



INTERNATIONAL JOURNAL OF SCIENCE FOR GLOBAL SUSTAINABILITY
**Fungi Species Associated with Spoilage of Some Edible Fruits Sold in
 Kebbi State, Nigeria**

^{*1}Keta, J.N., ²Shinkafi, S.A., ¹Aminu, M., ³Keta, M.N. ¹Abubakar, M., ¹Gudu, G.J. and ¹Patrick, R.J.

^{*1}Department of Plant Science and Biotechnology, Kebbi State University of Science and Technology Aliero,
 Kebbi State, Nigeria

²Department of Biological Science, Federal University, Gusau

³Department of Microbiology, Kebbi State University of Science and Technology, Aliero, Kebbi State, Nigeria

Corresponding Authors Email Address: Ketajb66@gmail.com

Received on: March, 2020

Revised and Accepted on: June 2020

Published on: July 2020

ABSTRACT

Spoilage of orange, mango and banana fruits sold in Aliero Local Government Area, Kebbi State, Nigeria, was conducted using random sampling methods and fungi were identify using standard chart. The spoilt samples of Orange (*Citrus sinensis*), Mango (*Mangifera indica*) and Banana (*Musa sapientum*) were collected within Aliero L.G.A and cut into pieces with a sterile razor blade. A total of Seventy-five (75) spoilt fruits were obtained and Potatoes Dextrose Agar (PDA) was used as media. From the results obtained, five fungal contaminants were found to be associated with orange fruits where *Aspergillus niger* had the highest frequency of occurrence (33.33 %,) while *Rhizofers stolonifer* and *Aspergillus flavus* were recorded with lowest percentage (11.11%). With respect to mango, *Aspergillus niger* also had the highest frequency of occurrence (25 %,) while *Penicillium notatum* had the lowest (8.33%). Four fungal isolates were found to be associated with contamination of banana fruits with *Aspergillus fumigatus* having highest percentage of occurrence (40%) while *Mucor heimalts* had the lowest (10%). Based on these findings, it was observed that perishable food such as orange, mango and banana are susceptible to spoilage by fungi probably because the spores of these organisms are easily transmitted via the air, during transportation, handling and preservations of this product which could lead to spoilage of these fruits. Therefore, care should be taken during handling and transportation of these fruits and improved technology based preservation methods are suggested to increase the shelf life of the fruits.

Keywords: Fungi, fruits, spoilage, Edible, Aliero.

1.0 INTRODUCTION

Fruits are the comestible part of mature ovary of flowering plants which are normally eaten raw and they include many structures that are not commonly called fruits such as bean pods, corn kernels, tomatoes, and wheat grains (Ikhiwili, 2012). The importance of fruit in human nutrition cannot be overestimated as it provides essential growth factors such as vitamins and minerals necessary for proper body metabolism (Al-Hindi *et al.*, 2011). Humans and many animals have become dependent on fruits as a source of food (Lewis, 2011). Fruits and vegetables generally give the body every necessary vitamin, fats, minerals and oil in the right proportion to maintain growth and development on humans (Amusa *et al.*, 2002). However, they have serious challenges to their existence and these include changes in climatic conditions, pests, inadequate rainfall and fungal attack (Amusa *et al.*, 2002).

Over the years, there has been an increase in the need to identify and isolate the fungi associated with their spoilage, which refers to any change in the condition of food in which the food becomes less palatable, or even toxic, these changes may be accompanied by alteration in taste, smell, appearance or texture (Singh and Sharma, 2007). The high concentration of various sugars, minerals, vitamins, amino acids, and low pH enhance the successful growth and survival of various parasitic and saprophytic forms of fungi on the fruits (Droby, 2006).

