen, and Halonen (2010).

Several scholarly sources reported that beside chemical agents, some natural agents have a high content of ethylene, a major ripening agent produced naturally in the fruits. For instance, apple, pear and tomato were used as natural ripening agents for banana (Gandhi, Sharma, & Bhatnagar, 2019; Singal, Kumud, & Thakral, 2012); however, the cost of these materials was tantamount to that of

the commercial agent. Other factors affecting the quality of banana such as the amount of reducing sugars and titratable acidity were also overlooked. Kamias (*Averrhoa bilimbi*) fruit, a small green tropical fruit common in the Philippines, is believed to be a possible source of ethylene. Phytochemical analysis revealed that the uninjured fruit evolved 86.8 nl/g/h in 24 hours while injuring the fruits by pricking with a needle-like wire to a depth of 15 mm increased the ethylene production from 0.86 nl/g/h by 65 times to 59.42 within 1 hour (Ali, Hasanuzzaman, & Shornaly, 2013).

The present study aims to determine the efficacy of Kamias (*Averrhoa bilimbi*) fruit as a ripening agent for Cavendish banana (*Musa acuminata*). It also aims to evaluate the reducing sugar present and the titratable acidity of the banana after treated with the ripening agent.

### **Statement of the Problem**

This study aims to evaluate the efficacy of Kamias fruit as a ripening agent for Cavendish banana. Specifically, the study attempts to answer the following questions:

1. What is the duration of Cavendish banana ripening treated with the following ripening agents:
  - 1.1 Positive control (Calcium carbide)
  - 1.2 Kamias fruit
  - 1.3 Kamias fruit extract – 25%, 50% and 75% concentration
  - 1.4 Negative control

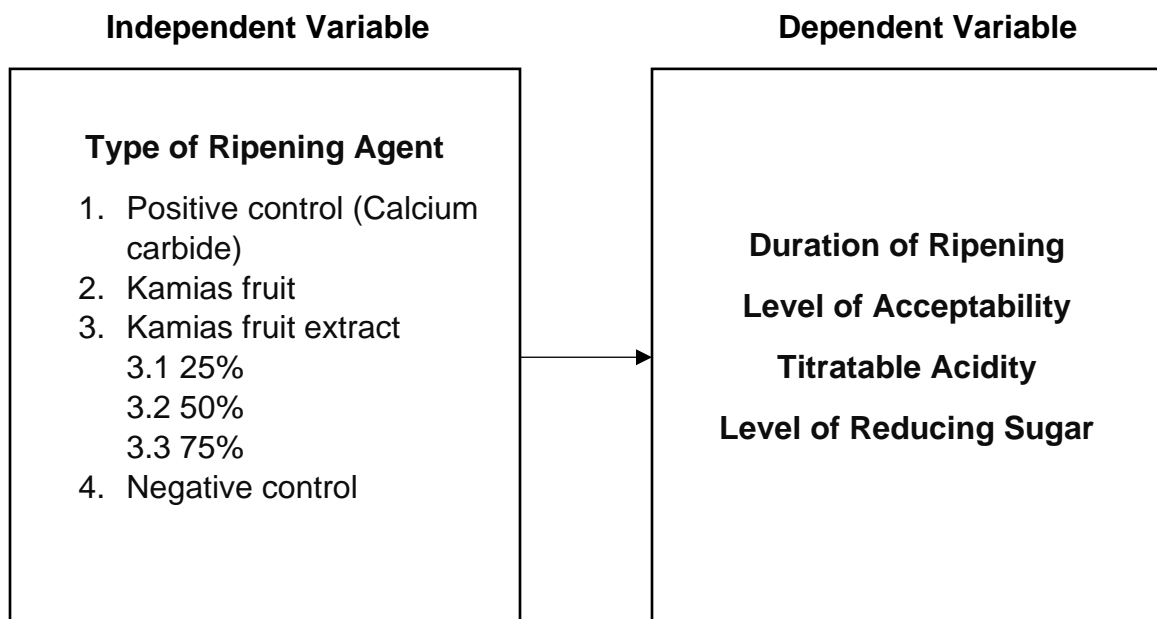
2. What is the level of acceptability of Cavendish banana treated with different ripening agents in terms of the following parameters:
  - 2.1 Appearance
  - 2.2 Skin color
  - 2.3 Aroma
  - 2.4 Firmness
  - 2.5 Taste
  - 2.6 Mouth-feel
3. What is the titratable acidity of Cavendish banana treated with the following ripening agents:
  - 3.1 Positive control (Calcium carbide)
  - 3.2 Kamias fruit
  - 3.3 Kamias fruit extract – 25%, 50% and 75% concentration
  - 3.4 Negative control
4. What is the level of reducing sugar of Cavendish banana treated with the following ripening agents:
  - 4.1 Positive control (Calcium carbide)
  - 4.2 Kamias fruit
  - 4.3 Kamias fruit extract – 25%, 50% and 75% concentration
  - 4.4 Negative control
5. Is there a significant difference in the duration of ripening, level of acceptability, titratable acidity, and level of reducing sugar when treated with different ripening agents?

## Hypothesis

The null hypothesis was formulated and tested at 0.05 level of significance stating:

H1: There is no significant difference in the duration of ripening, level of acceptability, titratable acidity, and level of reducing sugar when treated with different ripening agents.

## Conceptual Framework



**Figure 1. Research paradigm of the study**

Presented in Figure 1 is the research paradigm of the study showing the type of ripening agent will directly affect the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar. As shown in the table,

the independent variable is the type of ripening agent while the dependent variables are the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar.

### **Significance of the Study**

This study is important to the following:

**Local Market.** The findings of the study will pave the way to finding alternative ripening agent that could hasten ripening of the bananas without degrading its quality. The local market can use the agent to increase production and profitability.

**Agricultural Industry.** The findings of the study will prompt the industry to use the ripening agent during export of the crops. Improvised methods on increasing productivity will be further explored.

**Government.** The findings of the study will attract governmental agencies on the possible partnership in increasing research about the ripening agent. The methodology will be enhanced in order to come up with the most accurate result.

**Students.** The findings of the study will add to the body of scientific literatures regarding the Kamias fruit. Students will learn from these literatures and future application of other ripening agents can be done.

**Future Researchers.** The proposed study will benefit and help the future researchers. The ideas presented may be used as reference data in conducting new researches or in testing the validity of other related findings. This can also open in the development of the study.



## Definition of Terms

The following terms were defined operationally for ease and clarity:

**Benedict's Test.** This refers to the procedure used to determine the presence of reducing sugar.

**Hedonic Scale.** This term is used in tasting panels where the judges indicate the extent of their like or dislike for the food

**Reducing Sugar.** This term refers to any carbohydrate capable of being oxidized and causes the reduction of other substances without having to be hydrolyzed.

**Titrateable Acidity.** This refers to an approximation of the total acidity of a solution and is the basis for the quality of food, as well as the presence of microorganisms in the food.

## Review of Related Literature

Presented in this chapter is a synthesis of research that supports the study about the Efficacy of Kamias fruit (Averroah Balimbi) as Ripening agent for Cavendish Banana (Musa Acuminata). Included in this chapter are the reasons that the Kamias fruit (Averroah Balimbi) has the component to ripened naturally the Cavendish Banana (Musa Acuminata).

### Cavendish Banana

According to McMahon (2019) stated that, the Cavendish banana is the most broadly developed banana cultivar. Estates committed to this banana can be found in Latin America, Africa, and Southeast Asia, and the heft of bananas on the racks of Western grocery stores are Cavendish bananas. These organic products

are omnipresent, efficiently accessible all year in new structure. These bananas began in Southeast Asia, explicitly Vietnam, and they turned out to be broadly developed during the 1950s.

