

Mini Review

Health hazards posed by the consumption of artificially ripened fruits in Bangladesh

¹Hossain, M. F., ²Akhtar, S. and ³Anwar, M.

¹*School of Agriculture and Rural Development, Bangladesh Open University, Gazipur-1705, Bangladesh*

²*Department of Community Medicine, Shahabuddin Medical College and Hospital, Dhaka, Bangladesh*

³*Department of Surgery, Ibn Sina Medical College and Hospital, Dhaka, Bangladesh*

Article history

Received: 3 September 2014

Received in revised form:

13 February 2015

Accepted: 14 April 2015

Abstract

This review paper discusses the impact of chemicals used in fruits as ripening agent on fruit quality and consumers' health. Chemicals and plants hormones are also being used in harvested fruits at the time of marketing in Bangladesh. Chemicals like acetylene, ethylene etc. are used for ripening immature fruits and thus promote their cosmetic quality. Sometimes fruit sellers ripen immature fruits artificially to meet the high demand and make high profit. During transportation, the naturally ripened fruits may become over ripen and inedible. Many fruit wholesalers make fruits ripen with calcium carbide and also treat those with formalin to protect against microbial attack and thus minimize financial loss. The fruits ripened with calcium carbide may develop uniform attractive surface color, but poor in flavor and the inside may remain unripe. Use of chemicals accelerates ripening, but affects the nutritional quality of fruits. Most of these chemicals are harmful for human health. It is necessary to build awareness among fruit producers, traders and consumers.

Keywords

*Artificial fruit ripening
Calcium Carbide
Health hazards
Bangladesh*

© All Rights Reserved

Introduction

The South Asian countries like India, Pakistan, Bangladesh, Nepal, Sri Lanka, Bhutan and the Maldives have a wide range of climatic conditions with the altitude and agro-ecology suited for a wide diversity of tropical fruits. This region is the center of origin of about 50 species of fruits (Haque *et al.*, 2009). The major fruits grown in these countries are banana, mango, citrus, pineapple and papaya. Besides these, a large number of minor fruits are also grown in the region such as black berry, tamarind, palmyra palm, monkey jack, Indian olive, carambola, star apple, mangosteen, Burmese grape, velvet apple, wood apple, Indian apple, custard apple, and Indian goose berry are very common and popular (Chandha, 1989; Haque *et al.*, 2009). Large amount of tropical fruits are produced in Bangladesh. In recent times there is much concern about artificial ripening of fruits in many parts of the world including Bangladesh (Rahman *et al.*, 2008). People of Bangladesh take on an average of 126 g of fruits and vegetables daily. This is far below the minimum daily requirements (400 g) of fruits and vegetables as recommended by FAO and the World Health Organization (WHO, 2003). Fruit ripening is a natural process in which the fruit goes through various chemical changes

and gradually become sweet, flavored, colored, gets soft and become palatable (Brady, 1987). But various artificial methods of fruit ripening have been observed mostly to meet consumers' demand and other economic factors. Recently in Bangladesh, people are consuming fruits, ripened with hazardous chemicals like calcium carbide. These pose great health risks to consumers (Rahim, 2012). Fruit sellers artificially ripen green fruits even during the due season to meet the high demand and make high profit of seasonal fruits. Transporting and distributing fruits from the farmers' orchards to consumers' baskets can take several days. During this time the naturally ripened fruits may become over ripen and inedible. A part of naturally ripened fruits can also be damaged during harsh condition of transportation. It indeed increase great economic loss for the fruit sellers and therefore, to minimize the loss, fruit sellers sometimes prefer collecting fruits before full maturity and artificially ripen fruits before selling to the consumers (Mursalat *et al.*, 2013). The consumers can also play an important role in terms of selecting the right fruit by keenly observing the variation of color and buying seasonal fruits. Many wholesalers confessed that they used to sell fruits like mangoes ripened with calcium carbide and treated with formalin to avoid financial loss in the business

*Corresponding author.