Mango (*Mangifera indica* L.) a member of the Anacardiaceae family known as “Mangwaro” by Hausa speaking, is an evergreen tree reaching up to a height of about 15-30 meters with trunk girth 4 meters and heavy branched from a stout trunk. *Citrus sinensis* known as “Lemon zake” in Hausa

belong to the family of Rutaceae, is an evergreen flowering tree with height of 9-10m generally (although very old specimens have reached 15m), leaves 4-10cm long arranged alternately, ovate in shape with crenulated margins with thin smooth, gray brown to greenish bark, single-trunked and hard wood. Canopy with range slender to broad. Fruit is a hesperidium type of berry that range widely in size, color, shape and juice quality which is globose to ovoid in shape. *Musa sapientum* is a large, herbaceous monocots belong to the family Musaceae called “*Ayaba*” in Hausa that are 6 to 15 ft tall, may reach up to 25 ft in some. The pseudostem is not a true stem but only clustered, cylindrical aggregation of leaf stalk bases. Leaves are among the largest of plants, becoming up to 9ft long and 2 ft wide (Pillay and Tripathi, 2007).

Annual reports have shown that 20% - 25% of fruits produced are lost to spoilage (Barth *et al.*, 2009; Thiyam and Sharma, 2013), especially during post-harvest stages (Singh and Sharma, 2007). This has been associated with spoilage fungi which can be toxigenic or pathogenic (Zhu, 2006). Toxin-producing fungi have been identified and isolated from spoiled fruits by previous researchers (Al-Hindi *et al.*, 2011). Postharvest losses and decay of the fruits can be traced to infections that occur either between flowering and fruit maturity or during harvesting and subsequent handling and storage activities (Singh and Sharma, 2007).

Despite these damages, little information is available with respect to the fungal pathogens affecting fruits in Aliero. Therefore, there is need to put efforts towards the production of these fruits by identifying these fungal pathogens causing the fruits spoilage so as to enhance their production in the area. Data from this study will provide baseline information on fungi species affecting the fruits and it will serve as a tool in optimizing fruits yields and production in Aliero Local Government area and Kebbi State entirely.

2.0 MATERIALS AND METHODS

2.1 Study Area

Aliero local government area is located at approximately latitudes 11° 03' S, 12° 47' N and longitudes 3° 6' W and 4° 27' E in Kebbi state, north western part of Nigeria. It has a total area of 412 square kilometers and is bordered in the east by Tambuwal Local government area of Sokoto State, in the North West by Birnin Kebbi local government

area and in the South West by Jega Local Government area (Singh and Abubakar, 2013). It typically has a flat but undulating elevation of about 150m in the flood plains. The alluvial sediment in the flood plains ranges from gravel level to clay level. The area enjoys a tropical climatic condition, generally characterize by wet and dry season. The rainfall begins in April with the heaviest rainfall recorded in the month of July and August. The cold harmattan periods characterized by dust laden wind prevails in the month of November to January while the month of February and March are extremely hot. The mean annual temperature varies considerably but usually stand at 42°C while the mean annual rainfall is 500mm (Singh, 2013).

2.2 Field Sampling and Sample Collection

Fruits were collected within Aliero Local Government Area. Fruits collected include orange, mango and banana, five (5) spoiled fruits each from the five locations were collected which making a total of 75 fruit samples collected. The symptoms were carefully noted; completely rotten fruits were avoided for isolation as they contained mostly secondary pathogens. The collected fruits were taken to microbiology laboratory, Kebbi State University, Kebbi for further analysis.

2.3 Sterilization of Glass Wares

All the glass wares were first washed with tap water and detergent solution. They were then rinsed with distilled water and air dried. The glass petri-dishes were wrapped with aluminum foil and autoclaved at 160°C for one hour (1hr). They were allowed to drop for 30 minutes before usage to avoid cracking.

2.4 Sample Preparation and Inoculation

The contaminated portions of the samples were cut into pieces each with sterilized razor blade, sterilized in 1% sodium hypochlorite solution for 2 minutes and then placed gently on Potato Dextrose Agar plate (PDA) using spread technique as described by Dimpka and Onugba (2010), Akintobi *et al.* (2011) and Kutama *et al.* (2012).

2.5 Media Preparation

All the media used were weighed, prepared and sterilized according to the manufacturer's instruction.

2.6 Incubation of the Inoculated Plates

The inoculated plates were incubated at room

temperature for 5-7 days under light to enhance fungal growth and sporulation (Sani *et al.*, 2018).

2.7 Purification of the Fungal Isolates

After the appearance of a mixed growth, each spore was sub-cultured in a fresh Potato Dextrose Agar in order to obtain a pure culture using streak method as described by Cheesbrough (2002).

