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Study on the Effects of different methods of Delaying Ripening in Avocado Pear and Banana Fruits

A.I. Izundu [a], O.A. Mbaukwu [a], C.O. Chiawa [b], C.F. Iroka [a,*], S.O. Azode [a]

[a] Department of Botany, Nnamdi Azikiwe University, P.M.B. 5025 Awka, Anambra State, Nigeria
[b] Federal Collage of Forestry Resource Management, Ishiagu Ebonyi State, Nigeria
*Corresponding author Email: harlyz14@yahoo.com
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Abstract: The safety of the food we consume is a global concern and in Nigeria particularly. In previous decades, fruit processing industries have developed rapidly in Nigeria. To achieve high quality in terms of visual appearance, texture, flavor and nutritional value, fruits must be harvested when they've has attained proper maturity. After harvesting, quick ripening of fruits is responsible for reduced shelf life. This issue can be solved either by using preservatives or manipulation of ripening in fruits. Due to its low cost and availability, Formaldehyde has been popularly used as preservatives in Nigeria despite having detrimental health impacts. All these raises very severe health concerns including cancer, male sterility and many more. Considering the present situation in Nigeria, artificially delaying fruit ripening seems to be an encouraging alternative to address the problem and this is also being practiced in many countries. For fruits to successfully ripe, it requires the release of ethylene during the process and ripening of fruit can be delayed by inhibiting the activity of ethylene. The present study tries to evaluate the different safe and cost-effective ways of retarding ripening in avocado pear and banana fruits. Calcium chloride was used to soak the fruits; some were treated with cold treatment while others were placed at room temperature. Ripening was successfully delayed in the cold treated banana and avocado fruits; the external abnormality was quite much and this is a problem. Maybe, in further studies, temperature of cold treatment should be adjusted and regulated in order to reduce fruit external abnormality and thereby, maintain a good fruit skin texture. For the $CaCl_2$ treatment, flesh colour and flavor development was significantly delayed and the external abnormality was lower. This simply relates that the $CaCl_2$ treatment will be useful in delaying ripening even for commercial purposes, while room temperature treatment showed similar developments with the control sample.

Keywords: Ripening, Fruit, Avocado pear, Banana, Treatment, Cold, Calcium chloride.

1. Introduction

Fruits have proven to be very important in human nutrition and they are rich source of vital constituents like vitamins, minerals, dietary fibers, different important carotenoids (lycopene, beta-carotene, xanthophyll etc.), flavonoids, phenolic and other phytochemicals [1, 2]. Asides regular consumption, various types of fruits have varying ways that they are processed for different applications. Fleshy and succulent fruits such as apple, peach, pear, pineapple, watermelon, banana, pawpaw and mango all have commercial value as human food which are eaten fresh or in processed forms such as jams, marmalade, puree, smoothie amongst others. Fruits are useful in the manufacture of foods like cookies, muffins, yogurt, ketchup, parfait, sauces, soup, salad, ice cream, cakes and many more. Nigeria is a country on the tropics with plenty of fruit varieties growing in seasons all-round the year. It is however, unfortunate that the consumption of these fruits is not as much as it is supposed to be, due to the unavailability when it's out of season and also due to lack of proper post-harvest preservation. More so, the World Health Organization (WHO) made a recommendation that the daily per capita consumption of fruits and vegetable for every healthy person to be at a total of 400g. Hence, in Nigeria, the per capita consumption of fruits and vegetables is as low as 126g; including only 14g of fruits [3]

Generally, in Nigeria, fruits are expensive to purchase when compared to other countries like India, US and Europe and this is because of the post-harvest spoilage of fruits in the supply chain and the exorbitant preservation procedure. Most fruit vendors in the fruit

business are not familiar with effective methods or techniques of fruit preservation that can bring about better post-harvest management and less wasteful spoilage of fruits. About 3362 thousand Metric tons of fruits are produced every year in Nigeria, Paul *et al*. [4] and post-harvest losses of fruits and vegetables is within the range of 18-40% at different levels of the supply cycle. These wasteful spoilage costs about 3 billion naira per year [5]. Thus, to do away with this problem, different chemicals are used in an unofficial and illegal manner; however, most of these chemicals are very hazardous to human health. This scenario therefore raises the emphasis on the necessity for a safe, suitable, cost-effective and consumer acceptable methods that can ameliorate the spoilage by preserving the fruit quality or by delaying the ripening of harvested semi-ripen fruits. Availability of such method will extend the shelf life or storability of fruits and in turn, assist in effectively checkmating the direct financial loss and possible health problems.

