

# BANANA RIPENING BY SMOKING CABINET

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**Abstract**— Ethylene is the hormone that is responsible for the ripening. It is naturally producing in climacteric fruits even after harvested even though this process is time-consuming. As the demand gets higher day by day, artificial ripening becomes famous in order to increase the production capacity. There are already so many methods are available for this purpose but people tend to use harmful techniques to ripen climacteric fruits as those methods are cheaper and easier to use. To solve this problem a harmless, successful and efficient method should be found that can be continued at a low cost. This smoking cabinet is designed using ancient techniques that have been successfully used for years to stimulate natural ethylene production and enhance ripening efficiency.

**Index Terms**— Banana, Ethylene, Ripening, Smoking Cabinet

## 1 INTRODUCTION

Banana (*Musa accuminata* and *Musa balbisiana*) is a climacteric fruit which ripens after harvesting due to the continuous ethylene production. Ethylene is a natural colorless gaseous plant hormone that is responsible for many processes including ripening. Ripening is also known as de-greening and it is a chemical-free natural process. Ripening is a process that includes physiological, biochemical and organoleptic changes in fruits which attains the desirable color, aroma, and texture that are unique to the optimum eating quality [1]. The natural ripening process is unpredictable and not uniform [2]. During the ripening process color changing from green to yellow due to pigments. Two compounds are responsible for this which names are chlorophylls and carotenoids. When the ripening process begins chlorophylls starting to degrade and simultaneously carotenoids give the yellow color for the fruit. In addition to the degradation process of pectin, the texture of the banana getting soft and sweetness getting high because of the degradation of starch into simple sugar such as fructose and glucose. edible fruit comes because of the ripening process. reduction of astringency, the increment of sweetness and softness of peel, yellowing peels are organoleptic changes that occur during the ripening process. A banana is one of the major fruit in the world in production and consumption. Due to the increasing demand, the supply should also be increased. Normally banana is harvesting at an immature stage and consumes when it is matured by the proper ripening. Enhancing the ripening efficiency is important to maintain proper supply-demand system. Normally it takes three to four days to ripe an immature banana. To reduce this time, people tend to use so many artificial ways such as using calcium carbide, acetylene, ethylene, propylene, ethrel (2-chloroethyl phosphonic acid), glycol, ethanol which are harmful to humans [2]. The use of artificial ripening agents has become a common practice due

to slow, unpredictable and non-uniformity caused by the natural ripening. Therefore, food producers use several artificial ripening agents to speed up the ripening process. Ancient people in Sri Lanka used smoking which is practically 100% successful. However that process was a little bit complex because due to a lack of proper apparatus and knowledge. It increases the temperature when smoking which accelerates the ethylene production [3]. If the banana is stored at elevated temperatures it gives soft de-greened banana in a shorter period [4]. By using this method, the natural ripening process can be accelerated without using any harmful chemicals.

## 2 METHODOLOGY

This ripening cabinet is developed by incorporating several traditional methods mainly including smoking. Smoke is generating by the combustion of coconut shells which is thrown away as waste. When a banana is exposed to warm smoke it accelerates the ripening as it increases the temperature. The high temperature helps to stimulate ethylene. This cabinet helps to maintain a high-temperature level inside as it is fully airtight. This cabinet is better than other chambers as the internal temperature, pressure conditions are displayed so they can be maintained at an optimum level. There is a gas outlet to control the high CO<sub>2</sub> levels accumulate inside the cabinet. This module is airtight to prevent any leaking of produced ethylene. It should not continuously smoke until ripening because subjecting to a high temperature for a longer time is undesirable for the banana pulp quality. First of all, the smoking cabinet should open by the sliding door which is used to place and remove the commodities inside the cabinet and it should be properly cleaned.

- Then the commodities that wanted to ripen, should be placed on the perforated racks inside the smoking cabinet. (Bananas which are needed to firstly ripen or that are more immature should be kept on the below layer and others must be kept on the different layers accordingly based on the requirement as the commodities placed on the below layer exposed to smoke better than in the upper layer).
- Then after that, properly dried ingredients (coconut husks) which are using as fuel should be placed inside the outer combustion unit and let it ignite.
- After a while as smoke is produce, the “mainahama”

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part should be used to force the smoke generated through the pipes into the bottom part of the cabinet.