The account of the Cavendish is really an interesting look into the universe of business banana development, particularly since this is a world that many normal purchasers think minimal about. Bananas previously turned out to be broadly prominent during the 1800s, when railroad organizations began building up estates of Gros Michel or "Enormous Michael" bananas along their tracks. These bananas could be effectively transported once they were ready, creating twofold benefits for the railroad by enabling the organization to charge for travelers and cargo, and to transport an expensive intriguing nourishment on a similar train. The cost of bananas began to drop, and bananas rapidly turned into a well-known tropical organic product. By the 1920s, be that as it may, an issue was beginning to create with the Big Michael cultivar; the bananas were powerless to Panama Disease, a growth which assaults and executes banana plants.

During the 1950s, plainly this cultivar was in a bad position, and the Cavendish banana was chosen to supplant it. In any case, after 50 years, the Cavendish banana additionally kept running into inconvenience, raising worries that this cultivar may likewise wind up terminated. Bananas by and large are particularly helpless to malady in light of the fact that the plants are clones of one another. Bananas are repeated by developing their corms, as they don't deliver seeds, and thus, all Cavendish bananas around the globe are hereditarily indistinguishable. This implies when an ailment develops to assault the Cavendish cultivar, it can conceivably affect each Cavendish plant on the planet, clearing the cultivar out in a brief timeframe. Scientists have recommended that the helplessness of the banana is a solid contention for attempting to hold hereditary decent variety for this tropical plant. By reproducing extra cultivars with the utilization of wild stock and urging individuals to purchase a scope of bananas, scientists plan to keep bananas in grocery stores in the years to come, regardless of whether the Cavendish banana at last surrenders to malady.

## Ripening Agents

Several studies found out that Ethylene is a characteristic plant development controller, it is a vaporous hormone normally delivered in organic product. Ethylene being a characteristic hormone does not represent any wellbeing danger for customers of the organic products. It is a de-greening specialist, which can divert the strip from green to consummate yellow (in the instance of bananas) and keep up the sweetness and smell of the organic product, along these lines esteem expansion in the natural product is conceivable as it looks all the more engaging. It has been known for a long time that treatment of unripe natural products with ethylene would simply invigorate characteristic aging until the natural product itself begins delivering ethylene in extensive amount in the natural product (Siddiqui and Dhua, 2010).

Out of all the aging specialists, calcium carbide is usually utilized, in light of the fact that it is modest and effectively acquired. The utilization of this concoction for this object is illicit in most nations (Siddiqui and Dhua, 2010), however it is openly utilized in India, Pakistan, Bangladesh, Nepal and different nations like Nigeria. The vast majority of the aging operators are lethal and their utilization can cause genuine medical issues, for example, heart malady, skin illness, lung disappointment and kidney disappointment. Analysts have moreover announced that standard utilization of misleadingly aged natural products may cause tipsiness, shortcoming and heart-related ailment (Asif, 2012).

Capacity temperature impacts the maturing changes in bananas. An increment away temperatures somewhere in the range of 14°C and 30°C improves the rate of maturing and the natural product diminishes at a quicker rate. The breath rate and ethylene generation were additionally appeared to increment with an expansion of temperature. High temperature can additionally result in harm to maturing natural product. Temperatures under 14°C can cause uneven aging due to chilling damage. Amid banana aging, the strip shading changes, the flavor creates, and the mash mellows. The first perceptible indication of maturing is a

shading change from green to yellow. The aging treatment of banana organic products has been improved through a provisional technique by the exact of prepared workers into an automatic ethylene gas control way. In any case, this technique has not constantly achieved in bringing the formally dressed aging of banana organic products, in view of its lacking any observing framework to distinguish the aging nature of banana fruits. Bananas are commonly misleadingly aged in nearby markets by the utilization of restricted substance, calcium carbide. The utilization of this compound is restricted because of wellbeing reasons. Business aging is a basic piece of natural product business as ready organic products are not appropriate to convey and circulate because of their quick spoiled. Along these lines natural product dealers get ready foods grown from the ground diverse approaches to secure the aging handling of fruits. This examine intended to survey any progressions between the normally matured banana and banana matured by the fake aging specialists.

Maturing specialists are substances which rush the aging procedure, and it comes in various structures. These incorporate ethylene gas, ethephon, ethylene glycol, etherel and calcium carbide (Singal et al, 2012); African shrubbery mango natural product (*irvingia gabonesis*) and leaves, Palm nut, Cassia leaves, Yellow Pawpaw leaves, burn light battery, calcium carbide, potash and slag (Ajayi and Mbah, 2007). African mango organic products, calcium carbide and newbouldia leaves were likewise detailed by Adewole and Duruji (2010). As indicated by Singal et al. (2012), the business practice is to utilize these aging specialists to falsely mature the natural products at the goal advertise before retailing. Ethylene gas is costly to create so minimal effort indigenous aging innovations including the utilization of risky materials are utilized (Singal et al 2012; Ajayi and Mbah, 2007). The antagonistic capability of calcium carbide as an aging specialist has been set up (Singal et al, 2012) while other synthetic aging operators like ethephon, etherel and ethylene glycol are additionally viewed as dangerous to wellbeing and they must be utilized inside prescribed safe cutoff points (Hakim et al 2012; Food and Beverage Online, 2010). The utilization of dangerous and suspicious aging specialists is of incredible worry as the exercises of people have been said to add

to presentation of sustenance materials to overwhelming metal pollution (Orisakwe et al, 2012). The utilization of counterfeit specialists may give more worthy shading than normally matured natural products (Hakim et al, 2012) however it might expand the danger of pollution of nourishment materials. With the nonattendance of enactment to control the unpredictable utilization of unsafe maturing specialists, look into exertion is expected to continually screen their quality in sustenances developed locally.

The normal procedure of organic product maturing is a mix of physiological, biochemical and sub-atomic procedures (Brady, 1987; Prasanna et al., 2007; Kendrick, 2009; Bouzayen et al., 2010). Natural product aging includes coordination of various digestion with actuation and deactivation of different qualities prompting change in shading, increment in sugar content, decline in corrosiveness, mellowing of natural product also, increment in flavor and fragrance (Tucker and Grierson 1987; Lizada, 1993; Prasanna et al., 2007; Kendrick, 2009; Bouzayen et al., 2010; Singal et al., 2011; El Hadi et al., 2013). This maturing procedure can be actuated falsely by utilizing diverse concoction specialists (Goonatilake, 2008; Hakim et al., 2012; Rahman et al., 2008; Siddiqui and Dhua, 2010). Diverse research bunches have detailed that ethanol, methanol, methyl jasmonate, ethylene glycol, ethephon and calcium carbide are utilized to mature leafy foods falsely (Chace, 1934; Goonatilake, 2008; Koros, 2014; Nagel, 1989; Rahman et al., 2008; Siddiqui and Dhua, 2010). As of late, smolder from the lamp fuel stove or lamp has been utilized to start the maturing procedure of various organic products which is the burning result of lamp fuel that initiates maturing (House et al., 1929). Be that as it may, the impacts of these counterfeit maturing specialists on the healthy benefits of foods grown from the ground wellbeing danger caused by expending misleadingly matured natural products are yet to be completely comprehended (Mursalat et al., 2013). Diverse research bunches have detailed that conceivable wellbeing dangers are brought about by direct introduction or direct utilization of counterfeit maturing operators (Goonatilake, 2008; Siddiqui and Dhua, 2010). For instance, calcium carbide is soluble in nature and bothers the mucosal tissues of the stomach locale. A few instances of stomach

issue in the wake of eating carbide-aged mangoes have too been accounted for (Siddiqui and Dhua, 2010). A liberal utilization of ethylene glycol may cause kidney disappointment (Goonatilake, 2008). Synthetic concoctions, for example, ethylene and methyl jasmonate are accounted for to be nontoxic for human utilization. They are generally costly and in this manner are not broadly utilized (Rahman et al., 2008). In many creating nations, synthetic concoctions, for example, calcium carbide (Rahman et al., 2008; Siddiqui and Dhua, 2010), ethylene glycol (Goonatilake, 2008) and ethephon (Hakim et al., 2012) are favored because of their minimal effort (Islam, Mursalat, and Khan, 2016; Islam, Rahman, Mursalat, Rony, and Khan, 2016).