Email: faridhossain04@yahoo.com

(Fattah and Ali, 2010). Some developed countries allow using some post-harvest ripening chemicals not beyond tolerance limit for selective fruits following specific dosing protocols. The presence of artificial ripening agents is usually encountered on the fruit skin. It is also important to quantify the presence of chemicals within fruit-flesh and to analyze the chemical impact on the food value of artificially ripened fruits (Hakim *et al.*, 2012). However, chemicals agents like calcium carbide and ethephon are frequently used in developing countries to activate fruit ripening process. Though, the consumers suffer the risk of indirect effect of ripening agents. Food safety became very important for both governments, producers of food products and consumers as well. Food safety is an important and growing challenge for Bangladesh and an issue that has to be addressed by introducing preventive measures throughout the food chain (Islam and Hoque, 2013). The paper is an overview of different aspects of artificial ripening and chemical use in fruits. The information outlined in this article have been collected from different national and international journals in agricultural, food and medical sciences, different reports of Food and Agriculture Organization of the United Nations and World Health Organization (FAO, 2010; WHO, 2003 and 2009) and visited of useful websites.

Chemical used in fruits

Fruits are highly nutritious and form an important food item in the human diet. On the other hand these are highly perishable due to their short shelf life. These food commodities are reported to be contaminated with toxic and health hazardous chemicals like calcium carbide, ethylene which are being used for ripening fruits and protecting them from rotting and damage. Moreover, formalin and some other chemicals are also used for extending the shelf life of fruits which are reported to cause several health problems like such as dizziness, weakness, ulcer, heart disease, skin disease, lung failure, kidney failure and cancer etc. The widespread use of formalin and other chemicals for preservation of fruits has become a great concern among the people. The chemicals used as spray solution make fruits attractive. Use of non-edible coloring and coating materials on fruits for extending shelf life are reported have serious health hazardous effect (Rahim, 2012). People have been adopting several ways to ripen fruits since long period. Ancient Egyptian harvesters used to cut figs in order to stimulate the ripening process, while Chinese farmers used leaves of pears plant in confined chambers with added heating. In 1901 Russian scientist, Dimitry Neljubow observed that

ethylene gas emerging from larger pipes influenced ripening process of fruits. After almost three decades, researchers observed that the plants not only respond to ethylene but also produce ethylene themselves and hence accelerate ripening process. Diffusion and transfer of endogenous ethylene take place simultaneously from one cell to another in fruits at a high pace which accelerate the rate of ripening. Unripe fruits often contain various types of organic acids, namely citric acid, malic acid, ascorbic acid, formic acid, tartaric acid etc. These acids are held responsible for the sour taste of fruits. After certain chemical changes these acids are transformed into sugars and the fruits turn sweet (Kendrick, 2009). Later on researches showed that treating of fruits with high temperature also triggers fruit ripening (Bouzayen *et al.*, 2010). In testing food qualities, odor, visual color, and texture are important because choosing a item is closely related to a persons. Consumers judge food products seriously when buying them. Discolorations, abnormal proportions and abnormal visual aspect have influence on consumer behavior (Meulenaer, 2006). The consumption of banana by people, from little children to adults is very common. It supplies necessary calories and essential micronutrients. It is highly perishable, having short shelf life leading to high post-harvest losses of about 20-50% due to poor handling and quality deterioration (Ajayi and Mbah, 2007; Zewter *et al.*, 2012). In order to reduce the high post-harvest losses, bananas are harvested when green but mature, and artificially ripened when needed with the use of ripening agents. Ripening agents are substances, which hasten the ripening process, and it comes in different forms. These include ethylene gas, ethephon, ethylene glycol, etherel and calcium carbide (Singal *et al.*, 2012). Calcium carbide can induce ripening within 24 hrs and the fact that it is cheap makes it to be a popular ripening agent among banana marketers especially in the developing countries (Ajayi and Mbah, 2007). The adverse potential of calcium carbide as a ripening agent has been established (Singal *et al.*, 2012). While other chemical ripening agents like ethephon, etherel and ethylene glycol are also considered hazardous to health and they have to be used within recommended safe limits (Hakim *et al.*, 2012). The use of toxic ripening agents is of great concern as the activities of human beings have been said to contribute to exposure of food materials to heavy metal contamination (Orisakwe *et al.*, 2012). The use of artificial ripening agents may give more acceptable color than naturally ripened fruits (Hakim *et al.*, 2012). But it may increase the risk of contamination of food materials. The use of toxic