- At the end of the pipeline, there is a proper filter that can be clean and replaced again to trap carbon and other undesirable compounds which avoid them flowing inside. (It helps to eliminate the black color layer accumulate inside the cabinet which reduces the ability to observe inside apart from eliminating the undesirable effects on the commodities.)
- Then the smoke will be flow through the perforated racks and touch the banana surface and initiate to accelerate the ripening process.
- The internal temperature and pressure are displaying in the display located on the top of the cabinet which helps to control the conditions by opening the cabinet if the conditions are undesirably high.
- Glass walls of the cabinet helps to observe the inside of the cabinet.
- Accumulation of moisture which may condense as a result of this process can be occur and this downward prism shape helps to reduce the accumulation of moisture in the corners and the bottom tap helps to easily remove that accumulated moisture.
- Wheels helps to easily move this cabinet to anywhere and enhance the convenience of handling by that.

Glass material is used as it helps to observe inside of the cabinet. But as the cost is high, other suitable material such as stainless steel can be used with only a one glass side. Fig. 1 is showing the ripening cabinet in different angles.



Fig. 1. Ripening Cabinet

### 3 DISCUSSION

There are various types of banana and they can be differentiated based on the colour, texture, size, taste. Some of the banana types are given below.

#### Cavendish (dessert banana) -

This is the most popular banana type all around the world (Fig. 2). These are sweet when they are ripen. The peel colour change from green to yellow. Brown spots that gets larger with the ripening process will appear on the peel surface .

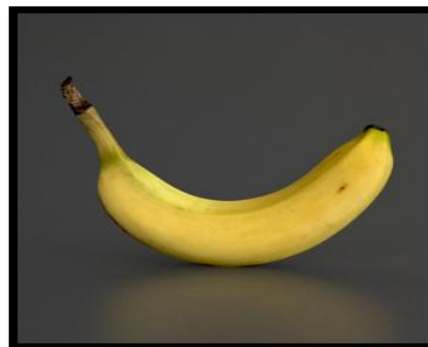


Fig. 2. Cavendish

#### Plantain (Green Banana)-

Well known as cooking banana. It is a larger, firm, less sweeter banana with a thicker peel. It have a different flavor. The main difference with other types of bananas is the major carbohydrate in it is starch not sugars.

Origin- South Asia, Southeast Asia, West Africa (Fig. 3).



Green Banana

Fig. 3.

#### Red Banana-

These are even sweeter and softer than Cavendish banana. Have a reddish purple peel. When ripen the skin will be lighter (light pink). It contains more beta carotene and vitamin C than other types (Fig. 4). Origin- South East Asia.



Fig. 4. Green Banana

A 54% of the total fruit lands are covered with banana cultivation [5]. Banana is leading in the world fruit production as it takes the fourth place in the total crop production of the world after rice, wheat and maize.

#### Importance of banana:

It is eaten as it is or cooked. It can be used to produce products like beverages including smoothies, fruit salads, puddings, cakes, confectioneries, etc. When concerning the

composition of banana, it contains a lot of micronutrients as well as macronutrients. So, a banana gives energy due to the presence of a high amount of carbohydrates. Banana is a fruit therefore it has less amount of protein and lipid content. In addition to that banana has some amount of dietary fibers which helps to proper digestion. When moving into the micronutrients, banana is rich in potassium, magnesium, phosphorus like minerals and lack of sodium and zinc. Other than that banana is a good source of vitamin c.

Hydroxyl radicals, superoxide ions, nitric oxide radicals, and singlet oxygen and hydrogen peroxide like free radicals may affect for human health. Arthritis, diabetes, arteriosclerosis, age-related macular degeneration, certain types of cancer, inflammation, genotoxicity, and Alzheimer disease-like disorders can be expected because of free radicals. Banana is

rich in many bioactive compounds, such as carotenoids, flavonoids, phenolics, amines, vitamin C, and vitamin E having antioxidant activities so they help to reduce the effect of those free radicles by act as an antioxidant. Most of the pigments have provitamin A activity other than anti-oxidant properties. In addition to that due to gallic acid, catechin, epicatechin, tannins, and anthocyanins like polyphenolic compounds heal the most of disorders that come from the presence of free radicles (Table 1).