According to Asif (2015) he stated that, as of late, there has been impressive research in the writing concerning the activity of various synthetic concoctions on the maturing procedures of organic products. Under specific conditions, doubtlessly these synthetic concoctions are equipped for hurrying the maturing of a few products of the soil as appeared by the rates of relaxing, breath, starch hydrolysis, flavor and shading changes. The diverse aging specialists like calcium carbide, acetylene, ethylene, propylene, ethrel (2-chloroethyl phosphonic corrosive), glycol, ethanol and some different operators are utilized for aging of products of the soil. The ethylene glycol, when weakened with water, can age different organic products quicker than the ordinary maturing rate of the natural products, specifically colder climatic conditions. Water does not remove the impacts of ethylene glycol in the maturing of organic products. Ethanol can possibly be utilized to restrict ready natural product, and utilization of low-fixation ethanol inside organic product may go about as a bolstering stimulant. Ethanol is a normally happening substance coming about because of the maturation by yeast of natural product sugars. Ethylene is a combustible dismal gas with a sweet scent. Ethylene is a normally happening plant hormone that is created by numerous products of the soil. It influences the physiological procedures in plants and starts the aging procedure when inner fixations increment from 0.1 to 1.0 ppm (parts per million). Remotely connected ethylene can likewise start the maturing procedure.

Then again, products of the soil have poor stockpiling characteristics, and advances for long haul stockpiling, for example, controlled or altered climate have not been connected effectively to these leafy foods. They put away in altered climate frequently show bothersome qualities, for example poor shading, poor eating quality and nearness of unfortunate flavors. In this way, to take care of the issue of short timeframe of realistic usability of products of the soil, diverse synthetic concoctions are utilized to postpone the aging. Although calcium carbide has been every now and again utilized since long occasions to improve aging procedure of organic products; nonetheless, some other calcium salts particularly calcium chloride ( $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ ), calcium sulfate ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ) or calcium ammonium nitrate  $\text{Ca}(\text{NH}_4\text{NO}_3)_2$  have been accounted for in writing to postpone the maturing and senescence in natural products by bringing down the breath rate. The calcium salts in various fixations have either been utilized as pre-reap splashes or invaded into collected organic products, while a few specialists treated the gathered natural products by inundating in calcium answer for fluctuating occasions. These calcium salts keep up organoleptic properties (like skin shading, skin shrinking, fragrance, mash shading, flavor and taste) of the natural products for long term as contrasted and control aging. Accordingly, unique centralizations of different calcium salts (for example calcium chloride, calcium sulfate and calcium ammonium nitrate) were utilized to find out their consequences for postponing the aging and eating nature of organic products (Asif, 2015).

The tests revealed that the "Calcium Carbide ( $\text{CaC}_2$ )" treatment hurries the maturing procedures of unripe organic products as appeared by the rates of relaxing, breath, flavor and shading changes. Calcium carbide is generally utilized for maturing of organic product; while, its utilization is being debilitated around the world, due to related wellbeing dangers. Secondly, calcium carbide ( $\text{CaC}_2$ ) is the ordinarily utilized compound for aging of natural products, because of its low cost and accessibility in nearby market; nonetheless, utilization of this synthetic in organic product industry is being debilitated worldwide because of risks of blast and remainder of lethal materials like arsenic and phosphorus to buyers, along these lines making the solid organic product toxic. Since no specialized learning is



viewed as important for its bizarre use, higher amount of calcium carbide expected to age juvenile organic product makes them boring. In perspective on the above issues, considers for another maturing specialist for natural product were basic. Further, the nearby business is likewise hoping to supplant calcium carbide with any reasonable exchange. Calcium carbide retains dampness and produces acetylene, which is a powerless simple of ethylene, in charge of activating aging procedure. Today or in future we will be capable discover some better options for organic product aging specialists that have negligible or are without well-being perils (Asif, 2015).

Individuals presented to elevated amounts of arsenic can have queasiness and retching, looseness of the bowels, sickness, and low pulse. These manifestations might be trailed by a sentiment of "pins and needles" in the hands and feet (neuropathy). Constant (long haul) introduction to arsenic can cause stomach sicknesses, cerebral pains, exhaustion, neuropathy, dim splotches on the skin, and little "corns" or "moles" on the palms of the hands, bottoms of the feet, and middle. Individuals presented to inorganic arsenic can have more malignant growth of the lung, skin, bladder, liver, kidney, and prostate. Concentrates have not connected arsenic introduction to leukemia in grown-ups or youngsters. Ordinary pee dimensions of arsenic are under 50  $\mu\text{g/L}$ . A dimension somewhere in the range of 50 and 200  $\mu\text{g/L}$  not really speak to a wellbeing hazard. A dimension more than 200  $\mu\text{g/L}$  is viewed as anomalous and may require treatment if manifestations of arsenic harming are available. Purposeful or inadvertent ingestion of arsenic has been infamous as a method for suicide and crime. Arsenic is utilized in rodenticide. Arsenic introduction delivered serious edema of the eyelids, gastrointestinal aggravation, and both focal and fringe neuropathies. It is the primary remedy to overwhelming metal harming, and the reason for chelation treatment today. English Anti-Lewisite (dimercaprol) has sulfhydryl bunches that predicament arsenic, just as different metals, to shape stable covalent bonds in a procedure called complexation. The nonionic edifices would then be able to be discharged by the body. In spite of the fact that an abnormal state of doubt for arsenic harming must be kept up as a result of its job in harming, it is infrequently



observed clinically. Physical discoveries in arsenic poisonous quality change with age and portion. Any blend of GI protests, neurologic brokenness, and pallor should provoke a scan for arsenic poisonous quality. GI objections prevail in grown-ups. Kids are progressively inclined to CNS brokenness, including encephalopathy. Encephalopathy is uncommon in grown-ups. Encephalopathy may present as an intense occasion with seizures, or it might grow gradually over weeks to months with variable nonspecific protests. Cholera like looseness of the bowels can be found in intense arsenic harmfulness. Neurologic grumblings going from neuropathy to encephalopathy have been accounted for in instances of intense arsenic danger. Arsenic harmfulness displaying as climbing limp loss of motion is frequently (Asif, 2015).

### **Kamias Fruit (Averroah Billimbi)**

According to Alhassan, & Ahmed (2016) they stated that Averroah bilimbi (normal name: Bilimbi) is a therapeutic plant having a place with the family Oxalidaceae. The sort Averrhoa was named after an Arab Philosopher, doctor and Islamic Jurist Ibn Rushd frequently known as Averroes. Averroah bilimbi is firmly identified with Averrhoa (carambola, starfruit). It started in the Southeast Asia and is asserted as a local of the West Malaysia and the Indonesian Moluccas. It is developed all through Malaysia, Indonesia, Singapore, Philippines, Thailand, Bangladesh, Myanmar, and India. It likewise stretches out to different nations like the US, Argentina, Australia, Brazil, Colombia, Ecuador, Jamaica, Puerto Rico, Tanzania, and Trinidad and Tobago. The other regular names of A. bilimbi will be bilimbi, cucumber tree, tree roan, pickle tree (English); kamias, camias, and pias (Philippines); ta ling pling (Thai); huang gua shu (Chinese); bilimbim, biri-biri, limao de caiena, and azedinha (Brazil); vilimbipuli, irumpanpuli, and bilimbi (India); khe tay (Vietnamese); taling pling (Thailand); and belimbing buluh and blimbing asam (Malaysia). Averroah bilimbi is a little tree which grows up to 15 m high with inadequately masterminded branches. It has compound leaves with twenty– forty pamphlets each and 5– 10 cm long. The leaves are shaggy with pinnate shapes and structure groups toward the finish of branches. The tree is cauliflorous with

18– 68 blossoms in panicles that structure on the storage compartment and different branches. The blossoms are heterotristylous with petal 10– 30 m long, yellowish green to rosy purple. The natural products are delivered on the exposed stem and trunk. The natural products are greenish in shading with a firm and succulent substance which turns out to be delicate on ripening. The organic product juice is acrid and very acidic. Averroah bilimbi holds extraordinary incentive in correlative drug as prove by the considerable measure of research on it. In this way, we intended to incorporate a cutting-edge and thorough audit of Averroah bilimbi that covers its customary and society drug uses, phytochemistry, and pharmacology.