2.8 Identification of the Isolates

The fungal isolates were subjected to certain comparative morphological studies by an image and analysis system using published descriptions in a mycological atlas contained in the Microbiology Laboratory of Department of Biological Sciences, Kebbi State University. This was followed by a slide mount of each isolate. The characteristics observed were matched with those available in the aforementioned mycological atlas. They were then identified accordingly (Ricciardi *et al.*, 2012)

2.9 Determination of Percentage Occurrence of the Isolates

This was done to determine the percentage occurrence of the different fungal isolates. The number of occurrence for each of the isolates were recorded and calculated as a ratio of the total number of occurrence and was then expressed using standard percentage formulae.

Percentage Frequency =

$$\frac{\text{Number of Isolated Fungi}}{\text{Total number of Isolates}} \times 100$$

3.0 RESULTS

3.1 Morphological Characteristics of fungal isolates from selected fruit samples

The fungal contaminants associated with the spoilage of orange, mango and banana fruits were identified based on colony appearance, morphology and cellular characteristics as seen in (Table 1). The isolates include *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Rhizopus stolonifer*, *Penicillium notatum*, *Alternaria alternata* and *Mucor hiemalts*.

3.2 Fungal Contaminants Associated with Spoilage of Orange in Aliero Metropolis

The frequency of occurrence of the fungal isolates associated with orange were presented in (Table 2), where *Aspergillus niger* had the highest percentage (33.33%) while *Aspergillus flavus* and *Rhizopus stolonifer* obtained with the lowest (11.11%) respectively.

3.3 Frequency of Occurrence of Identified Fungal Isolates from Spoilt Mango Fruit.

Table 3 shows the frequency of occurrence of the fungi isolates from the spoiled mango fruits where *Aspergillus niger* had the highest percentage (25%) with *Penicillium notatum* being the lowest (8.33%).

3.4 Frequency of Occurrence of Identified Fungal Isolates from Spoilt Banana Fruit

The results in Table 4 showed the fungal species identified from the banana fruits. *Aspergillus fumigatus* has the highest percentage of occurrence of 40% followed by *Aspergillus niger* (30%) while *Mucor hiemalts* was recorded with lowest (10%)

Table 1: Morphological Characteristics of Fungal Isolated from Selected Fruit Samples

Fungal isolate	Macroscopic Features	Microscopic Examination
<i>Aspergillus niger</i>	Black colour with white edges	Large conidial heads, dark brown becoming radiate and split to columns
<i>Aspergillus flavus</i> .	Dark colony The conidia were black in colour. The hyphae were well developed, profusely branched, septate and hyaline. Flat and smooth conidia are borne in chains at the tips of sterigmata	It has ball head, two hyphae with ball heads. Presence of conidiophores with a lot of spores.
<i>Aspergillus fumigates</i>	Yellowish green colony. The conidia were green in colour. The hyphae were well developed, profusely branched, septate and hyaline flat and smooth conidia are borne in chains at the tips of sterigmata.	Spores are scattered, cytoplasm is coiled and has strands. Cell wall is thin
<i>Rhizopus stolonifer</i>	Whitish becoming brown-black	Non-septate mycelia with branching sporangiospheres
<i>Penicillium notatum</i>	Dark green colony. The culture was green diamond in colour and sparkling as it	The conidia are globe-like and resemble glass beads under the microscope. The

	matured	hyphae appeared branching and septate conidiophores were erect, septate and faint
<i>Aspergillus alternate</i>	Colony on MEA at 25c attaining a diameter of 6cm in 7 days, black or olivaceous-black or grayish	Conidiospores 1-3 septate, simple or sometimes branched, straight or flexuous or sometimes geniculate, with one or several apical spores, medium brown, smooth walled
<i>Mucor hiemalts</i>	Grey colony becoming brownish	Non-septate mycelia with branches sporangiospheres

Table 2: Fungal Contaminants Associated with Spoilage of Orange in Aliero Metropolis