Table 1. Benefits of Banana

Bioactive compound	Health benefits	Reference source
Gallocatechingallate Catechin	Cholesterol reduction Resistance of LDL to oxidation, brachial artery dilation increased plasma anti oxidation activity, and fat oxidation	[6] [7]
violaxanthin	Used as food colourant	
Cinnamic acid	Is a precursor to the sweetener aspartame by the means of enzyme catalyzed amination to phenylalanine	[8]
Trans alpha carotene	Precursor to vitamin A	[9]
Trans beeta carotene	Reduce the risk of and cancer	[9]
Campesterol and stigmasterol	Reduces the absorption of cholesterol in the human intestines	
Gallic acid	Antioxidant and potential hepatoprotective effects	[10]
serotonin	Might contribute to the to feelings of well-being and happiness.	[11]
dopamine	Reduce the plasma oxidative stress and enhance the resistance to oxidative modification of LDL	[12]
Beetasitosterol	Potential to reduce blood cholesterol levels and benign prostatic hyperplasia(BPH)	[13]
Tannic acid	Applied as medical agents for the treatments of burns	[14]
Cryptoxanthin	Food courant might reduce the risk of lung cancer	[15]
quercetin	Promote overall cardiovascular health by encouraging blood flow.	[16]

Banana is harvested before it is fully ripen due to many reasons mainly because,

- Ripen fruits are more prone to mechanical damages so they are hard to handle
- Animals like monkeys, birds are attracted to ripen bananas so they eat the fruit

So the fruits are harvested before it gets fully ripen. That is fine as banana is a climacteric fruit and it get ripen even after harvesting due to the continuous ethylene production. But this natural ripening process takes a long time.

### Ripening Process

Ripening is an essential process as it makes the fruit palatable as it is responsible for many compositional, biochemical, physiological changes such as,

- **Color changes** - Due to the changes in pigments. It occurs due to the breakdown of green pigment (Chlorophyll) and accumulation of other pigments such as anthocyanins and carotenoids which are responsible for yellow, red, purple, pink and orange colors [17].
- **Softening** - Due to enzymatic activities the compounds causing the firmness like pectin breaks down and make the texture softer. Immature fruits contain proto pectin and pectin which cause firmness. Enzymes like polygalacturonase (PG) and pectin methyl esterase (PME ) helps to breakdown pectin and reduce the firmness [18]. The chemical changes of starch grains are also contributing for this softening [19]. Averagely 50% of the firmness is dropping down during 3 days of ripening [20].
- **Taste (sweeter)** - Immature bananas containing high amount of starch and with the maturation these compounds break down into sugars like sucrose, fructose and glucose which cause sweetness [21]. In unripe bananas only 1%-2% of sugar is present but after ripening this percentage increase up to 15%-20% [22]. Moreover, decrease the starch content from 15.7% to 3.4% [23]. A Reduction of tannins which cause astringency will also happening during the ripening [24].
- **Aroma** - Production of aroma and flavor causing volatile compounds which gives the unique banana aroma such as alcohols, esters, ketones, aldehydes and phenol esters [25]. These are produced as a result of the metabolism of fatty acids and branched amino acids [26].

So there is no doubt to say that the ripening process is essential for the consumer acceptance as these changes make the fruit more demandable. Since the population is increasing and the demand for banana fruit is also increasing day by day marketers are using various artificial ripening methods which required lesser time.

There are some important conditions which are affecting the ripening process of banana as well as other climacteric fruits.

- **Temperature:**  
Elevated temperatures stimulates the ethylene production by increasing the rate of enzymatic activities. But too much heat is also unfavorable.