Averrhoa bilimbi Linn. is mainly developed for restorative purposes in numerous tropical and subtropical nations of the world. Writing overview about this plant demonstrates that A. bilimbi is mostly utilized as a society medication in the treatment of diabetes mellitus, hypertension, and as an antimicrobial operator. The prime target of this survey is to aggregate and compose writing dependent on customary cases and relate those with current discoveries on the utilization of A. bilimbi in the administration of various sicknesses. Through translating officially distributed logical original copies (1995 through 2015) recovered from the diverse logical web crawlers, in particular Medline, PubMed, EMBASE, and Science Direct databases, distributed articles and reports covering customary and logical writing identified with A. bilimbi's potential job against different infirmities have been completely assessed, deciphered, and examined. A few pharmacological investigations have shown the capacity of this plant to go about as antidiabetic, antihypertensive, thrombolytic, antimicrobial, cell reinforcement, hepatoprotective, and hypolipidemic operator. A. bilimbi holds extraordinary incentive in the correlative and elective drug as prove by the generous measure of research on it. Accordingly, we expected to order a modern and exhaustive survey of A. bilimbi that covers its conventional and society prescription uses, phytochemistry, and pharmacology. Consequently, this paper introduces a state-of-the-art and far reaching survey of the ethnomedicinal utilizes, distinctive substance constituents, and pharmacological exercises of A. bilimbi. Up until this point, the naturally

dynamic operators have not been segregated from this plant and this can be a decent logical investigation for the future antidiabetic, antihypertensive, and antimicrobial ramifications. Consequently, this survey focuses at accentuating the differing customary cases and pharmacological exercises of *A. bilimbi* regarding completing increasingly logical examinations to separate dynamic standards through trend setting innovation (Alhassan, & Ahmed, 2016). *Averrhoa bilimbi* additionally called Bilimbi are found all through the Indonesia, Philippines, Bangladesh, Sri Lanka, Myanmar (Burma) and Malaysia. It is additionally regular in other Southeast Asian nations. Bilimbi has been utilized in conventional medication to control weight and diabetes mellitus. It likewise has hostile to hyperlipidemic properties (Rahman et al., 2014).

Plant delivers an expansive number of phenolic mixes with a few natural activities. Phenolics, for example, phenolic acids, flavonoids and tannins are viewed as the real supporter of the cancer prevention agent capacity of plants. These cancer prevention agents of the plant likewise have assorted natural exercises, for example, hostile to cancer-causing, free extreme forager, against atherosclerotic and mitigating, exercises. These all exercises are identified with their cell reinforcement capacity. Phenolic mixes contribute clearly to antioxidative activity and they comprise the real class of regular cancer prevention agents present in plants; [30] subsequently, it is important to ascertain all out phenolic content in plant species. In present investigation, utilizing Folin-Ciocalteu strategy we found distinctive reaction from three unique examples in different fixation for every which were quantitatively communicated as mg GAE/g of concentrate. Here, sodium carbonate produces blue shade of phosphormolybdicphosphor tungstic phenol complex. In this manner, most focused blue shading contains most astounding absolute phenolic content. According to results, *G. sylvestre* has the most noteworthy measure of phenolic content than *C. frutescens* and *A. bilimbi*. Present examinations demonstrate the nearness of polyphenolic compound in *G. sylvestre*, *C. frutescens* and *A. bilimbi* (Rahman et al., 2014).

The quantitative estimation of flavonoid substance of *C. frutescens*, *G. sylvestre* and *A. bilimbi* demonstrates that they are likewise rich with this compound. In this manner our consequence of flavonoid content assurance test indicated that *C. frutescens* is wealthy in flavonoid than *G. sylvestre*, *A. bilimbi* yet all are with an extensive sum. Flavonoids are the normally happening mixes in plants and thought to have positive effects on human wellbeing. A few examinations on flavonoids subsidiaries demonstrated that they have a wide scope of mitigating antibacterial, antiviral, calming, antiviral, anticancer and against hypersensitive activities. It is entrenched that plant flavonoids are exceptionally powerful, free radical searching and cell reinforcements. Flavonoids are utilized for the avoidance and fix of various diseases. Recent enthusiasm for these substances has been invigorated by the potential medical advantages emerging from their cell reinforcement exercises and free radical searching limits in coronary illness and cancer (Rahman et al., 2014).

Phenolic mixes are ordinarily found in both consumable and unpalatable plants and they have been seen to have more extensive organic impacts, including cell reinforcement movement. It has been accounted for that mixes, for example, phenolics, flavonoids, which contain hydroxyls, are in charge of the radical searching action of most plant. The consequence of DPPH rummaging action of ethanolic removes shows they are genuinely noteworthy forager of free extreme when contrasted and standard ascorbic corrosive estimated at IC<sub>50</sub> esteem. IC<sub>50</sub> esteem is a parameter ready to repress half of the DPPH. IC<sub>50</sub> estimation of concentrates was contrasted with the IC<sub>50</sub> of the standard gotten by a similar technique. In relative examination, *G. sylvestre* is the most dynamic and critical ( $P < 0.05$ ) scrounger than other two, while *A. bilimbi* extricate showed the most reduced movement among three examples of various species. Concentrates demonstrate a steady increment in action with increment of fixation. DPPH is a normally utilized substrate for fast appraisal of cancer prevention agent movement due to its strength and straightforwardness of the assay. DPPH rummaging limit of cell reinforcements is because of hydrogen giving capacity. DPPH is steady nitrogen focused free radical, which produces violet shading in ethanol solution

and acknowledges an electron or hydrogen radical to wind up progressively stable diamagnetic particle. At the point when a DPPH arrangement is blended with a hydrogen particle benefactor, a stable non-radical type of DPPH is found with concurrent change in shading from violet to pale yellow. This measure gives dependable data about the cell reinforcement action of the tried compounds. It is conceivable to connect the decrease in the quantity of DPPH atoms with the number hydroxyl groups. Diminishing force is a decent pointer of cell reinforcement action. The plant having high diminishing force commonly answered to convey high cancer prevention agent potential too. Reduction of Fe(III) by electron-giving movement of the mixes mirrors the cell reinforcement instrument of the compound. In this investigation, Ferric particles are diminished to ferrous with the shade of the response blend changes from yellow to pale blue green. The ferric lessening power movement of *C. frutescens*, *G. sylvestre* and *A. bilimbi* remove with contrasted with ascorbic corrosive are accounted. Concentrate showed portion subordinate lessening power potential. Be that as it may, the adequacy was observed to be lower than that of ascorbic corrosive (Rahman et al., 2014).