ripening agents is common in developing countries. Artificial ripening accelerates ripening, but affects the nutritional quality of the fruits (Sogo-Temi *et al.*, 2014). Fruits ripened with calcium carbide are overly soft, inferior in taste and flavor. They also have a shorter shelf life. The fruits ripened with calcium carbide may develop uniform attractive surface color, but the tissue inside would not ripe or may remain green or unripe. Calcium carbide is used in immature fruits the amount of the chemical needed to ripen the fruits has to be increased. As a result fruit becomes tasteless, unhealthy and toxic. National food safety laboratory of Bangladesh found nearly 40 percent of 82 samples of milk and milk products, fish, fruits and vegetables full of banned DDT, aldrin, chlordane, heptachlor and others. Those pesticides are present 'at 3 to 20 times the limits set by the European Union'. Among the tested vegetables, 50% were found contaminated with those pesticides while in fruits it was 35% (Hasib, 2014). Formalin is a toxic substance illegally used by merchants to preserve food, to make these look fresh and attractive in the market for longer periods, thus maximizing profits. The widespread use of formalin in fruits, vegetables, fish and meat poses a great threat to public health. Ethylene develops in fruits naturally that induces usual process of maturation. This process of maturation can be artificially accelerated by using different chemicals of which calcium carbide is the most common. Calcium carbide is widely used in different parts of the world (Hoque, 2012). Packets of calcium carbide powder are kept in the container of fruits where in contact with moisture, acetylene gas is produced and acts as a ripening agent. Once applied on the fruits calcium carbide comes into the contact of the moisture and releases acetylene, which has fruit ripening characteristics similar to ethylene.

Industrial grade of calcium carbide contains traces of arsenic and phosphorus hydride, which are hazardous for human health if ingested (Rahman *et al.*, 2008). Most of the ripening agents used by the fruit-sellers are of industrial grade, collected from unauthorized sources, and may contain a high percentage of toxic impurities. These chemical impurities also cause serious health hazard like such as ulcer, heart disease, skin disease, lung failure, kidney failure, cancer etc. To compensate the transportation and distribution issues in developing countries, Government or local authorities can help fruit-sellers and farmers providing with convenient transportation and adequate cold storage facilities especially for the seasonal fruits. In addition, the government agencies and scientific communities can investigate to develop safer, low concentration and economically viable