The exportation of fresh fruits and vegetables from Nigeria has increased significantly over the years from 50.71 million USD in 2008-2009 to 182.23 million USD in 2012-2013 [6]. Moreover, it is still insignificant when compared to other countries of the world. In 2012 to 2013, fresh fruits exportation was takeover by India (93.94%), Middle East countries (4.3%), EU region (0.42%) and other countries 1.34% [6].

Recently, Nigeria is improving in terms of food processing and agro-based industries and export market from these sectors are growing massively. These sectors have shown great potentials to be a key driver in the economic growth of Nigeria in the near future. Nevertheless, post-harvest losses of fresh fruits are the main challenge that needs to be taken care of. In order to reduce the losses, the local farmer and vendors often use some unauthorized and hazardous chemicals of which formalin is one of the most common examples. Formalin, a 37% water solution of formaldehyde, is very poisonous and can cause terminal diseases such as cancer, liver and kidney failure [7].

Traders often make use formalin as a preservative to make fruits and vegetables look fresh for longer period of time [8, 10]. Also, most recently, there have been reports of horrific findings about the use of formalin on many food items. It was discovered that 100% citrus fruits, 95% of grapes, 91% of bananas, 82% of mangoes, 77% of dates, 75% of tomatoes, 60% of eggplant, 59% of apples and 20% of cucumbers were found to have dangerous levels of formalin or other chemicals during a random sampling analysis [11]. This disturbing situation is getting even worse for the fruit farmers and vendors, as they lack techniques to put a stop to the spoilage or preserve their remaining produce. This issue can either be addressed by using healthy preservation techniques and manipulating ripening times of the fruits so that farmers and fruit vendors can have some control over the shelf life of their fruits. Current healthy preservation options such as FDA approved methods are too expensive or sometimes not easily accessible by the local farmers and fruit vendors. Although, research is still on going to develop considerable cost-effective techniques to preserve and delay ripening in fruits [12, 13]. The aim of this study is to ascertain the potential methods that can be used to delay fruit ripening in avocado pear and banana without any harm to the fruit or negative health impact for human consumption.

2. Materials and Method

Freshly harvested avocado pear and banana fruit were purchased from Oye Amansea village market Awka under special arrangement. The fruits were taken to the Department of Botany laboratory where they were washed and the various treatments introduced to reduce their ripening. The $CaCl_2$ salt used for the study was gotten from the department laboratory store, while the refrigerator used was a private owned refrigerator.

2.1 Treatments Used for the Reduction of Ripening

A total of three methods was used in reducing ripening in Avocado pears and Banana and a total of ten (12) avocado pears and ten (12) banana (fingers) fruits were used for the study.

$CaCl_2$ Treatment

Three (3) of avocado pears and 3 banana fingers were dipped into calcium chloride solution for 15-20min. The fruits were labeled and placed in a dry corner for further observations for a period of 10 days.

Cold Treatment

Three (3) avocado pear and 3 banana fruits were put in the refrigerator (cold treatment). The refrigerator was adjusted to a temperature of 0 to -4^{o}C. The fruits were observed for changes for 10 days.

Room Temperature Treatment

Another three (3) avocado pear and 3 banana fruits were placed in a dry container at room temperature.

Control sample

Three (3) control specimen of each of the fruits was left on the open. The specimens were monitored daily for physiological changes and observations were recorded.

Rate of fruit ripening and fruit quality were assessed using a three-man panel. The panelists scored the ripeness of the fruits using the following parameters:

- Rate of ripening estimated as a percentage of full-ripened color, with normal color development expressed as 0 to 100%.
- External abnormalities, which were divided into six grades based on the percentage of area affected (0 = 0%> 1 = 1% to 10%, 2 = 11% to 35%, 3 = 36% to 65%, 4 = 66% to 90%, 5 = 91% to 100%).
- Flavor as evaluated by the observers (1 = under-ripe, 2 = ripe and normal, 3 to 5 = overripe, with increasing severity degrees of off-flavor)

Each member of the panelist assessed the fruits for scoring every two days. The experiment continued for ten days until the fruits started decaying. At the end of the experiment (after 10 days), the results of the panelists were put together and records taken.