*A. bilimbi* is developed essentially for its succulent however extremely sharp eatable foods grown from the ground use in conventional drug. The organic product is utilized in the readiness of jams and jams and for cooling drinks. In such cases organic products are pricked or cut into little pieces and saturated with water medium-term for decreasing harshness and for cutting down the oxalic corrosive dimension. Natural products, after sharpness decrease, are utilized in different arrangements, including both fish and vegetables. In Pakistan, for instance, the natural product is regularly protected in sugar and here and there cured (Flora of Pakistan, 2015), and in Malaya the organic products are prepared and made into dried cut bites (Hanelt et al., 2001). In Philippine food the organic products are generally used to include a tart or corrosive flavor, much like how lemon juice and tamarinds are utilized (Staples and Herbst, 2005). In spite of the fact that the organic product is by and large viewed as unreasonably corrosive for eating crude, Morton (1987) reports that the green, crude natural products are utilized to make a relish which is presented with rice and beans in Costa Rica, and that ready

natural products are much of the time added to curries in the Far East. In Costa Rica the species is utilized both as seasoning and an additive (Burger, 1991). *A. bilimbi* is made into chutneys and is utilized instead of crude mango and tamarind. Blossoms are likewise gathered, washed, air dried and safeguarded in sugar syrup (Ravindran, 2016).

According to Invasive Species Compendium (2018), in the Philippines organic products are eaten crude, curried or included as a souring specialist for conventional Filipino dishes; frequently the natural product is made into a stock for use in different dishes that need sharpness. In Indonesia it is additionally safeguarded after sun drying, the item being regularly known as asam sunti. For its arrangement bilimbi natural products are cut daintily, salted and dried in the sun for a long time. Dried bilimbi is a famous fixing in the cookery of Sumatra, particularly in the Aceh locale that is situated in the northern tip of the island. In Kerala (India) it is made into a savoring pickle, while in Karnataka, Goa and in numerous different spots the natural products are eaten crude together with salt and flavors. In rustic regions of southern India and Sri Lanka, the commonest utilization of bilimbi organic product is in the readiness of fish curries for which this sharp zest gives an unconventional flavor and taste. Bilimbi is generally utilized in the Seychelles, giving a special taste to numerous neighborhood fish arrangements. In Hawaii, gourmet experts use squeezed organic product as a substitute for vinegar in plate of mixed greens dressings and soups. It is additionally dried and reconstituted with different squeezes and flavors for use in sauces. As a business nourishment crop, *A. bilimbi* requires exceptional dealing with; organic products must be handpicked, as a result of the slim skin, and can't be put away for in excess of a couple of days (Morton, 1987). The leaves, blooms, and products of this species include restorative uses inside different societies. In Pakistan, the natural product is utilized as an astringent and, when cooked, is eaten to fix heaps and scurvy (Flora of Pakistan, 2015). In the Philippines its leaf glue is connected as a poultice on tinges, swellings, mumps and ailment and in

different sorts of skin ejection. In other Asian conventions, juice from the natural product is utilized in a mixture for fevers, a glue can be produced using the leaves and connected tropically to fix mumps, ailment, and pimples, or fermented to treat syphilis, and an imbue of the blossoms is utilized to treat hacks and thrush (Quisumbing, 1951). In Malaysia, leaves, either new or after maturation, are utilized to treat venereal infections. Imbue of leaves is given for hacks and it is taken as a tonic by ladies after labor. Imbue of blooms in bubbling water is endorsed as a successful solution for hacks and thrush. In Java, bilimbi organic product blended with dark pepper is endorsed for diseases brought about by climate changes and a glue of bilimbi and pepper is spread over the body for decreasing fever. Natural product safeguarded in sugar is demonstrated for hacks, beriberi and biliousness. Natural product syrup is utilized as a remedy for fever and irritation, and to prevent seeping from the rectum and reducing inside hemorrhoids. In numerous nations leaf glue is utilized as a cure for toxic creatures. Further ethnobotanical data for this species can be found in Duke's (2015) Phytochemical and Ethnobotanical Databases. Most different uses identify with the natural product's high acidic substance, for example, cleaning sharp edges, as mordants in the arrangement of an orange color for silk textures, and for cleaning material and metal (Morton, 1987; Staples and Herbst, 2005). It is broadly utilized as a stain remover all through South East and Far East nations in light of its high oxalic corrosive substance (Ravindran, 2016). Its wood can likewise be utilized as fuel, a purple color from the petals is utilized as a marker in science, and the species has potential in agroforestry (FAO EcoCrop, 2015). Bilimbi natural product squeeze and water remove (yet not liquor or hexane separates) show prominent enemy of hypercholesterolaemic and hypoglycaemic exercises. A functioning compound was segregated from the part that indicated ideal movement at a portion dimension of 0.3 mg/kg; in any case, the compound remains uncharacterized. The powerful portion is shown as: organic product (125 mg/kg) and the watery concentrate (50 mg/kg); it was viable in decreasing lipids in rodents bolstered a high-fat eating regimen. A few investigations have likewise demonstrated a noteworthy hypoglycaemic impact for bilimbi leaves. Furthermore, bilimbi leaves

additionally have hypotriglyceridaemic, against lipid peroxidative and hostile to atherogenic properties in creature frameworks. The ethanol concentrate of bilimbi was appeared to raise fundamentally serum HDL cholesterol focus by 60% contrasted and a standard control. The concentrate fundamentally improved the counter atherogenic list and HDL/all out cholesterol proportion yet did not influence LDL-cholesterol and absolute cholesterol. Bilimbi organic product juice has been appeared to have high bacteriostatic and bactericidal properties, and washing new shrimps in bilimbi natural product juice was appeared to restrain bacterial development very essentially amid protection. Chloroform and methanol concentrate of natural product were appeared to be dynamic against microscopic organisms.



## **Chapter 2**

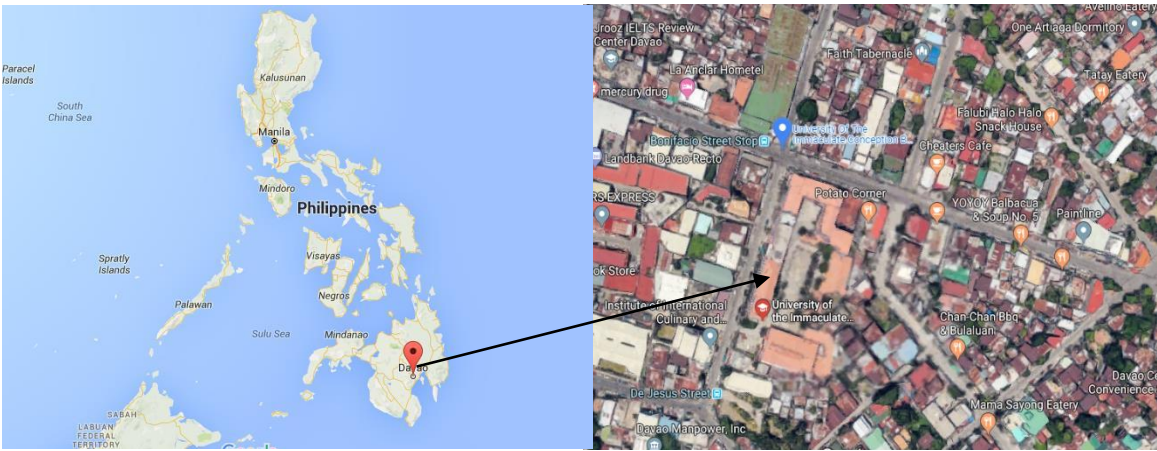
### **METHODOLOGY**

#### **Research Design**

This study utilized a quantitative experimental research design. According to Creswell (2013), this design is a systematic and scientific approach to research in which the researchers manipulate one or more variables, and controls and measures any change in other variables. Hence, it measures the causal relationship of the independent (type of ripening agent) and dependent (the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar) variables of the study. It is this light that this design was used because the researchers want to know if the type of ripening agent would affect the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar of the Cavendish bananas.