dosing protocols and guidelines for fruit ripening (Mursalat *et al.*, 2013). Calcium carbide an extremely harmful chemicals is used alongside ethephon in fruits for overnight ripening and making attractive in colour, while formalin is used to preserve food items from nutritional damage. Calcium carbide is used as ripening agent for mangoes, bananas, jackfruits, litchis and other fruits as well. Immature fruits are harvested in early season and ripen with chemicals for high profit. Moreover, green fruits are transported easily with minimum damage and ripened at the place of retail sell. A very small concentration (1 ppm) of ethylene in air is sufficient to promote the fruit ripening process (Brady, 1987). Externally applied ethylene is likely to trigger or initiate the natural ripening process of apple, avocado, banana, mango, papaya, pineapple and guava, and therefore, can be marketed before the predicted time (Mursalat *et al.*, 2013). Ethephon is another agent, which is used to artificially ripen fruits (Singal *et al.*, 2012). Ethephon is often considered better than calcium carbide because pineapple, banana and tomato treated with 1000 ppm of ethephon required less time for ripening (48, 32 and 50 h, respectively) than other treated fruits as compared with the non-treated fruits. The fruits ripened with ethephon have more acceptable color than naturally ripened fruits and have longer shelf life than fruits ripened with calcium carbide (Rahman *et al.*, 2008; Medlicott *et al.*, 1987). To evaluate the relevant health hazard it is critical to quantify the toxic concentration within the chemically ripened fruit-skin and flesh. In different studies, sample fruits are collected from local market rinsed in water and analyzed rinsed water to identify the presence of ripening agent(s) on the fruit skin; this process of testing may not confirm or quantify the presence of chemicals within fruit-flesh (Mursalat *et al.*, 2013). There are few studies reported the presence of chemicals within fruit-flesh and have addressed the changes of biochemical and nutritional properties of fruits because of treating with fruit ripening agents (Siddiqui and Dhua, 2010; Hakim *et al.*, 2012). The nutrition values like the protein content, vitamin-C and beta-carotene decrease in artificially ripened pineapples and bananas. Chemically ripened pineapples and bananas have higher sugar content than non-treated samples; other fruit nutrition values like Vitamin C and b-carotene are higher in naturally ripened fruits (Hakim *et al.*, 2012). Chemicals and hormones are also being used in harvested crops at the time of marketing. Most of these chemicals are harmful for human health. By using excess chemical fertilizers, the chemical composition of harvested crops may change. However, the banana wholesalers

use ripening agents like Promote, Ripen-15, Tomtom, Ethrel, Ethophen etc. Some of them used heat for ripening banana and some of them do nothing for ripening. Three fourth (74%) of the banana wholesalers used different types of ripening agent for quick ripening of banana. The wholesalers often drop the banana in the liquid mixture of ripening agents like calcium carbide for quick ripening and attractive color. Besides using ripening agents, they drop the banana again in the formalin to protect from rotting. More than half (52%) of the banana wholesalers were the high users of ripening agent compared to 9% and 13% as low and medium users respectively. Only one-fourth (26%) of the banana wholesalers did not use any ripening agent for quick ripening of banana. Based on descending order of obtained total effect score of using ripening agents for banana marketing, decrease in banana shelf-life ranked first followed by degradation in food taste, increase in human diseases and increase in food toxicity and degradation in food value (Bhuiyan *et al.*, 2009). For many years, ethylene had been used as a fruit-ripening agent. Nowadays calcium carbide is getting popular, as it has a faster ripening property. However, inappropriate use of calcium carbide to ripen fruits is associated with many health hazards. Fruits ripened with calcium carbide are soft and have good peel color development but poor in flavor. Calcium carbide not only changes the skin color of the fruits but it also initiates the enzymatic action that breaks down the glucose resulting in a quick ripening of the fruits. Use of calcium carbide sometimes gives ripening color to an immature fruit. It also increases the shelf life and maintains the ripened color (Rahman *et al.*, 2008). The optimum dose of calcium carbide required to induce ripening of mangoes to achieve overall acceptability was found to be 1g/kg fruit. At this level of calcium carbide, there was no difference in the total soluble solids content, titratable acidity and taste between artificially and naturally ripened fruits (Amarakoon *et al.* 1999). Mango fruits ripen unevenly on the tree and natural ripening can be very slow and unpredictable. Hence, to overcome these problems certain chemicals are used to ripen the fruits artificially. Fruits are briefly exposed to ethylene or similar gases like acetylene to initiate the ripening process. Ethylene is known to be a plant hormone that triggers fruit ripening. It has been reported that if ethylene is applied exogenously it helps fruit ripening (Medlicott, 1988). Ethepon is known as another most common ethylene-generating chemical for post-harvest treatment. Ethepon accelerates ripening and improves the peel color of the mangoes (Lakshminarayana *et al.*, 1975). Use

of edible coating like Chitosan, Aloe Vera gel, non-chemical ripening processes, non-chemical process of extending shelf life of different fruits has also been suggested. Consumers must be aware of the use of toxic chemicals in fruits (Rahim, 2012).