3. Results

Figure 1a shows the percentage rate of ripening of banana fruit after treating with various treatments to delay ripening. For the specimen treated with $CaCl_2$, first rate of ripening was observed on the fourth day and the color was sustained to the fifth day. Another level of ripening was recorded on the sixth day and there was a consistent increase until the ninth and tenth day. For the banana specimen exposed to cold treatment and room temperature, first colour change was observed on the fourth day, it was further sustained on the fifth day before attaining another rate of ripening change which remained consistent until the tenth day. Significantly, the $CaCl_2$ treated banana fruit only attained a 25 percent colour change; cold treated banana attained a 30 percent colour change while room temperature treated banana and the control sample attained 40 percent colour change in 10 days.

Figure 1b shows the percentage rate of ripening of avocado fruit after treating with various treatments to delay ripening. For the specimens treated with $CaCl_2$ and cold, first rate of ripening was observed on the fourth day and the colour was sustained to the sixth day. Another level of ripening was recorded on the seventh day. For the CaCl2 treated avocado, the colour change on the sevent day was sustained until the ninth day and another level was attained on the tenth day. But for the cold treated avocado, the colour development on the seventh day attained another level of colour development on the eighth day which was sustained on the ninth day and another level on the tenth day. For the avocado specimen exposed to room temperature and the control sample, first colour change was observed on the fourth day, it was further sustained on the fifth day before attaining another level of flesh colour change on the sixth day, there was another level of flesh colour change was attained on the seventh day which remained consistent until the eighth day and it remained consistent on the ninth day before another increase on the tenth day.

Figure 2a shows the external fruit abnormalities on banana fruit after treating with various treatments to delay ripening. For the specimens exposed to cold treatment and room temperature, first level of external abnormality was observed on the third day, the abnormality was continuous until the fifth day. There was no change on the sixth day but on the seventh day there was another level of abnormality observed with another level of abnormality attained on the ninth and tenth day.

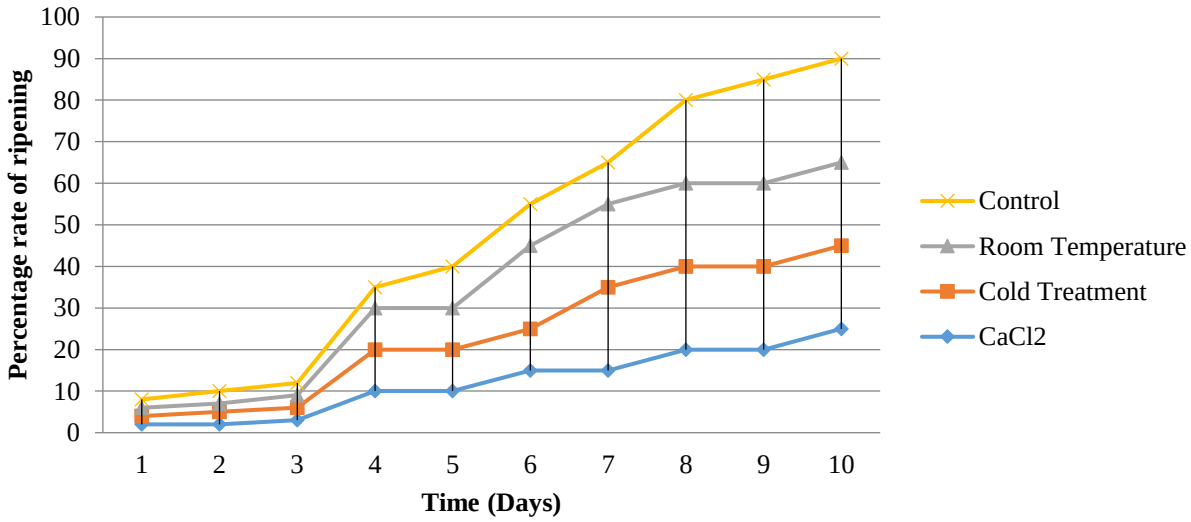

Figure 1a. Percentage ripening of banana fruit treated with different treatments to delay ripening.