#### **Setting**

The experiment was conducted at the University of Immaculate Conception, Father Selga Street, Davao City. University of Immaculate Conception is a Roman Catholic higher education institution in Davao City, Philippines administered by the Religious of the Virgin Mary. The researchers conducted the study in this area because of the availability of the materials and machine that were used in the experiment. Specifically, the study was conducted at the General Laboratory of the school. The setting of the study is shown through a site map in Figure 2.



**Figure 2. Site Map of University of Immaculate Conception**  
<https://www.google.com/maps>

**Measures**

The level of acceptability of the Cavendish banana, one of the dependent variables, was measured using the Hedonic scoring method. According to Popper and Kroll (2011), in Hedonic scoring method, the stimuli (actual samples or food names) are presented singly and are rated on a scale where the nine categories range from "dislike extremely" to "like extremely". The mean score of the level of acceptability was interpreted based on the following:

Range of Means	Descriptive Equivalent
1.00 – 1.80	Very Low
1.81 – 3.60	Low
3.61 – 5.40	Moderate
5.41 – 7.20	High
7.20 – 9 .00	Very High

The level of reducing sugar was assessed using the Benedict’s test (Simoni, Hill, & Vaughan, 2002). A five-point Likert scale was used to determine the level of reducing sugar corresponding to the color change during the test. The mean level of reducing sugar was analyzed based on the following:

<b>Observation</b>	<b>Range of Means</b>	<b>Descriptive Equivalent</b>	<b>Interpretation</b>
No color change (blue)	1.00 - 1.79	Very Low	No reducing sugars present
Green	1.80 - 2.59	Low	Trace amounts of reducing sugars present
Yellow	2.60 - 3.39	Moderate	Low amounts of reducing sugars present
Orange	3.40 - 4.19	High	Intermediate amounts of reducing sugars present
Brick-red	4.20 - 5.00	Very High	Large amounts of reducing sugars present

## **Procedure**

A letter of permission to conduct the study was given to the Principal of University of Immaculate Conception – Senior High School. After securing the approval, the researchers proceeded to the actual experimentation.

## **Collection and Preparation of Cavendish Bananas and Kamias Fruits**

Unripe Cavendish bananas and Kamias fruits were procured from the local market at Bankerohan, Davao City. Time from harvesting the plant material to procurement was two days. The obtained plant materials were then specified and verified by Maria Theresa C. Baslot, a Botanist. The samples were washed with distilled water to remove any debris. These were air dried at room temperature for two hours until the surface became moisture-free.

## **Preparation of Ripening Agents**

The commercial ripening agent, Calcium carbide, was obtained from the local market at Bankerohan, Davao City. Collected dried Kamias fruits were ground

using a house blender and the extracted material was then subjected to the extraction process. The extraction process followed the procedures written in the book of Guevara (2005) entitled, "A Guidebook to Plant Screening: Phytochemical and Biological".

The ground dried plant material was weighed at 500 g, placed in an Erlenmeyer flask and treated with 650 mL of distilled water to completely submerge the material. The flask was stoppered, and the material was kept soaked for 24 to 48 hours. The mixture was then filtered using Whatman's filter paper No. 1 and the filtrate was concentrated by rotary evaporator at temperatures below 50°C to about 10 mL. The concentration of fruit extract was recorded as grams of dried plant material per mL of the extract obtained. Concentrations of fruit extract at 25%, 50% and 75% were prepared. The container was properly labeled with the name of the plant, the concentration of the plant extract and the date of extraction. The extract was stored with a tight stopper in the cold, at temperatures between 0°-5°C.

## **Processing**

Six bunches of unripe bananas labeled A, B, C, D, E and F containing five bananas each, were exposed to similar environmental conditions maintained at temperature of 15-25°C and 85% relative humidity. These batches were exposed to different types of ripening agent. Batch A was allowed to ripen naturally while Batch B was exposed to 2 grams of Calcium carbide. Batches C, D and E were exposed to 2 grams of Kamias fruit extract at 25%, 50% and 75% concentrations, respectively. Batch F was exposed to 2 grams of Kamias fruit. The changes, if any, in extent of ripening were observed regularly and recorded. The change in skin

color of the fruit from green to yellow was considered as the stage for the ripening of fruit.

### **Sensory Evaluation**

Various methods have been used to measure food preferences. The most common method is a questionnaire of generated foods or food categories in which a hedonic scale is used to rate the degree of likings. Hedonic scale is an organoleptic quality rating scale where the judge expresses his degree of likings. One to nine-point balanced scale is used. Over all tests were conducted by using seven-point Hedonic scale. The general form of the scale: 1. like extremely, 2. Like very much, 3. Like moderately, 4. Like slightly, 5. Neither like nor dislike, 6. Dislike slightly, 7. Dislike minor; 8. Dislike very much; and 9. Dislike extremely.

Appearance, Skin color, Aroma, Firmness, Taste and Mouth-feel tests of the samples were accomplished. This test has been used by expert and untrained consumers, but it is felt to be more effectively applicable to the latter. Ten sensory panels were participated to accomplish these organoleptic tests. In Hedonic scaling, responses, i.e., state of like and dislike, were measured on a rating scale. Points given by the sensory panel based on the liking and disliking were analyzed by SPSS software version 23.

### **Titratable Acidity Test**

The following materials were prepared: 250 mL Erlenmeyer flask, 5 mL volumetric pipet, hot plate, 10 or 25-mL burette, Pipet Safety Bulb or Syringe, 0.10 N Sodium hydroxide, Phenolphthalein with dropper and distilled water. Five mL of the banana sample from the different batches was pipette into an Erlenmeyer flask.

Approximately two mL of distilled water was then added to cover the bottom of the flask with liquid. Three drops of Phenolphthalein solution were added. A prepared 25-mL burette with 0.10 N Sodium hydroxide was titrated with the Erlenmeyer flask containing the sample. The pH of the sample was measured as titration went near the end point. The pH reading at the endpoint should read at 8.2. The titration was continued until an 8.2 pH was achieved. Upon reaching the end point, the level of Sodium hydroxide in the burette was recorded. The reading was then subtracted from the first reading to determine the mL of Sodium hydroxide used. Millimeters of Sodium hydroxide x 0.15 equals the percent titratable acidity.

### **Determination of Reducing Sugar**

The determination of reducing sugar was done using the Benedict's test. One liter of Benedict's solution was prepared by mixing 100 grams of anhydrous sodium carbonate, 173 grams of sodium citrate and 17.3 grams of copper (II) sulfate pentahydrate. Approximately one mL of sample banana from different batches was placed into a clean test tube. Two ml (ten drops) of Benedict's solution was placed in the test tube. The solution was then heated in a boiling water bath for 3-5 minutes. The color change in the solution of test tubes or precipitate formation was then observed and recorded.

### **Ethical Considerations**

The researchers secured the Plant Ethics Checklist before conducting the study involving plant subjects. The form was filled-up to guide the researchers on the ethical way of utilizing plant subjects that were used in the experiment of this research.

## Data Analysis

The following statistical tools were employed in the study using the SPSS Software 23.0 version:

**Mean.** This was used to calculate the average duration of ripening of the Cavendish banana as well as the average level of acceptability and titratable acidity.

**One-Way Multivariate Analysis of Variance (MANOVA).** This was used to know if there is a significant difference in the duration of Cavendish banana ripening when treated with different ripening agents, in the level of acceptability of Cavendish banana when treated with different ripening agents, in the titratable acidity of Cavendish banana when treated with different ripening agents and in the level of reducing sugar of Cavendish banana when treated with different ripening agents. To confirm where the differences occurred between groups, a Post Hoc Test using Tukey's Honest Significant Difference was used.

