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REVIEW ON USE OF CALCIUM CARBIDE IN FRUIT GROWTH, ITS HARMFUL EFFECTS AND METHODS OF DETECTION

R R. Gupta[1] and G. D. Satpute[2]
[1]Mohota Science College, Nagpur, Maharashtra, India.
[2]Shree Govindrao Munghate College of Arts and Science, Kurkheda tehsil, Gadchiroli, Maharashtra, India.

ABSTRACT

Fruit ripening has been an integral part of the agricultural process. A variety of ripening chemicals try to mimic the action of a natural plant hormone Ethylene, to create the same effects on the edibility and economic value of fruit. Farmers try to maximize their profit margins and, in this quest, have started using a multitude of such chemicals. Most popular of them all is calcium carbide. Calcium carbide hugely accelerates the ripening process, but this comes at the cost of nutritional value of the fruit. Often the excessive use of CaC2 has been proven to introduce toxic elements and compounds into the peel or the pulp of the fruit. In this review, we try to evaluate the various studies conducted on the toxicity of Calcium carbide induced toxicity and methods of Detection of calcium carbide in artificially ripened fruits.

KEY WORDS: - *Fruit ripening , natural plant hormone.*

INTRODUCTION

Fruits are widely distributed in nature, commercially essential and nutritionally imperative part of a balanced diet. Fruits play a vital role by supplying the essential elements required for normal health[1].

The commercial value of a fruit is gauged by its short ripening period and longer post-harvest shelf life. Fruit ripening depends on genetics as well as epigenetic factors such as surrounding chemical and physical environment. The process of ripening involves a sequence of biochemical changes that finally result in a ripe edible fruit with qualities which are considered to have economic value.

In recent years, there has been research towards the action of different chemicals on the ripening processes of fruits.

The natural process of ripening takes place when the plant roduces Ethylene gas (C_2H_4). Ethylene is a flammable colourless gas with a sweet odour. Ethylene was the first identified naturally occurring plant hormone known to regulate numerous plant process such as growth, development and response to biotic and abiotic stresses[2].

The ripening process is seen when the concentration of ethylene increases from 0.1 ppm to that close to 1 ppm[1].

The best alternative to natural ripening is externally applying Ethylene gas. However, owing to its highly flammable nature and profit margin, this is not a viable option for the farmers.

The closest and cheapest alternative to ethylene gas is using an analogue of ethylene gas, i.e. acetylene gas (C_2H_2).

Acetylene gas can be produced in vitro by using reagents Calcium Carbide (CaC_2) and water from the following reaction.

$CaC_2(s) + H_2O(l) \rightarrow Ca(OH)_2 + C_2H_2(g)$

Calcium carbide is the most commonly used chemical due to its low cost and abundance in agricultural markets. No technical knowledge is needed for the application of CaC_2. Calcium carbide is used as a ripening agent for a variety of fruits including mangoes, bananas, jackfruits, litchis.

Traders pick green fruits before maturation, ripen these artificially to serve in the market earlier than the season for higher profits[3]. Moreover, green fruits are transported easily with minimum damage and ripened at the place of retail sell.

Calcium Carbide (CaC_2) treatment expedites the ripening processes of unripe fruits by increasing the rates of softening, respiration, flavour and colour changes. However, the use of this chemical in agriculture is being discouraged worldwide due to the dangers of explosion and carryover of toxic materials like arsenic and phosphorus to consumers products, making food potentially toxic. It was banned in India under the Prevention of Food Adulteration (PFA) Act 8-44 AA, 1954 1, Food Safety & Standards Act (FSSA), 2006 and Food Safety & Standards Regulation (FSSR), 2011.

Industrial grade calcium carbide also contains trace amounts of more toxic arsenic and phosphorous that converts healthy fruits into toxins.

Calcium carbide is a known carcinogen. It is also known to cause food poisoning, gastric irritation and mouth ulcers[4]. Impurities in carbide such as phosphide produces phosphine when hydrolysed with heavy metals like arsenic.

While applying these chemicals for ripening one needs to take precautions to prevent the contact of fruits with calcium carbide because these hydrides are fat soluble, and may dissolve in the wax layer of fruits.

OPTIMUM METHOD OF APPLICATION:

A study conducted by R. Amarakoon et al. in 1999 performed a series of experiments to optimize the application of Calcium carbide.