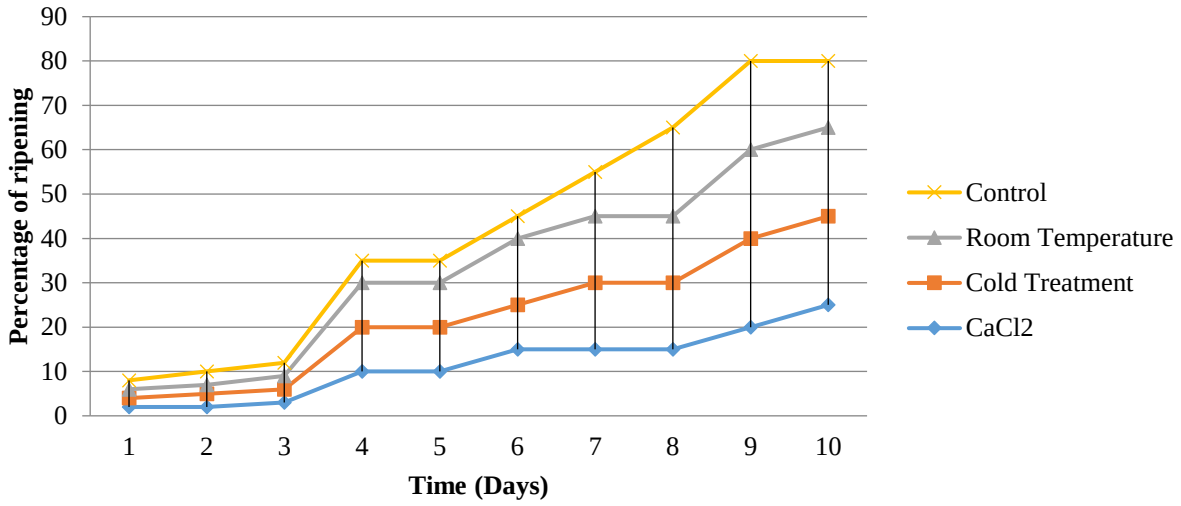

Figure 1b. Flesh color development of avocado fruit exposed to different treatments to delay ripening.

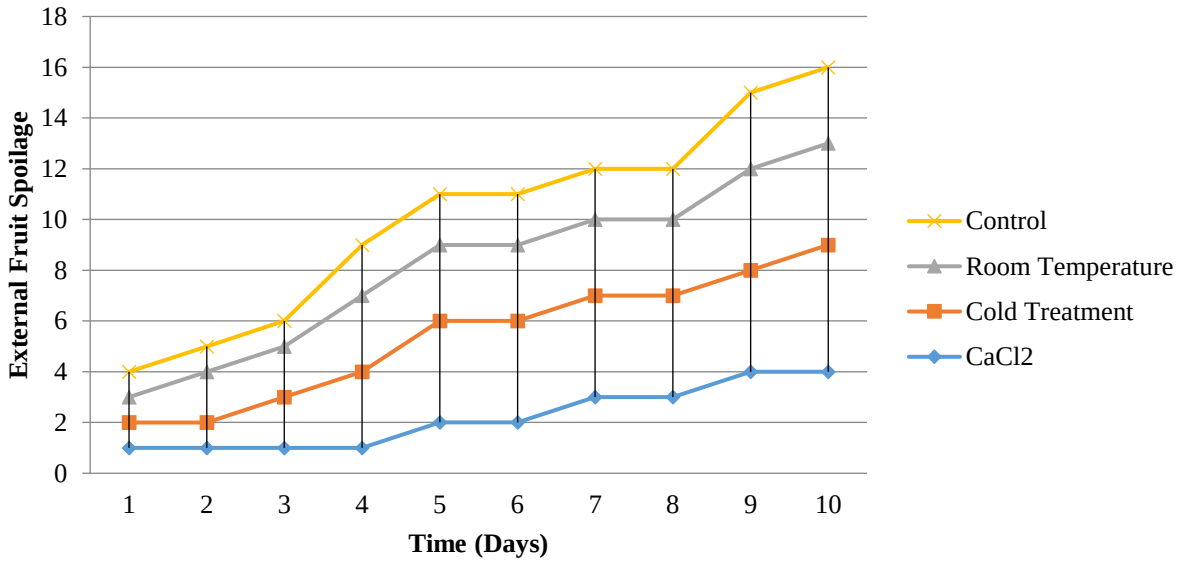

Figure 2a. External fruit spoilage of banana fruit exposed to different treatments to delay ripening.

