Eating artificially ripened fruits is harmful

Md. Wasim Siddiqui and R. S. Dhua*

Presently, the whole world is emphasizing on malnutrition, food safety and health security. Several programmes have also been launched in this regard. The year 2008–09 was declared as the 'Food Safety and Quality Year' by the Government of India. Most fruit sellers use Calcium carbide for ripening the fruits. Calcium carbide is extremely hazardous to the human body as it contains traces of arsenic and phosphorus. It is banned in many countries of the world, but it is freely used in India, Pakistan, Bangladesh, Nepal and other countries. Thus we are at risk of short-term and long-term health effects simply by eating fruits that are induced to ripen. This article discusses the common yet most important fact related to fruits – how nutrition changes over to malnutrition?

Keywords: Artificial ripening, calcium carbide, fruits, health hazards, nutrition.

EXCEPT fruits, no other class of food has a variety of pleasant and attractive flavour. With their delicate colouring, fruits please the eye as well as the plate. With modern transport and cool chain management system, it is possible to have fresh fruits practically all the year round, where it is produced and also in areas where it is not possible to grow fruits. As a consequence, consumption of fruits has increased considerably in our country. Studies have indicated that people do not consume enough vitamin C not because of increased cost or unavailability, but because they are often unaware of the nutritious value and sources.

There is growing interest and concern among people regarding foods and their relationship to nutrition and diseases[1]. Food security used to be the primary concern of countries and individuals alike. But, as agricultural research succeeds in alleviating the effect of diseases and adverse climate, food security is generally not perceived as a problem any longer; instead concern over quantity has been replaced by preoccupation with quality[2]. Simultaneously, people are more conscious about issues such as ecology, energy conservation and management practices for food production, including pretreatment, which facilitates or increases the attractiveness and ultimately presentation.

Fruits are the best natural food for all. Nowadays fruits are deliberately being contaminated by chemicals causing serious health hazards. Toxic chemicals are indiscriminately used to grow, ripen and make fruits appear fresher or even last longer, particularly during early and off-season[3]. Among the pretreatments, which are mostly followed for fruits intended for better consumer acceptance and facilitating better marketing, is artificial fruit ripening. Artificial ripening is done to achieve faster and more uniform ripening characteristics[4,5].

Ripening, in general, is a physiological process which makes the fruit edible, palatable and nutritious[6]. In nature fruits ripen after attainment of proper maturity by a sequence of physical and biochemical events and the process is irreversible, ultimately leading to senescence. Whether fruits ripen on the plant or after harvest, the general ripening changes associated with the ripening process are easily recognizable. During ripening fruits soften, change colour and develop characteristic aroma and flavour. There is also a reduction in sourness (acids) and increase in the sweetness, etc.[6]. Underlying these changes, there may be changes in hormone levels, respiration and cellular organization[7,8]. Factors influencing the process of ripening include stage of fruit maturity and the environment where it has to be allowed to ripen, including temperature and relative humidity[4,9].

Artificial ripening

Unsaturated hydrocarbons, particularly acetylene, ethylene, etc. can promote ripening and induce colour changes effectively[4,5,10,11]. Although the cosmetic quality of such artificially ripened fruits was found to improve, the organoleptic quality was impaired especially when harvested fruits were subjected to treatment without considering their maturity status[3,12]. Besides, the quantity of ripening agent required to induce ripening for better cosmetic quality, including appearance, etc. will be much more than the conventional dose, when properly mature fruits are not used for such purposes. The internal ethylene concentrations, measured in several climacteric and non-climacteric fruits are presented in Table 1.

The following are the sources of ethylene or acetylene production.

The authors are in the Department of Post Harvest Technology of Horticultural Crops, Faculty of Horticulture, BCKV, Mohanpur, Nadia 741 252, India.
*For correspondence. (e-mail: wasim_serene@yahoo.com)

Explosion-proof ethylene mixture: Ethylene (6%) in carbon dioxide by weight.

Ethylene generator: Ethanol is heated in the presence of catalyst to produce ethylene.

$$C_2H_5OH \rightarrow C_2H_4 + H_2O.$$

Ethephon (2-chloroethyl phosphonic acid), commercial name – Ethrel, Florel, Cepa: It is acidic in water solution and liberates ethylene in neutral to basic medium generally above pH 5.

Calcium carbide (CaC_2): When hydrolysed, it produces acetylene, containing trace amounts of ethylene sufficient to be used in fruit ripening. Acetylene, the end-product of CaC_2 and water provokes the same effects as the fitohormone ethylene, but neither CaC_2 nor synthetic ethylene when used to 'ripen' less mature fruits, produces results similar to fruits harvested closer to their peak.

$$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2.$$

The concentrations of ethylene required for the ripening of various commodities vary, but in most cases they are in the range 0.1–1 ppm. The time of exposure to initiate full ripening may vary, but for climacteric fruits exposure of 12 h or more is usually sufficient. Full ripening may take several days after ethylene treatment[6]. General optimum ripening conditions are given in Table 2.