Identified fungal isolate	Number of isolates	Frequency of occurrence (%)
<i>Aspergillus niger</i>	3	33.33
<i>Aspergillus flavus</i>	2	22.22
<i>Rhizopus stolonifer</i>	1	11.11
<i>Aspergillus fumigates</i>	1	11.11
<i>Penicillium notatum</i>	2	22.22
Total	9	100

Table 3: Frequency of Occurrence of Identified Fungal Isolates from Spoilt Mango Fruits

Identified fungal isolate	Number of isolates	Frequency of occurrence (%)
<i>Aspergillus niger</i>	3	25
<i>Aspergillus flavus</i>	2	16.67
<i>Rhizopus stolonifer</i>	2	16.67
<i>Aspergillus fumigates</i>	2	16.67
<i>Penicillium notatum</i>	1	8.33
<i>Alternaria alternate</i>	2	16.67
Total	12	100

Table 4: Frequency of Occurrence of Identified Fungal Isolates from Spoilt Banana Fruits

Fungal isolates	Number of isolates	Frequency of occurrence (%)
<i>Aspergillus fumigates</i>	4	40.00
<i>Mucor hiemalts</i>	1	10.00
<i>Aspergillus niger</i>	3	30.00
<i>Rhizopus stolonifer</i>	2	20.00
Total	10	100

4.0 DISCUSSION

Fruits or vegetables are important farm produce that can get infected by pathogenic microorganisms particularly fungi at the point of harvest, during handling, processing, storage or at point of sale (Sani *et al.*, 2018). This has caused serious economic impact on the farmers, consumers and the society at large. The findings of this study showed that several fungi at different frequency of occurrences were found to be associated with contamination of mango, orange and banana fruits commonly sold in Aliero metropolis. The most heavily infested of this selected fruit was mango with six (6) species of the isolates. The higher number could probably be due to mechanical injuries such as cuts that occur during harvesting, transportation, post harvesting or storage periods

which could provide infection sites for spoilage fungi, improper handling and lack of good storage facilities, ability of the fungi to produce spores and their ubiquitous nature, environmental conditions such as temperature and relative humidity (Baiyewu *et al.*, 2007). This may serve as the source of various fungal pathogens responsible for postharvest diseases of various other fruits. The distribution of these fungi from the selected fruits showed that genera *Aspergillus fumigatus*, constituted the most frequently (40%) isolated fungi followed by *Aspergillus niger* (33.33%) while *penicillium notatum* (8.33%) was the least isolated species from all the samples. These agreed with the reported by Akintobi *et al.*, (2011) who reported that *Aspergillus flavus*, *Aspergillus niger*, *Aspergillus fumigatus*, *Penicillium notatum* and *Rhizopus stolonifer* were

found in fruits sold in major markets in Ibadan, Oyo State, South Western Nigeria. It's also in line with the results obtained by Sani *et al.* (2018) from Jigawa State, Nigeria where five species of fungi were identified as the contaminants of vegetables with *Aspergillus niger*, having the highest percentage of occurrence (55.55%).

Rotten fruits were similarly reported (Senjuti *et al.*, 2014; Jediti *et al.*, 2014; Oranusi *et al.*, 2011) to be host to *Aspergillus* species. Similarly previous reports by Miller, (2008), Beckacem *et al.* (2013) and Mailafiya *et al.* (2017) found *Aspergillus niger* as the dominant fungal isolates in tomato, orange, onions and other spoiled fruits in Nigeria. However, several workers including Nathalie (2006), Tomassini *et al.* (2009) and Hidayatte *et al.* (2007) had implicated other fungal species in earlier reports, to be responsible for postharvest diseases of mango associated with fruit rotting during ripening worldwide.

The presence of these six different genera fungal species identified in the selected fruits obtained from Aliero market had provided an impetus upon the dangers associated with the consumption of such fruits without proper washing. More so, these fungal pathogens impart severe losses of marketable quality and posed threat to public health resulting in major economic problem in Nigeria. The species isolated in this study were previously identified in different fruits obtained in Nigeria by Mbajiuka *et al.* (1999), Amadi and Oso (2000), Oyetunji *et al.* (2012), Amadi *et al.* (2014) and Ezikanyi (2016). These fruits might likely be contaminated via infestation in the field prior to harvest, handling during harvesting and methods of packaging and distribution of produce to the market as stressed by Amadi *et al.* (2014).