According to research it is shown that bananas ripe under relatively high temperature has less green than others [27]. So it will be a good advantage for improve market acceptance as well as customer satisfaction. Moreover, according to the statistical analysis of same research that mentioned the firmness of peel significantly softer in bananas which kept at higher temperature. In addition to that TSS also getting high of bananas which ripe under high temperature and high temperature help to reduce the starch percentage when ripening. Therefore those bananas has high sweetness, less astringency and flavor than others.

- **Humidity:**  
An optimum humidity level should be maintained. If it is higher there can be microbial growth which leads to spoilage. Lower levels will increase the ripening efficiency. Optimum RH is reported as 85%-95%. Weight loss can be happening during the ripening process due to respiration and transpiration. Therefore, humidity directly affecting for the weight loss. According to literature, it is mentioned that weight loss is reduced for bananas which ripened under high humidity conditions. Weight loss is an important factor because it adversely affects the appearance, flavor, and firmness of the peel. So according to the statistical analyses, bananas kept at high humidity levels showed greater peel firmness than lower humidity level. In addition to that high humidity level helps to increase the sweetness and flavor of bananas.
- **Light:** According to the given research it is shown that light treatment accelerate the ripening process and help to reduce green color and textural integrity [29].
- **Aircomposition:**  
When bananas are ripening, they required oxygen as they continue to respire and they release carbon dioxide as a result. CO<sub>2</sub> concentrations above 1% will slow down the ripening process.
- **Artificial ripening methods:** Artificially ripening process important to transport raw bananas due to low susceptibility of mechanical damages. By using artificial ripening agents raw bananas can ripe timely. Bananas can artificially ripen by using several kind of agents such as calcium carbide(acetalene), ethephon, and ethylene are used for artificial fruit ripening.
- **Acetylene-** Acetylene gas produces when hydrolyzed the calcium carbide. Sri Lanka like developing countries prefers to use this method due to low cost. Even though it is prohibited by the government it is still widely use in Sri Lanka. According to the series of experiments conducted by researchers has shown that acetylene can speed up the banana ripening after 120 hours while control sample remained as unripe after same period [30]. Acetylene has a lower biological activity than ethylene and concentration should be 2.8ml/L to enhance ripening of bananas [31]. According to the

past research that found there is no significant differences in sensory properties between ethylene treated bananas with acetylene treated bananas at 1ml/L when they are compared at same ripening stage. However, calcium carbide is not safe anymore and it is banned by the government [32].

Some of these artificial ripening agents has a different kind of impurities and also this kind of artificial ripening agents might be cause for different kind of health effects [33]. Ethephon might have monochloroethyl ester of phosphonic acid-like impurities [34]. So these can be destroyed monochloroacetic acid [35]. Because of that symptoms can appear such as fatal systematic poisoning and burn injury when monochloroacetic acid contact with skin [36]. As a result of the reaction of water with calcium carbide acetylene gas will be produced it may involve into ripening process of banana as a ripening agent. It acts as ethylene. When mechanically evaluating, calcium carbide there are phosphorous hydride and arsenic can be found [37]. Therefore, when dealing with calcium carbide it can cause the formation of liquids in the human lungs.

#### **Health defects of artificial ripening agents-**

As primary symptoms burning sensation of chest and abdomen, vomiting, diarrhea, weakness, thirst, irritation or burning skin and eyes, the difficulty in swallowing, sore throat, permanent eye damage, shortness of breath and cough, an ulcer on the skin can be expected [38]. According to past researches, direct consumption or exposure of artificial ripening agents cause most of the health hazards [39]. Renal failures can be caused due to ethylene glycol. Ethylene is considered as a safe artificial ripening agents but those are not commonly used worldwide due to high cost [40]. Most farmers and producers are willing to use low-cost agents such as calcium carbide and ethephon likewise [41]. Acetylene produced by compounds like carbide is reducing the brain oxygen supply and affects the nervous system. Also, carbide is a flammable solid.

#### **What happens when you consume artificially ripe bananas for a long time?**

There are no available human studies about it but as these fruits which are ripened by carbide may contain some amount of heavy metals like arsenic which increases the risk of cancer [42]. In most countries, using calcium carbide for ripening is illegal but still, farmers use this method as it is very cheap.