Use of ethylene-releasing compounds, particularly 2-chloroethyl phosphonic acid for induction of fruit ripening is limited due to lack of required information regarding the use of chemicals for commonly available fruits in the distant markets and also the high cost and scarcity of such chemicals. On the contrary, use of acetylene gas generated from CaC_2 induces ripening of fruits similar to ethylene[3–5,10–12]. This method is being used in most of the climacteric fruits (fruits which are picked when mature, and ripened off the tree, i.e. only after harvesting) like mango and banana and in non-climacteric fruits like citrus for degreening[10,11,13,14].

Table 1. Internal ethylene concentrations measured in several climacteric and non-climacteric fruits[6]

Fruit	Ethylene (µl/l)
Climacteric	
Apple	25–2500
Pear	80
Peach	0.9–20.7
Avocado	28.9–74.2
Banana	0.05–2.1
Tomato	3.6–29.8
Non-climacteric	
Lemon	0.11–0.17
Lime	0.30–1.96
Orange	0.13–0.32
Pineapple	0.16–0.40

Although fruits developed good peel colour with CaC_2, the intensity of colour developed commensurates with increase in the concentration of CaC_2 used; but fruits were less in flavour volatiles and had shorter shelf-life[14]. Actually CaC_2 only changes the skin colour, whereas the fruit remains raw inside. More raw/immature the fruit, higher CaC_2 is required to ripen it[14]. This makes the fruit tasteless, unhealthy and slightly toxic. It also breaks down the organic composition of vitamins and other micronutrients. Chemicals have the potential to damage the vital organs of the body. CaC_2 is used for ripening mango and banana in Brazil, Senegal and Malaysia[15,16]. Comparative effectiveness of ethylene and related compounds is given in Table 3.

Mangoes of the Langra, Himsagar and Fazli varieties, Cavendish banana and some varieties of tomato are not yellowish or fully red when they are ripe[4,10]. But people are not aware of this and are mostly attracted by the colour of the fruits. Traders sell the chemical-mixed fruits in the market, subjecting consumers to risk, as chemically ripened fruits contain traces of arsenic and phosphorus which are hazardous to the human body.

Reports reveal that cheap chemical compounds are used for ripening many fruits including apricots, bananas,

Table 2. General optimum ripening conditions for different fruits[35]

Parameter	Value
Temperature	18–25°C
Relative humidity	90–95%
Ethylene concentration	10–100 ppm
Duration of treatment	24–72 h depending on fruit king and maturity stage
Air circulation	Sufficient to ensure uniform distribution of ethylene, which reduces its effectiveness

Table 3. Comparative effectiveness of ethylene and related compounds[36]

Compound	Relative activity (mol/unit)
Ethylene	1
Propylene	130
Vinyl chloride	2370
Carbon monoxide	2900
Acetylene	12500
1-Butene	140000

Table 4. Fruits and countries where CaC_2 is used for artificial ripening[3–5,10,11,13,16–18]

Fruit	Country
Mango	Brazil, Costa Rica, India, Malaysia, Pakistan, Philippines, Senegal, South Africa
Banana	Australia, Egypt, India, Pakistan, Philippines, South Africa, Sudan, Taiwan, USA, Yemen
Citrus fruits	Australia, Philippines, South Africa
Plums	South Africa
Peaches	South Africa
Tomato	Australia, Morocco, Philippines, USA

papayas, dates, plums, etc. There are a few exceptions like apples, grapes, pomegranates and melons. Fruit traders report that the availability of chemically ripened fruits will reduce, once the naturally ripened fruits arrive in the market[17,18]. Countries where CaC_2 is used for artificial ripening of fruits in different countries are given in Table 4.

What is CaC_2?

Calcium carbide has numerous applications in chemical and steel industries and agriculture. It is popularly known as 'masala', and is used as a ripening agent, though banned in many countries. It is colourless when pure, but black to greyish-white in colour otherwise, with slight garlic-like odour. When it reacts with water, CaC_2 produces acetylene gas which is an analogue of ethylene and quickens the ripening process[19]. It also contains traces of arsenic and phosphorus hydride[20]. Acetylene prepared from CaC_2 also contains phosphine and some arsine up to 95 and 3 ppm respectively[21,22]. A strong reactive chemical, CaC_2 has carcinogenic properties and is used in gas welding[3]. Acetylene gas is flammable and explosive even in a low concentration compared to ethylene[23].