The occurrence of these organisms may be attributed to their ability to produce resistant spores, as reported by Hocking (2006) that *Aspergillus* generally grow at higher temperatures or lower water activities than *Penicillium* and they usually grow more rapidly than *Penicillium*, although they take longer to sporulate, and produce spores which often are more resistant to light and chemicals

(Hocking, 2006). This is also in line with some of these pathogens which have been reportedly isolated from sweet range fruits in Nigeria (Chukwuka *et al.*, 2010).

Colonization of fruits and vegetable by the invading microorganism is a critical phase in the microbial spoilage of produce. Also, the prevalence of fungi as the spoilage organisms of fruits and vegetables is due to a wide range of factors which are encountered at each stage of handling from pre-harvest to consumption and is related to the physiological and physical condition of the produce as well as the extrinsic parameters to which they are exposed (Efiuvevewwere, 2000). The smallest injury to the fruits can lead to post-harvest rots of fruits especially due to growth of postharvest mycoflora. It is very difficult to restrict the rot of injured fruits. Transportation of unpacked fruits causes about 60% loss of fruits due to skin injuries observed in mango fruits, (Amin *et al.*, 2008). Some of the fungi isolated from this research have been reported to produce secondary metabolites which are potentially harmful to humans and other animals (Baiyewu *et al.*, 2007).

5.0 CONCLUSION

The results in this study revealed that, some selected fruits sold in Aliero markets were found to be contaminated with different species of fungi which are responsible for their spoilage. The research also revealed that mango, orange and banana had the highest contamination from *A. niger* and *A. fumigates* with 33.33%, 25% and 40% respectively. This spoilage inferred a great loss to the retailers and imposed clinical threat to the consumers via severe food poisoning.

6.0 RECOMMENDATIONS

Since these fruits are contaminated easily by the activity of fungal pathogens, there is need to educate the growers, consumers and sellers to store these produce properly in clean, cool and dry environment with less humidity as failure to do this, paves way for fungal pathogens. Also damaged ones should be removed immediately to avoid further infection of the healthy ones. Washing these fruits thoroughly before consumption is also recommended to avoid infection.