Even though there are no human studies yet, there is a rat study about the changes in health after the consumption of bananas which are ripened by using carbide. According to the result of the rat trail, white blood cells and eosinophil levels of female animals are getting high and also in male rats hemoglobin amount getting high when consuming carbide applied fruits. In addition to that after consuming carbide applied fruits, it will be cause for the imbalance of sex hormones in the body. After observing the overall study, consumption of calcium carbide applied fruits may have potential health hazards such as lower the immunity, imbalance of the hormonal functions and might be affected for the overall reproductive functions and it will cause infertility.

#### **Method of enhancing the ripening efficiency naturally.**

Using ethylene gas artificially in a ripening chamber for this ripening process is a harmless efficient method but it required

a huge investment that cannot be bear by small scale farmers. Ethylene releasing solutions are also good but most of the farmers and sellers use those solutions in improper ways to get the results faster and that can again be harmful to the consumers as they could be contaminated with heavy metals like hazardous compounds which may cause serious health issues. In countries like Sri Lanka, they have a wide knowledge on indigenous methods for so many purposes including ripening. The best thing is most of them are natural and harmless.

01) Keeping ripen and un-ripen fruits together in an air tight container is a very simple method to ripe unripe fruits as absorbing the ethylene hormone which is released by ripen fruits as a gas to the surrounding. So the ripening will be accelerated.

02) Spreading unripe fruits between paddy husk or wheat straw layers.

03) Uncooked rice seeds are used to cover the fruits. It helps to trap ethylene gas releasing from the fruits without wasting them to the outer environment and thereby increase the effective usage of ethylene to increase the ripening speed.

04) Smoking

Green bananas can artificially ripen by using smoke. Smoke treatment is also one of most popular method [43]. In this method, banana expose to smoke for 24 hours inside a air tight chamber. Then the temperature is getting high inside the chamber. Then the ethylene production get stimulated .The ethylene gas helps to enhance the enzymatic reactions inside the banana as a hormone. As a result of that the de greening process will start and fruit tend to ripe early and evenly.

#### **Ripening acceleration by traditional smoking:**

Smoking is a traditional practice done to obtain many purposes including ripening of climacteric foods like banana, preservation and enhance the sensory qualities of some foods. It has proven results of ripening bananas by incorporating traditional smoking as it has practiced successfully by ancient people. Also, the enhancement of ripening by smoking have scientifically proved recently as smoke contains ethylene (C<sub>2</sub>H<sub>4</sub>) and acetylene (C<sub>2</sub>H<sub>2</sub>) which accelerate the ripening of climacteric fruits [44]. Also, the smoke generated by combustion is high in temperature. This high-temperature levels also accelerate ripening by stimulating the ethylene production [45]. The smoking technique has been underused basically due to the resulting burnt scars and poor appearance of ripening banana by smoking [46]. These problems can be solved by understanding the reason for them and properly eliminating them. The poor appearance means the darken and dull color it gets because of the compounds containing in the smoke such as carbon. Burn scars and spots may occur when this process is not properly controlled. But this suggested protocol helps to maintain and control the conditions as well as to observe the process happening inside the cabinet. So it helps to withdraw commodities when they are ripened to the expected levels before burning.

#### **What makes our product special**

- Using a successfully used hidden indigenous knowledge to develop it
- No energy consumption
- No operational cost
- No chemical usage. Only stimulating the natural

ethylene production.

- Can use it continuously
- No need of skilled workers to operate
- Can control temperature and pressure like conditions.
- No microbial spoilage during ripening.

#### 4 CONCLUSION

As banana is a climacteric fruit, it can be ripened after harvesting and it is usually harvested before ripening to avoid post-harvest losses. This developed smoking cabinet is an ideal solution to reduce the usage of harmful techniques farmers and sellers using to further ripening. It can be successfully used as it is constructed with the hidden indigenous knowledge that ancient people have already used. By using this module anyone can ripen banana without any chemicals which leaves harmful contaminations. Zero energy consumption is the other plus point of this module and it only required small effort to monitor the conditions while smoking. By using this module, we can bring our hidden indigenous techniques back to our lives which are less harmful for humans.

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