Health hazards

Human exposure to chemicals at toxic levels, as well as nutritional imbalances, are known or suspected to be involved in causing cancer, cardiovascular disease, kidney and liver dysfunction, hormonal imbalance, reproductive disorders, birth defects, premature births, immune system suppression, musculoskeletal disease, impeded nervous and sensory system development, mental health problems, urogenital disease, old-age dementia, and learning disabilities. Among these disorders and diseases some might be attributed due to exposure of human body with harmful chemicals used in food items. Consequently, the protection of our diet from these hazards must be considered one of the essential public health functions of any country (WHO, 2009). Most of the ripening agents are toxic and their consumption can cause serious health problems, such as heart disease, skin disease, lung failure and kidney failure. Scientists have also reported that regular consumption of artificial ripened fruits may cause dizziness, weakness, skin ulcer and heart related diseases (Jayan, 2011; Hakim *et al.*, 2012). Calcium carbide is alkaline in nature and irritates the mucosal tissue in the abdominal region. Cases of stomach upset after eating carbide ripened mangoes has been reported recently (Siddiqui and Dhua, 2010). Calcium carbide has cancer-causing properties and causing neurological disorders. It can result in tingling sensation and peripheral neuropathy. A significant number of pregnant women consumed fruit ripened with carbide, the children born with abnormalities (Rahim, 2012). Consumption of carbide-ripened fruits is extremely hazardous for health, mainly for the nervous system. Acetylene, generated from carbide reduces oxygen supply to the brain. In 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. Immediately after consumption, there may be abdominal pain, vomiting and diarrhea. Other toxic effects include skin burn, allergy, jaundice and carcinogenic potential (Fattah and Ali, 2010).

Responsible organizations and rules in Bangladesh

Bangladesh pure food (Amendment) Act, 2005 prohibits use of any poisonous chemical like calcium carbide, formalin, pesticides or toxic color and flavor

in any food that may cause harm to human body. The Bangladesh high court recently issued some directives to the government to stop this practice and some administrative drives are also been taken. Despite this legal prohibition, chemically treated fruits are selling openly in all markets. However, in recent times consumption of fruits became extremely hazardous due to artificial ripening of fruits by different toxic chemical agents (Fattah and Ali, 2010). The constitution of Bangladesh also gives importance to food safety. Article 15 of the Bangladesh Constitution states 'it is a fundamental responsibility of the state to secure provision of the basic necessities of life including food'. Article 18 of the constitution states, 'State shall raise the level of nutrition and improve public health as its primary duties' (GoB, 1972). In Bangladesh, the agencies and organizations responsible ensuring the proper practice of inspecting, examining and controlling harvesting, ripening and marketing fruits are: BSTI (Bangladesh Standard and Testing Institute), Bangladesh Ministry of Agriculture, Customs, Mobile court, Ministry of health, Ministry of Information and Communication Technology etc. These agencies implement the laws and acts in order to maintain the quality of the home grown and imported fruits. Laws and acts are: Pesticide law 2007, Pure food rules and act 1967 and 2005, Quarantine rules 1968, Mobil court act 2009, and Penal code 1860 (FAO, 2010). The above laws and acts prohibit using any chemicals to ripen fruits and penalize any person who is mixing, selling and/or using illegally ripened fruits. Artificial fruit ripening is a complex issue especially in developing countries like Bangladesh and requires the combined involvement of the government agencies, policymakers, fruit-sellers, farmers, scientists and consumers for an effective solution to this matter. Instead of generalizing the issue, it is important to assess different aspects of artificial fruit ripening, investigate standard practices and carry out extensive scientific studies to improve the situation (Mursalat *et al.*, 2013). To overcome the situation a laboratory in the name of 'The National Food Safety Laboratory' has been installed in October 2012 at the Institute of Public Health in Dhaka of Bangladesh. The European Union and Netherlands financed the laboratory and has been built on FAO's technical assistance. Despite legislation and enforcement initiatives, high uses of calcium carbide, formalin and other chemicals in the food are increasing threatening the life and health of the Bangladeshi people (Siddiqui and Dhua, 2010).