## Scope and Limitation of the Study

This study focused on the efficacy of Kamias (*Averrhoa bilimbi*) fruit as a ripening agent for Cavendish banana (*Musa acuminata*). This study used only three concentrations of the fruit extract and fruit to confirm the efficacy as a ripening agent. The study was conducted from November 2018 to February 2019.

## Chapter 3

### RESULTS AND DISCUSSION

#### Duration of Cavendish banana ripening treated with various ripening agents

**Table 1.** Duration of Cavendish banana ripening after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control

Treatment	Mean Ripening Duration (hours)
Positive control	72.00
Kamias fruit	76.00
Kamias Extract 25%	96.00
Kamias Extract 50%	96.00
Kamias Extract 75%	76.00
Negative control	112.00

Presented in Table 1 is the duration of Cavendish banana ripening after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control. As shown in the table, the bananas which took the longest time to ripe were those treated with negative control at 112.00 hours, followed by Kamias Extract 25% and Kamias Extract 50% at 96.00 hours. Application of Kamias fruit and Kamias Extract 75% allowed ripening of banana in 76.00 hours. The bananas which took the shortest time to ripe were those treated with positive control at 72.00 hours.



## Level of acceptability of Cavendish banana treated with various ripening agents

**Table 2.** Level of acceptability of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control

Treatment	Appearance	Skin color	Aroma	Firmness	Taste	Mouth-feel	Overall	Descriptive Equivalent
Positive control	3.33	2.67	2.67	3.00	3.33	2.67	2.94	Low
Kamias fruit	7.67	7.67	6.67	6.67	6.33	6.67	6.94	High
Kamias Extract 25%	6.67	6.67	6.33	6.67	6.67	7.33	6.72	High
Kamias Extract 50%	6.67	7.33	6.67	6.67	6.00	6.67	6.67	High
Kamias Extract 75%	6.67	7.33	7.00	7.33	7.33	7.67	7.22	Very High
Negative control	6.33	6.33	7.00	6.00	5.67	6.33	6.28	High

Legend: 1.00 – 1.80=Very Low; 1.81 – 3.60=Low; 3.61 – 5.40=Moderate; 5.41 – 7.20=High; 7.20 – 9.00=Very High

Table 2 presents the level of acceptability of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control. As presented in the table, the bananas treated with Kamias Extract 75% had the highest level of acceptability at 7.22 with a descriptive equivalent of 'Very High'. This was followed by Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, and Negative control with acceptability levels of 6.94, 6.72, 6.67, and 6.28, respectively, which all correspond to a descriptive equivalent of 'High'. The lowest level of acceptability was achieved by positive control-treated banana at 2.94 with a descriptive equivalent of 'Low'.

### Titrateable acidity of Cavendish banana treated with various ripening agents

**Table 3.** Titrateable acidity of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control

Treatment	Mean Titrateable Acidity
Positive control	0.27
Kamias fruit	0.47
Kamias Extract 25%	0.37
Kamias Extract 50%	0.43
Kamias Extract 75%	0.73
Negative control	0.53

Table 3 presents the titrateable acidity of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control. As presented in the table, bananas treated with Kamias Extract 75% had the highest titrateable acidity at 0.73, followed by Negative control, Kamias fruit, Kamias Extract 50%, and Kamias Extract 25% at 0.53, 0.47, 0.43, and 0.37, respectively. The lowest titrateable acidity was achieved by positive control-treated banana at 0.27.

### Level of reducing sugar of Cavendish banana treated with various ripening agents

**Table 4.** Level of reducing sugar of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control

Treatment	Mean Level of Reducing Sugar	Descriptive Equivalent
Positive control	3.67	High
Kamias fruit	5.00	Very High
Kamias Extract 25%	2.67	Moderate
Kamias Extract 50%	2.67	Moderate
Kamias Extract 75%	4.67	Very High
Negative control	2.67	Moderate

Legend: 4.20 - 5.00=Very High; 3.40 - 4.19=High; 2.60 - 3.39=Moderate; 1.80 - 2.59=Low; 1.00 - 1.79=Very Low

Table 3 presents the level of reducing sugar of Cavendish banana after treatment of various ripening agents (Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, Kamias Extract 75%), negative control and positive control. As presented in the table, the bananas treated with Kamias fruit had the highest level of reducing sugar at 5.00 with a descriptive equivalent of 'Very High', followed by Kamias Extract 75% at 4.67 with a descriptive equivalent of 'Very High'. The bananas treated with Positive control had a high level of reducing sugar at 3.67. The bananas treated with Kamias Extract 25%, Kamias Extract 50%, and Negative control had a moderate level of reducing sugar at 2.67.

**Test of significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with various ripening agents**

**Table 5.** Multivariate test

Effect	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Wilks' Lambda	0.00	24.25	20.00	30.80	0.00	0.90	287.92	1.00

Table 5 shows the multivariate test of the one-way MANOVA. As shown in the table, using the Wilks' Lambda test, the F-value was 24.25 while the degrees of freedom for hypothesis and error were 20.00 and 30.80, respectively. The values of partial eta squared, noncentrality parameter, and observed power were 0.90, 287.92, and 1.00, respectively. Because the p-value of 0.00 was lesser than 0.05 alpha level of significance, the null hypothesis is rejected; therefore, there is a significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with different ripening agents. This means that the dependent variables were significantly dependent on the type of

ripening agent used. To determine how the dependent variables differ for the independent variable, test of Between-Subjects Effects was performed.

**Table 6.** Test of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power
Type of treatment	Duration of ripening	3744.00	5	748.80	41.60	0.00	0.95	208.00	1.00
	Level of acceptability	38.02	5	7.60	112.00	0.00	0.98	564.98	1.00
	Titratable acidity	0.380	5	0.08	22.80	0.00	0.91	114.00	1.00
	Level of reducing sugar	17.11	5	3.42	12.32	0.00	0.84	61.60	1.00

Table 6 presents the test of between-subjects effects. As shown in the table, the p-values of all dependent variables were 0.00. Because these values were lesser than 0.05 alpha level of significance, therefore, the type of treatment had a statistically significant effect on duration of ripening, level of acceptability, titratable acidity and level of reducing sugar. To account for multiple ANOVAs being run, an alpha correction using the Bonferroni correction was made. The correction calculated a 0.0125 p-value. In this case, the statistical significance was accepted at  $p < 0.0125$ . To confirm where the differences occurred between groups, Homogeneous subsets derived from Post Hoc Test using Tukey's Honest Significant Difference were used.

**Table 7.** Homogeneous subsets for duration of ripening derived from Post Hoc Test using Tukey's Honest Significant Difference

Type of treatment	N	Subset		
		1	2	3
Positive control	3	72.00		
Kamias fruit	3	76.00		
Kamias Extract 75%	3	76.00		
Kamias Extract 25%	3		96.00	
Kamias Extract 50%	3		96.00	
Negative control	3			112.00
Sig.		0.85	1.00	1.00

Table 7 shows the homogeneous subsets for duration of ripening derived from Post Hoc Test using Tukey's Honest Significant Difference. As shown in the table, the treatments Positive control, Kamias fruit, and Kamias Extract 75% are in subset 1; the treatments Kamias Extract 25% and Kamias Extract 50% are in subset 2; and the treatment Negative control is in subset 3. Within a subset, there is no significant difference while between subsets, there is a significant difference. This means that there is no significant difference in the duration of ripening among positive control, Kamias fruit, and Kamias Extract 75% and between Kamias Extract 25% and Kamias Extract 50%. However, both of these groups are significantly different from each other, as well as from negative control.