For the banana specimen treated with $CaCl_2$, first external abnormality was observed on the fourth day. A new abnormality was observed on the fifth day and it remained consistent on the sixth day, another external abnormality was noticed on the seventh day, none on the eight day but on the ninth and tenth day, new abnormalities were observed. The $CaCl_2$ and room temperature treated banana fruit sustained level 4 external fruit spoilage out of five levels; cold treated banana attained 5 out of 5 level of external abnormality while the control sample sustained a level 3 external spoilage.

Figure 2b shows the external fruit abnormalities on avocado fruit after treating with various treatments to delay ripening. For the specimens exposed to cold treatment and room temperature, first level of external abnormality was observed on the third day, the abnormality was continuous until the fifth day. There was no change on the sixth day but on the seventh day there was another level of abnormality observed with another level of abnormality attained on the ninth and tenth day. For the banana specimen treated with $CaCl_2$, first external abnormality was observed on the fourth day. A new abnormality was observed on the fifth day and it remained consistent on the sixth day, another external abnormality was noticed on the seventh day, none on the eight day but on the ninth and tenth day, new abnormalities were observed. The $CaCl_2$ and room temperature treated avocado fruit sustained level 4 external fruit spoilage out of five levels; cold treated avocado and the control sample attained 5 out of 5 level of external abnormality.

Figure 3a shows the flavor development on banana fruit after treating with various treatments to delay ripening. For the specimens exposed to $CaCl_2$

treatment, flavor development started on the fourth day and on the fifth day it gained another level of flavor but was the same on the sixth day. On the seventh day it gained another level of flavor which remained the same on the eight day before another gaining a new level on the ninth day through the tenth day. For cold treated banana fruit, the first level of flavor development was on the fourth day, it gained another level on the fifth day and then maintained a consistent increase until the seventh day when it remained on the same level until the eight day and then attained another level flavor on the ninth day through the tenth day. The room temperature treated banana fruit, the first level of flavor was attained on the fourth day, and there was an increase on the fifth day which remained consistent through the sixth and seventh day to the eight day and ninth day. The $CaCl_2$ and control specimen of banana fruit gained level 4 developments in their flavor out of five levels; cold treated banana and the room temperature sample attained only level 3 flavor development in ten days.

Figure 3b shows the flavor development on avocado fruit treating with to various treatments to delay ripening. For the specimens exposed to cold treatment, room temperature treatment and the control specimen, flavor development started on the fourth day and on the fifth day it gained another level of flavor through the sixth day but was the same on the seventh day. On the eight day it gained another level of flavor which kept on increasing until the tenth day in the room temperature and control specimens but the cold treated avocado stopped increasing on the ninth day and remained the same to the tenth day. For the $CaCl_2$ treated avocado fruit, the first level of flavor development was on the fourth day, it gained another level on the fifth day and was the same till the seventh day. There was another level on the eight day which also remained the same until the tenth day. The $CaCl_2$ and cold treated specimen of banana fruit gained level 3 developments in their flavor out of five levels; control and the room temperature samples attained level 4 flavor development in ten days.