"Calcium carbide was wrapped in a paper and kept at the bottom of a plastic container; the size of the container varied with the volume of the fruits to be treated. The fruits were packed and covered tightly with a newspaper to prevent leakage of acetylene. Calcium carbide was moistened with a drop of water before placing the fruits in the container to release the gas. After 24 hours, the packets of calcium carbide were removed from the container, and the fruits were uncovered and allowed to ripen. This method was successful, inexpensive, simple and commercially applicable. It allowed uniform ripening of mangoes and completely prevents the contact of the fruits with calcium carbide."

Highest overall acceptability was found to be 1 g/kg of the fruit[5].

Effects of CaC_2 on human health:

Consumption of carbide ripened fruits is exceptionally hazardous for health, mainly for the nervous system. Acetylene, generated from carbide reduces oxygen supply to the brain. In the acute stage, it causes headache, vertigo, dizziness, delirium, seizure and even coma. In the long term, it may produce mood disturbance and loss of memory[4].

Other toxic effects include skin burn, allergy, jaundice, mental confusion, memory loss, cerebral edema, seizures and carcinogenic potential[6]. Dissolved acetylene is a colourless gas that is non-poisonous and non-irritant to the skin and mucous membranes. When mixed with oxygen, it acts as a sedative and has been used in anaesthesia. Acetylene gas may affect the neurologic system by prolonged hypoxia.

In Germany, acetylene was used as an anaesthetic, yet it never achieved widespread use in the United States owing to undesirable cardiovascular effects such as atrial or ventricular dysrhythmias, hypotension, myocardial ischemia, and eventual asystole[7].

Use of high doses of calcium carbide to induce ripening of mangoes has become a problem to the consumer. Often using higher doses of artificial ripening agents leads to tasteless fruits laden with toxins.

Methods for detection of fruits ripened using artificial reagents:

1. Electrochemical method:

In this work an **enzyme based electrochemical biosensor** is developed to detect CaC_2 in mangoes. The mechanism involves competitive inhibition of Pt/CeO_2/AChE (acetylcholinesterase) bioelectrode by the mixture of calcium peroxide (CaO_2) and C_2H_2.

CeO_2 modified Pt electrode was developed for the determination of CaC_2 in artificially ripened mangoes based on AChE enzyme inhibition.

Since Calcium Carbide is applied to many crops as a pesticide due to its action as acetylcholinesterase (AChE) inhibitor.

$$\text{Acetylcholine} + H2O \xrightarrow{[AChE]} \text{Choline} + CH_3COO^- + H^+$$

In this study, Amperometric current was found to be decreasing linearly with an increase in CaC_2 concentration from 1 nM to 100 nM, which was the indirect inhibition of AChE activity on the addition of CaC_2. Interestingly, the Pt/CeO_2/AChE bioelectrode detected CaC_2 with a response time of 4s. Such low response time makes this method ideal for on-field applications and testing[8].

2. Indirect method to detect Calcium Carbide:

This method takes into account that industrial grade CaC_2 contains some impurities of Arsenic. Acetylene gas is catalysed the arsenic surface present and converts into Arsine gas. Arsine gas released from CaC_2 combines with oxygen and other elements to form inorganic arsenic compounds. As a rule, inorganic arsenicals higher greater toxicity than organic arsenicals.

This presence of arsenic can be used as an indicator of use of CaC_2 during the ripening period.

In this study arsenic residues were estimated from the fruit peel, pulp and surface using the method of wet digestion as per the standard analytical method (AOAC, 1998). Using this a correlation can also be drawn between the arsenic present and the amount of CaC_2 applied[9].

3. Image processing:

Identification of artificially and naturally ripened mangos using image processing via MATLAB was successfully made with 80% accuracy. The use of image processing for identifying the ripening can be applied not only to mango but also to other fruits. The accuracy of identification can be enhanced by further modifying test cases and obtaining a larger training set. This algorithm has huge potential in for industrial-scale where segregation of artificial and natural products is essential[10].

4. Gold nano-particle based method:

Residues of arsenic have been proven to be found on fruit surfaces artificially ripened by CaC_2. In this study gold based nanoparticles were used for the calorimetric detection of calcium carbide indirectly from arsenic residue. Lauryl sulphate-capped gold nanoparticle aggregate in the presence of arsenic as this replaces the lauryl sulphate, resulting in a colour change from red to purple. Hence the developed method can be used for easy and rapid detection of use of calcium carbide in artificial ripening of fruits. Hence the developed gold nanoparticles can be used as simple, selective, sensitive and rapid method of detection for fruit artificially ripened using calcium carbide[11].

CONCLUSION:

Further studies need to be conducted on the methods for detection for CaC_2. High potential exists for development of a test kit to identify artificially ripened fruits

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