Besides, indiscriminate use of pesticides on different types of fruits can lead to poisonous effects. Due to lack of awareness and education people consume chemically ripened fruits. Being cheap (1 kg of this chemical costs Rs 25–30, and can ripen 200 kg of mangoes), CaC_2 is indiscriminately used in preference to other recommended practices of inducing ripening like dipping fruits in a solution of ethephon/ethrel, or exposure of fruits to ethylene gas.

Effects of CaC_2 on fruit quality

As the fruits are sent to different places, requiring several days in ordinary or refrigerated transportation, only firm but mature fruits are least damaged during marketing[10,12,13]. They are ripened at the destination markets before retailing. Using CaC_2 is also a less cumbersome procedure. All that a trader has to do is to wrap a small quantity of CaC_2 in a paper packet, and keep this packet near a pile or box of fruits. As chemical reaction takes place, because of moisture content in the fruit, heat and acetylene gas are produced, which hastens the ripening process. In the case of banana, ripening starts within 24–48 h, depending on the ambient temperature. When the fruits yield to slight finger pressure, they are kept under ice slabs for lowering the temperature and colour develops[14]. Apparently, green bananas can transform into flavoursome yellow appetizers. However, fruits ripened with CaC_2 are overly soft and less tasty. They also have a shorter shelf-life. An artificially ripened fruit would present a yellow outer skin, but the tissue inside would not be ripe or itself remains green and raw[3]. Though mangoes ripen quickly (two days), they cannot be stored for more than two days. When CaC_2 is used on raw fruit, the amount of the chemical needed to ripen the fruit has to be increased. This results in the fruit becoming even more tasteless and possibly toxic[13].

Ban on using CaC_2

Considering the possibilities of its hazardous effects, CaC_2 is banned in many countries, but it is widely used in India, Pakistan, Bangladesh, Nepal and other countries for ripening fruits[3,18]. In spite of the high consumption of fruits, and the obvious shift to horticulture as part of the crop-diversification plan, the concerned authorities have failed to devise any effective action plan to check malpractices in ripening.

In India, artificial ripening is banned under the Prevention of Food Adulteration (PFA) Act, 1954, and the Prevention of Food Adulteration Rules, 1955. According to rules 44AA of the PFA Rules 1955, no fruit can be ripened with the aid of CaC_2. Those convicted under this Act could face imprisonment for three years and a fine of Rs 1000. But there are hardly any cases where the traders or retailers have been booked for accelerating ripening by the use of harmful chemicals[24]. Several news reports have highlighted the open use of CaC_2 in different parts of the country[18]. Recently, the Union Health Ministry has sent a circular to all state food authorities with the Food Safety and Standards Authority of India, stressing the need to take legal action against those found guilty of violation of the PFA rules[18].

Similarly, Part 7, Rule No 19 (d) of Nepal Food Regulation 2027, has strongly prohibited the use of carbide gas in the ripening of fruits[25]. In Nepal also, the Government has appointed District Agriculture Development Officers as food commissioners with the duty of monitoring the quality of food items sold in the markets. The Department of Food Technology and Quality Control under the Ministry of Agriculture and Cooperatives, Nepal is the central authority with responsibility for monitoring the market, conducting tests on food commodities and taking action against those found involved in producing and selling inedible food items in Nepal.

The Bangladesh Pure Food Rules of 1967, the law addressing food, is armed with such small fines that traders are hardly intimidated by it. The highest penalty for adulterating food is Tk 5000.

Health hazards

As discussed earlier, CaC_2 contains traces of arsenic and phosphorus hydride[20]. It causes several acute and chronic health effects[19,26]. In humans, acetylene is not acutely toxic below its lower explosive limit of 2.5% and inhalation of 10% acetylene for 1 h does not cause acute toxi-

city, whereas inhalation of 33% or 35% can cause unconsciousness within 7 and 5 min respectively[21]. The early symptoms of arsenic or phosphorus poisoning include vomiting, diarrhoea with or without blood, burning sensation of the chest and abdomen, thirst, weakness, difficulty in swallowing, irritation or burning in the eyes and skin, permanent eye damage, ulcers on the skin, irritation in the mouth, nose and throat. Throat sores, cough, and wheezing and shortness of breath may also occur soon after exposure to the chemical. Higher exposure may cause a build-up of fluids in the lungs. Eating artificially ripened mangoes causes stomach upset because the alkaline substance is an irritant that erodes the mucosal tissue in the stomach and disrupts intestinal function. Chronic exposure to the chemical could lead to peptic ulcer[27–30]. As CaC_2 imitates acetylene gas, it may affect the neurological system by inducing prolonged hypoxia[31]. Recent findings related to carbide poisoning have reported headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral oedema and seizure[32]. Though eating the fruit will not bring about such an allergic reaction, the method of ripening it could cause such problems. Studies conducted by Erciyes University (Turkey) during 2005 revealed that CaC_2 is hazardous as it contains traces of arsenic and phosphorus. It has also been observed that humans exposed to 35% acetylene were unconscious after 5 min and commencing intoxication was observed after 25 s, marked intoxication after 1 min (ref. 33).