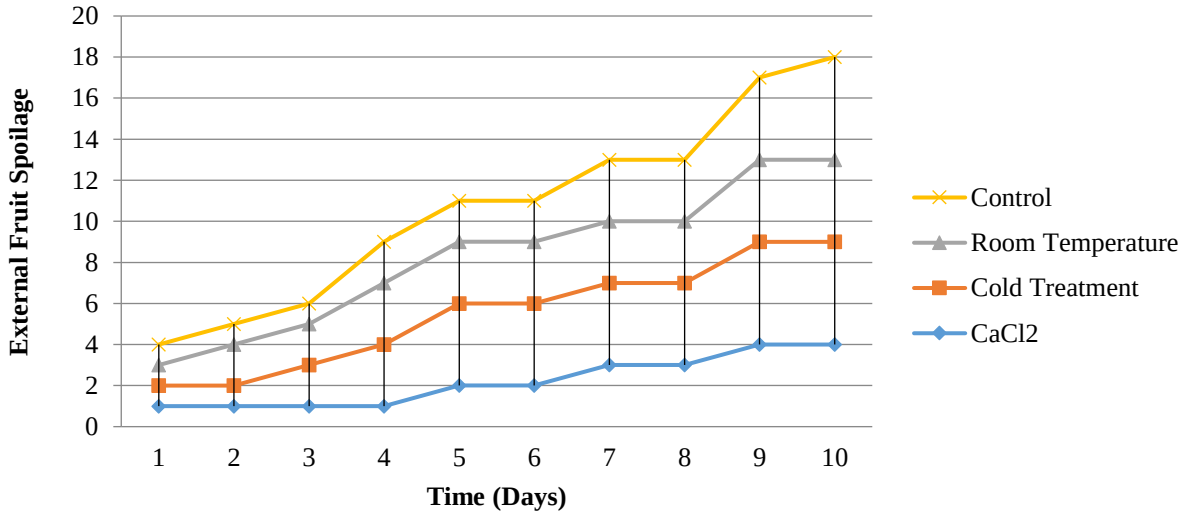

Figure 2b. External fruit spoilage of avocado fruit exposed to different treatments to delay ripening

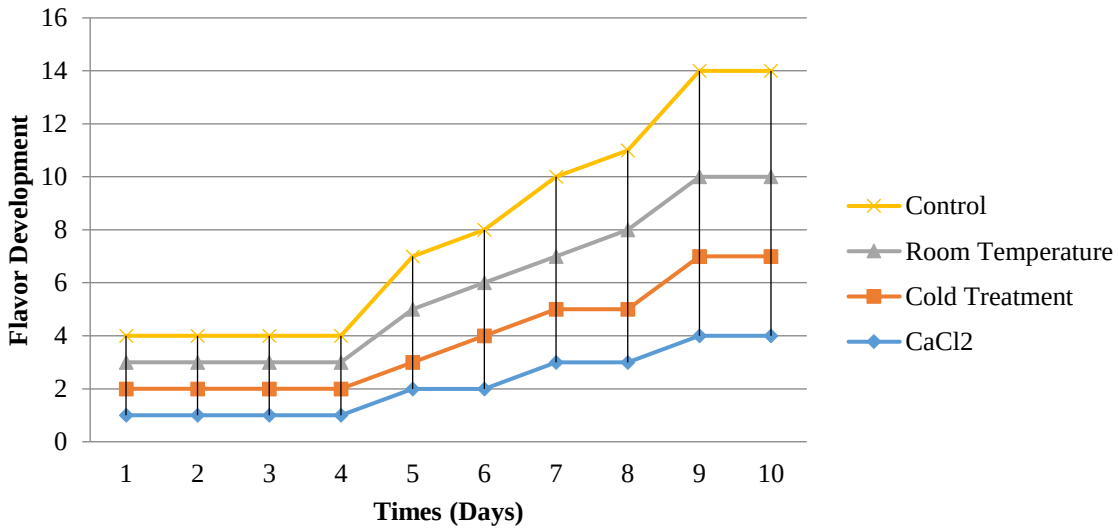

Figure 3a. Flavor development of banana fruit exposed to different treatments to delay ripening