**Table 8.** Homogeneous subsets for level of acceptability derived from Post Hoc Test using Tukey's Honest Significant Difference

Type of treatment	N	Subset		
		1	2	3
Positive control	3	2.94		
Negative control	3		6.28	
Kamias Extract 50%	3		6.66	6.66
Kamias Extract 25%	3		6.72	6.72
Kamias fruit	3		6.95	6.95
Kamias Extract 75%	3			7.22
Sig.		1.0	0.07	0.16

Table 8 shows the homogeneous subsets for the level of acceptability derived from Post Hoc Test using Tukey's Honest Significant Difference. As shown in the table, the treatment Positive control is in subset 1; the treatments negative control, Kamias Extract 50%, Kamias Extract 25%, and Kamias fruit are in subset 2; and the treatments Kamias Extract 50%, Kamias Extract 25%, Kamias fruit, and Kamias Extract 75% are in subset 3. Within a subset, there is no significant

difference while between subsets, there is a significant difference. This means that there is no significant difference in the level of acceptability among negative control, Kamias Extract 50%, Kamias Extract 25%, and Kamias fruit as well as among Kamias Extract 50%, Kamias Extract 25%, Kamias fruit, and Kamias Extract 75%; however, both these groups are significantly different from each other as well as from positive control.

**Table 9.** Homogeneous subsets for titratable acidity derived from Post Hoc Test using Tukey's Honest Significant Difference

Type of treatment	N	Subset			
		1	2	3	4
Positive control	3	0.27			
Kamias Extract 25%	3	0.37	0.37		
Kamias Extract 50%	3		0.43	0.43	
Kamias fruit	3		0.47	0.47	
Negative control	3			0.53	
Kamias Extract 75%	3				0.73
Sig.		0.34	0.34	0.34	1.00

Table 9 shows the homogeneous subsets for titratable acidity derived from Post Hoc Test using Tukey's Honest Significant Difference. As shown in the table, the treatments Positive control and Kamias Extract 25% are in subset 1; the treatments Kamias Extract 25%, Kamias Extract 50%, and Kamias fruit are in subset 2; the treatments Kamias Extract 50%, Kamias fruit, and Negative control are in subset 3; and the treatment Kamias Extract 75% is in subset 4. Within a subset, there is no significant difference while between subsets, there is a significant difference. This means that there is no significant difference in the titratable acidity between Positive control and Kamias Extract 25%, among Kamias Extract 25%, Kamias Extract 50%, and Kamias fruit; and among Kamias Extract 50%, Kamias fruit, and Negative control. However, these three groups are significantly different from each other, as well as to Kamias Extract 75%.

**Table 10.** Homogeneous subsets for level of reducing sugar derived from Post Hoc Test using Tukey's Honest Significant Difference

Type of treatment	N	Subset	
		1	2
Kamias Extract 25%	3	2.67	
Kamias Extract 50%	3	2.67	
Negative control	3	2.67	
Positive control	3	3.67	3.67
Kamias Extract 75%	3		4.67
Kamias fruit	3		5.00
Sig.		0.26	0.08

Table 10 shows the homogeneous subsets for the level of reducing sugar derived from Post Hoc Test using Tukey's Honest Significant Difference. As shown in the table, the treatments Kamias Extract 25%, Kamias Extract 50%, Negative control, and Positive control are in subset 1 while the treatments Positive control, Kamias Extract 75%, and Kamias fruit are in subset 2. Within a subset, there is no significant difference while between subsets, there is a significant difference. This means that there is no significant difference in the titratable acidity among Kamias Extract 25%, Kamias Extract 50%, Negative control, and Positive control, as well as among Positive control, Kamias Extract 75%, and Kamias fruit. However, both of these groups are not significantly different from each other.

## Chapter 4

### SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

#### Summary

The present study aimed to determine the efficacy of Kamias (*Averrhoa bilimbi*) fruit as a ripening agent for Cavendish banana (*Musa acuminata*). Specifically, the study attempts to know the duration of Cavendish banana ripening treated with various ripening agents, to determine the level of acceptability of Cavendish banana treated with different ripening agents, to calculate the titratable acidity of Cavendish banana treated with various ripening agents, to assess the level of reducing sugar of Cavendish banana treated with various ripening agents and to determine if there is a significant difference in the duration of ripening, level of acceptability, titratable acidity, and level of reducing sugar when treated with different ripening agents. The null hypotheses were then formulated and tested at 0.05 alpha level of significance.

A quantitative experimental research design was used in the study. The collection and preparation of Cavendish bananas and Kamias fruit, preparation of ripening agents, processing, sensory evaluation, titratable acidity test and Benedict's test were conducted at the University of Immaculate Conception - Bonifacio Campus. After a series of experimentation, the data were tabulated and analyzed using the SPSS 23.0 version.



The findings of the study were summarized and arranged based on the formulated research questions:

1. The bananas which took the longest time to ripe were those treated with negative control at 112.00 hours, followed by Kamias Extract 25% and Kamias Extract 50% at 96.00 hours. Application of Kamias fruit and Kamias Extract 75% allowed ripening of banana in 76.00 hours. The bananas which took the shortest time to ripe were those treated with positive control at 72.00 hours.
2. The bananas treated with Kamias Extract 75% had the highest level of acceptability at 7.22 with a descriptive equivalent of 'Very High'. This was followed by Kamias fruit, Kamias Extract 25%, Kamias Extract 50%, and Negative control with acceptability levels of 6.94, 6.72, 6.67, and 6.28, respectively, which all correspond to a descriptive equivalent of 'High'. The lowest level of acceptability was achieved by positive control-treated banana at 2.94 with a descriptive equivalent of 'Low'.
3. The bananas treated with Kamias Extract 75% had the highest titratable acidity at 0.73, followed by Negative control, Kamias fruit, Kamias Extract 50%, and Kamias Extract 25% at 0.53, 0.47, 0.43, and 0.37, respectively. The lowest titratable acidity was achieved by positive control-treated banana at 0.27.
4. The bananas treated with Kamias fruit had the highest level of reducing sugar at 5.00 with a descriptive equivalent of 'Very High', followed by Kamias Extract 75% at 4.67 with a descriptive equivalent of 'Very High'. The

bananas treated with Positive control had a high level of reducing sugar at 3.67. The bananas treated with Kamias Extract 25%, Kamias Extract 50%, and Negative control had a moderate level of reducing sugar at 2.67.

5. One-Way Multivariate Analysis of Variance (MANOVA) was used to determine if there is a significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with various ripening agents. Because the p-value of 0.00 was lesser than 0.05 alpha level of significance, the null hypothesis is rejected; therefore, there is a significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with different ripening agents. This means that the dependent variables were significantly dependent on the type of ripening agent used.

## **Conclusion**

Based on the findings of the study, the following conclusions were drawn:

1. The use of Kamias fruit allowed ripening of banana for 76 hours while a 25-75% concentration of Kamias fruit extract allowed ripening for 76-96 hours.
2. The bananas treated with Kamias Extract 75% had the highest level of acceptability.
3. The bananas treated with Kamias Extract 75% had the highest titratable acidity.
4. The bananas treated with Kamias fruit had the highest level of reducing sugar.

5. There is a significant difference in the duration of ripening, level of acceptability, titratable acidity and level of reducing sugar when treated with various ripening agents.

### **Recommendations**

Based on the findings and conclusion of the study, the following recommendations were formulated:

1. Kamias fruit as well as its extracts can be used as potential natural ripening agents for Cavendish bananas. The local market and the agricultural industry can utilize these agents to increase productivity and profitability.
2. The banana treated with Kamias Extract 75% exhibited the highest overall level of acceptability. Therefore, these are deemed acceptable to the consumers. Calcium carbide-treated bananas were found to be the least acceptable among others. The government should try to look for this issue as this would pose health hazards to the public.
3. The quality of banana was preserved during the ripening stage as manifested in the findings of titratable acidity and Benedict's tests. Hence, Kamias fruit-treated bananas can be a great source of minerals and carbohydrates.
4. Future researches should be done in order to evaluate others factors that were overlooked in the study.

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