Other effects include numbness in the legs and hands, general weakness, cold and damp skin and low blood pressure. Although most cases of arsenic and phosphorus poisoning are detected before they become fatal, pregnant women are particularly vulnerable. The chemical residue in the fruit could lead to miscarriage[26]. But, the literature on CaC_2/acetylene toxicity does not describe cardiovascular or electrocardiographic abnormalities.

Identification of CaC_2-ripened fruits

Fruits that look attractive outside may not be good for health. Fruits that have a uniform colour, for example, a bunch of bananas having a uniform colour, are more likely to have been artificially ripened.

Artificial ripening of fruits is done for commercial purposes with chemicals. The naturally ripened fruits are not uniformly yellow; rather, they are of green and yellow. When tomatoes are uniformly red, or mango and papaya are uniformly orange/yellow, then CaC_2 may have been used; bananas can also be identified if the stem is dark green whereas the fruits are all yellow.

While purchasing fruits and vegetables, one should not select those that are homogenously ripened and with eye-catching bright colours. Washing and peeling procedures before eating the fruit could help in minimizing the risks associated with the use of CaC_2. Washing the fruits under running water for a few minutes may help minimize the chemical contents, if any, adhering to the fruits. While eating mangoes and apples, it is better to cut the fruit into pieces, rather than consuming them directly.

It is not advisable to buy fruits when they arrive in the market before the due period. One can be almost sure that they have been artificially ripened. June and July, which marks the end of the mango season, would be the best time to taste the fruit as the market would be flooded with naturally ripe mangoes.

Suspected samples may be tested in the laboratory for phosphorus and arsenic residues on the surface of the fruits.

Ethrel/ethephon an alternative to CaC_2

Ripening of fruits with certain chemicals is permissible up to a limited concentration. The Government of India has allowed the use of ethephon/ethrel for ripening of fruits as it is less harmful. In the case of ethephon, the ripening is slightly cumbersome; the fruit sellers have to either dip the fruits in a solution of this mixture or pass fumes of this chemical through the fruits[10,34]. The chemical is mainly used to ripen mango, papaya, banana, etc. The fruits ripened with ethrel have more acceptable colour than naturally ripened fruits and have more shelf-life than fruits ripened with CaC_2 (refs 4, 5, 34). For example, Himsagar mango from West Bengal, does not develop apparent yellow colour on natural ripening, but in the markets we find yellow-coloured fruits ripened using CaC_2. Siddiqui and Dhua[10] standardized the ethrel dose (i.e. 500 ppm) for Himsagar mango, thus giving good acceptable colour and up to 5–6 days of storage. In Tamil Nadu, a solution has been developed to ripen mango – a mixture of water (5 litres), ethephone 39% (10 ml) and sodium hydroxide (2 g), kept in a bucket close to the mangoes heaped in an airtight chamber would release ethylene gas, which naturally facilitates the ripening of fruits without any harmful effects[17].

Recommendations

1. Food adulteration has become rampant due to inefficiency in Government-regulated quality assurance practices. The Departments of Health and Agriculture should realize the gravity of the problem and check the practice of fruit ripening with chemicals and also the use of toxic colours in food products.
2. Restrictions should be strictly imposed regarding procurement and selling of such banned compound to be used for these purposes.
3. The fruit traders need to be made aware of the danger and imbued with a sense of moral responsibility to the society. Vigilance at the wholesale markets should be strengthened to stop the practice.

4. The consumer rights groups should raise the issue on the use of this banned chemical agent.
5. Effective and better methods should be developed to prevent direct contact of the ripening substances with the fruits.
6. New compounds which are environmentally safe and are not harmful for human health must be discovered and tested.

Conclusion

Fruits are being treated with CaC_2 to ripen them faster. Considering its hazardous aspects, the use of CaC_2 must be strictly monitored and controlled. It is not solely the responsibility of the Government; the people must also become aware and avoid consuming contaminated fruits. The guilty must be punished to prevent further spread of such a harmful practice. Mass awareness and social resistance are the most effective deterrents to such dangerous activities.

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Received 10 April 2010; revised accepted 12 October 2010