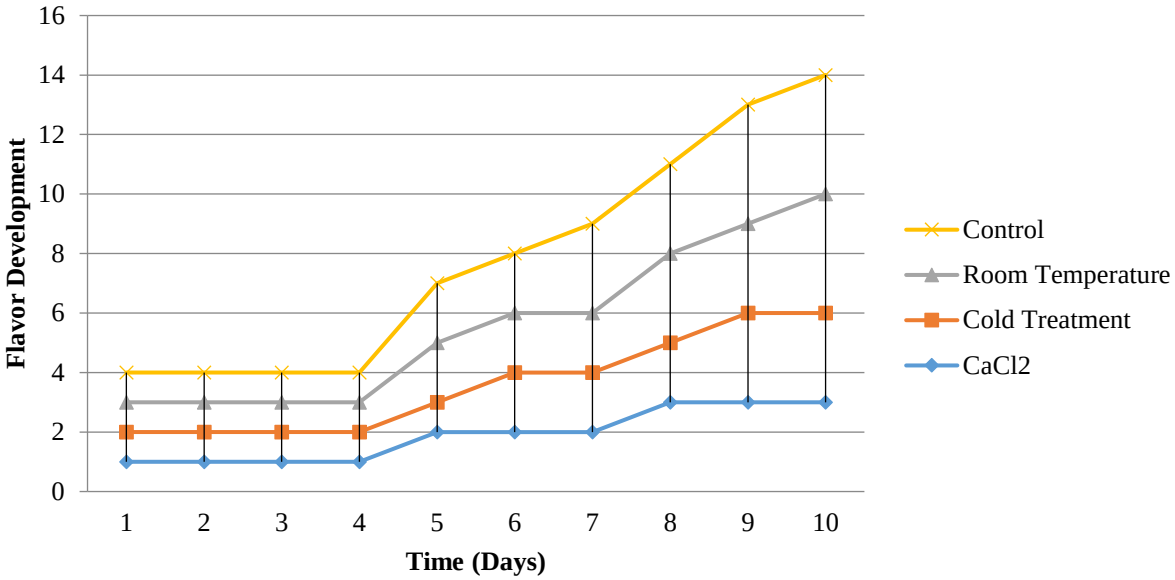

Figure 3b. Flavor development of avocado fruit exposed to different treatments to delay ripening.

4. Discussion

Fruit ripening has been described as a natural phenomenon that leads to a chain of biochemical changes which further brings about the change of color, pigment formation, starch breakdown, textural changes, volatile and aroma development and eventually the abscission of fruits [14]. The fruits used in this study (Avocado pear and pawpaw) were exposed to various treatments to delay ripening, attention was given to colour change on the flesh, textural change of the flesh and flavor of the fruits after ten days of observation.

The treatments on the fruit studied include; soaking with $CaCl_2$, cold treatment (refrigerating) and room temperature exposure. These treatments were meant to inhibit the activation of ethylene in the unripe fruits studied and in effect delay the ripening of the fruits. Plant cells contain ethylene binding receptors that have an ethylene binding site, which gets activated by ethylene and triggers ripening action of fruits [15]. Receptor-bound Ethylene molecules initiate series of interactions by propagating chemical signals inside the fruits' cells [16, 17].

These molecular activities bring about the ripening of the fruits by altering the color, flavor, aroma, and composition of the fruit (water content, starch content, sugar content etc.). From the study carried out, $CaCl_2$ and cold treatment successfully delayed the colour development and flavor development of banana fruit when compared to room temperature and control samples of the banana fruit. Also, avocado pear subjected to cold treatment and $CaCl_2$ had their colour and flavor delayed. Although, Ethylene has also been reported to act as a rheostat rather than as a trigger for climacteric fruits ripening; this simply implies that ethylene must be in place at all times in order to carry out the transcription of relevant genes required for fruit ripening [18].

To decelerate the ripening processes of fresh fruits and as a result, increase their shelf life; it is necessary to inhibit or slow down the activities of ethylene gas [19, 20]. Quite a number of chemicals have been reported to block the response of basal level of ethylene in fruits and of course delayed the natural ripening process significantly [21, 24]. These ethylene inhibitors undergo reactions with the ethylene receptor to inhibit the action of ethylene. Therefore, stimuli are not raised for the downstream interaction; hence, ripening process is delayed.

More recently, studies have been conducted which investigates the calcium chloride treatment for extending the storage life of mango. The use of calcium chloride in this study conforms to the previous studies by researchers. The method of Esguerra and Bautista is usually applied where the mangoes are submersed in a cold calcium chloride solution for 2 hours during postharvest [25]. In studies with the 'Julie' and 'Willard' varieties of mango, treatments of 4% to 6% calcium chloride increased the shelf-life of the fruit by 5 to 7 days [24]. In the study carried out, shelf life of banana and avocado fruits treated with $CaCl_2$ and cold treatment were increased more than those exposed to room temperature and the control sample. Although, external abnormality was high in avocado and banana fruits exposed to cold treatment but $CaCl_2$ and room temperature treatments showed subliminal external abnormality in both fruit.

5. Conclusion

In conclusion, ripening was successfully delayed in the cold treated banana and avocado fruits, the external abnormality was quite much and this is a problem. Maybe, in further studies, temperature of cold treatment should be increased and regulated in order to reduce fruit external abnormality and thereby, maintain a good fruit skin texture. For the $CaCl_2$ treatment, flesh colour and flavor development was significantly delayed and the external abnormality was lower. This simply relates that the $CaCl_2$ treatment will be useful in delaying ripening even for commercial purposes, while room temperature treatment showed similar developments with the control sample.

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Conflict of interest

The Authors have no conflicts of interest to declare that they are relevant to the content of this article.

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