Conclusion

Different methods of artificial fruit ripening are

in practice mostly to meet consumers' demand and other economic factors. Artificial ripening accelerates ripening, but affects the nutritional quality of the fruits. Consumption of fruits becomes a risk due to artificial ripening by different toxic chemicals. Some developed countries allow artificial ripening of fruits after harvest with selective chemicals at recommended doses. Bangladesh pure food (Amendment) Act, 2005 and Formalin Control Act, 2015 prohibits the use of any poisonous chemical like calcium carbide, formalin, pesticides, toxic color and flavor in any food that may cause harm to human body. Despite legal prohibition, some unscrupulous traders' trade chemically treated fruits in markets all over Bangladesh. Most of these chemicals are harmful to human body. It is imperative that the government, health authorities and law enforcing agencies of the country should pay more attention to control illegal use of calcium carbide and other chemicals. Consumers should pay attention whether the fruits are naturally ripened. Fruits should be thoroughly washed before consumption under running water for a few minutes. Peel off the fruits before consumption is safer to avoid the risk of contamination. Edible non-chemical substances may be allowed for extending shelf life of fruits. To facilitate the in time transportation and distribution of perishable fruits of growers and traders, appropriate authorities should establish storage and transport facilities wherever necessary. Conventional ripening techniques like heat, light, smoke and use of recommended ripening agents with appropriate dose may be practiced. Finally, massive awareness generating campaign against the use of chemicals in fruits is necessary.

Acknowledgement

The authors thanks to Dr. N. M. Talukder, former Professor, Department of Agricultural Chemistry, Bangladesh Agricultural University, Mymensingh, Bangladesh for his valuable suggestions and cordial cooperation.

References

- Ajaji, A.R. and Mbah, G.O. 2007. Identification of indigenous ripening technologies of banana and plantain fruits among women-marketers in Southeastern Nigeria. *Journal of Agriculture Food Environment and Extension* 6(2): 60-66.
- Amarakoon, R., Illeperuma, D.C.K. and Sarananda, K.H. 1999. Effect of calcium carbide treatment on ripening and quality of Velleicolomban and Willard mangoes. *Tropical Agricultural Research* 11: 54-60.
- Bhuiyan, M.H., Ali, M.S. and Molla M.M. 2009. Effects

- of using chemicals and hormones for cultivation and marketing of vegetables and banana. Final Report CF # 14/07. National Food Policy Capacity Strengthening Programme. USAID.
- Bouzayen, M., Latché A., Nath, P. and, Pech J.C. 2010. Mechanism of fruit ripening: In plant developmental biology–biotechnological perspectives, E.C. Pua and M.R. Davey, Editors. Springer.
- Brady, C.J.1987. Fruit ripening. Annual Review of Plant Physiology and Plant Molecular Biology 38: 155-178.
- Chadha, K. L.1989. Current situation and future prospects of production of minor fruits in the Asia-Pacific region. Regional Expert Consultation on Fruits held at Bangkok, Thailand from 13-16 June.
- FAO. 2010. Review of Food Safety and Quality Related Policies in Bangladesh. Food and Agriculture Organization of the United Nations: Dhaka, Bangladesh. p. 1-28.
- Fattah, S.A. and Ali, M.Y. 2010. Carbide Ripened Fruits-A Recent Health Hazard. Faridpur Medical College Journal 5(2): 37.
- GoB.1972. Government of Bangladesh. The Constitution of the People's Republic of Bangladesh. Part II: Fundamental Principles of State Policy.
- Hakim, M.A. Hakim, M.A., Obidul Huq, A.K., Alam, M.A., Khatib, A., Saha, B.K., Haque, K.M.F and Zaidul, I.S.M. 2012. Role of health hazardous ethephon in nutritive values of selected pineapple, banana and tomato. Journal Food Agriculture and Environment 10(2): 247-251.
- Hasib, N.I.2014. UN-FAO backed lab finds chemicals in Bangladeshi food. *bdnews24.com* (Published: 2014-04-16 22:09:44.0 BdST, Updated: 2014-04-17 00:01:13.0 BdST).
- Haque, M.N., Saha, B.K., Karim, M.R. and Bhuiyan, M.N.H. 2009. Evaluation of nutritional and physico-chemical properties of several selected fruits in Bangladesh. Bangladesh Journal Scientific and Industrial Research 44(3): 353-358.
- Hoque, M.A. 2012. Action against unscrupulous fruit ripeners, financial express. International Publications Limited. Dhaka, Bangladesh.
- Islam, G.M.R. and Hoque, M.M. 2013. Food safety regulation in Bangladesh, chemical hazard and some perception to overcome the dilemma. International Food Research Journal 20(1): 47-58.
- Jayan, T.V. 2011. Beware of these fruits. The Telegraph, Calcutta, India.
- Kendrick, M. 2009. The origin of fruit ripening, in Scientific American TM. Nature America, Inc.: New York.
- Lakshminarayana, S., Shetty, S. and Krishnaprasad. C.A. 1975. Accelerated ripening of Alphonso mangoes by the application of ethrel. Tropical Science 17: 95-101.
- Medlicott, A.P., Reynolds, S.B., New, S.W. and Thompson, A.K. 1988. Harvest maturity effects on mango fruit ripening. Tropical Agriculture 65: 153-157.
- Medlicott, A. P., Sigrist, J. M., Reynolds, S. B. and Thompson, K. 1987. Effects of ethylene and acetylene on Mango fruit ripening. Annals of Applied Biology 111: 439-444.
- Meulenaer, B.D. 2006. 'Safety in the agro-food chain', Lunning, P.A., Devlieghere, F., Verhe, R. (Eds.), Wageningen Academic Publishers, Wageningen, The Netherlands.
- Mursalat, M., Rony, A.H., Rahman, A.H.M.S., Islam, M.N., Khan, M.S. 2013. A critical analysis of artificial fruit ripening: Scientific, Legislative and Socio-Economic Aspects. CHE THOUGHTS-Chemical Engineering and Science Magazine 4(1): 6-12.
- Orisakwe, O.E., Nduka, J.K., Amadi, C.N., Dike, D.O. and Bede, O. 2012. Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern Nigeria. Chemistry Central 6(77): 1-7.
- Rahim, M.A. 2012. Indiscriminate use of chemical in fruits and their health effects. In proceedings of First AFSSA Conference on Food Safety and Food Security held at Osaka Prefecture University, Osaka, Japan, p. 17-25.
- Rahman, A.U., Chowdhury, F. R. and Alam, M. B. 2008. Artificial ripening: what we are eating. Journal of Medicine 9: 42-44.
- Siddiqui, M.W. and Dhua, R.S. 2010. Eating Artificial Ripened Fruits is Harmful. Current Science 99(12): 1664-1668.
- Singal, S., Kumud, M. and Thakral, S. 2012. Application of apple as ripening agent for banana. Indian Journal of Natural Products and Resources 3(1): 61-64.
- Sogo-Temi, C.M., Idowu, O.A. and Idowu, E. 2014. Effect of biological and chemical ripening agents on the nutritional and metal composition of Banana (*Musa spp*). Journal of Applied Science and Environment Management 18(2): 243-246.
- WHO, 2009. Food safety. General information related to chemical risks in food.
- WHO. 2003. Diet, nutrition and the prevention of chronic diseases. Report of a joint FAO/WHO. Expert Consultation. WHO Technical Report Series 916. Geneva. World Health Organization.
- Zewter, A., Woldetsadik, K. and Workneh, T.S. 2012. Effect of 1-methylcyclopropene, potassium permanganate and packing on quality of banana. African Journal of Agricultural Research 7(16): 2425-2437.