REFERENCES

- Akintobi, A.O., Okonko, I.O., Agunbiade S.O., Akano, O.R. and Onianwa, O. (2011). Isolation and Identification of Fungi Associated with The Spoilage of Some Selected Fruits In Ibadan, South Western Nigeria. *African Journal of Biotechnology*, 3(11):110-114
- Al-Hindi, R.R., Al-Najada, A.R. and Mohamed S.A. (2011). Isolation and identification of some fruit spoilage fungi: Screening of plant cell wall degrading enzymes. *African Journal of Microbiology Research*: 5(4):443-448
- Amadi, J.E., Adebola, M.O. and Eze, C.S. (2014). Isolation and Identification of a Bacterial blotch Organism from Watermelon (*Citrullus lanatus* (Thunb.) Matsum. and Nakai). *African Journal of Agriculture Research*, 4(11): 1291- 1294.
- Amin, M.H.A., Rahaman, M.S. and Azad, M.O.K. (2008). Effect of initial moisture content and different storage container on the quality of grass pea (*Lathyrus sativa*) seed. *International Journal on Sustainable Crop Production*, 3 (3): 18-24
- Amusa, N.A., Kehinde, I.A. and Ashaye, O.A. (2002). Biodeterioration of breadfruit in storage and its effects on the nutrient composition. *African journal of biotechnology*, 1(2): 57-60.
- Baiyewu, R.A., Amusa, N.A., Ayoola O.A. and Babalola, O.O. (2007). Survey of the post-harvest diseases and aflatoxin contamination of marketed Pawpaw fruit (*Carica papaya* L) in South Western Nigeria. *African Journal of Agricultural Research*; 2(4): 178-181.
- Barth, M., Hankinson, T. R., Zhuang, H. and Breidt, F. (2009). *Microbiologica Spoilage of Fruits and Vegetables*. W. H. Sperber, M. P. Doyle (eds.), *Compendium of the Microbiological Spoilage of Foods and beverages, food Microbiology and Food Safety*. C Springer Science Business Media, LLC, Pp 135-183.
- Belkacem-Hanfi, N., Semmar, N., Perraud-Gaime, I., Guesmi, A., Cherni, M., Cherif, I., Boudabous, A. and Roussos, S. (2013). Spatio-temporal analysis of post-harvest moulds genera distribution on stored durum wheat cultivated in Tunisia. *Journal of Stored Product Reserve*, 55:116-123.
- Cheesbrough, M. (2002). *District Laboratory Practice in Tropical Countries part 2*, Cambridge press. Cambridge. Pp. 47-54
- Chukwuka, K.S., Okonko, I. O. and Adekunle, A.A. (2010). Microbial Ecology of Organisms Causing pawpaw (*Carica papaya* L.) Fruit Decay in Oyo State, Nigeria. *American Eurasian, Journal of Toxicological Sciences*, 2(1): 43-50.
- Dimkpa S.O.N. and Onuegbu, B.A. (2010). Mycoflora of copra and effect of brining on some properties of copra in Nigeria. *Agriculture and Biology Journal of North America*, Vol. 1(3) Pp 391-394
- Droby, S. (2006). Improving quality and safety of fresh fruits and vegetables after harvest by the use of biocontrol agents and natural materials. *Acta Journal of Horticulture*, 709: 45-51.
- Efiuvwevwere, B.J.O. (2000). *Microbial spoilage agents of tomato and assorted fruits and vegetable (An illustrated references book)*. Paragraphics of Lishing Company, Port Harcourt, Pp. 1 -39.
- Ezekiel, C.N. and Sombie, J.I. (2014), Survey of aflatoxins and fungi in some commercial breakfast cereals and pastas retailed in Ogun State, Nigeria. *Journal of Natural Science*, 6: 27-32.
- Hedayati, M.T., Pasqualotto, A.C., Warn, P.A., Bowyer P. and Denning, D.W. (2007). *Aspergillus flavus: human pathogen, allergen and mycotoxin producer*. *Pulm. Med*, 153(Pt 6):1677-92
- Ikhiwili, O.M. (2012). *Isolation and Characterization of Microorganisms Associated with Rot Diseases of Fruit, Stem and Leaf of Carica papaya L. A Project Report Submitted to the Department of Biological Sciences, College of Science and Technology, Covenant University, Canaan and, Ota, Ogun state, Nigeria*. Pp. 5-6.
- Jeddi, M.Z., Yunesian, M., Gorji, M.E., Noori, N., Pourmand, M.R. and Khaniki, G.R.J. (2014). Microbial Evaluation of Fresh, Minimally-processed Vegetables and Bagged Sprouts from Chain Supermarkets. *Journal of Health Population Nutrition*, 32(3)
- Kutama A.S., Bashir, M. and Mani, M.A. (2012). Seed-borne mycoflora of local and improved wheat (*Triticum sativum* L.) cultivars in Kano, Nigeria. *Bayero Journal of Pure and Applied Sciences*, 5(2): Pp 101-103
- Lewis, R.A. (2011) *CRC Dictionary of Agricultural Sciences* CRC Press, Boca Raton, FL.
- Mailafia, S., Okoh G.R., Olabode, H.O.K. and Osanupin, R. (2017). Isolation and identification of fungi associated with spoilt fruits vended in Gwagwalada market, Abuja, Nigeria, *Veterinary World*, 10(4): 393-397
- Miller, J.D. (2008). Mycotoxins in small grains and maize: old problems, new challenges. *Food*

- Addition Contemn. 25: 219-230.
- Nathalie, J. (2006). Plant protein inhibitors of cell wall degrading enzymes. *Trends Plant Science*, 11: 359-367
- Oranusi, S. and Olorunfemi, O.J. (2011). Microbiological safety evaluation of street vended Ready-to-eat fruits sold in Ota, Ogun state, Nigeria. *International Journal of Research in Biological Sciences*, 1(3): 27-32
- Pillay, M. and Tripathi, L. (2007). Bananas chapter 15. C kole edited. *Genome mapping and molecular breeding in plants volume fruits and nutss*. Springer-verling. Berlin. Pp. 281-301
- Ricciardi, C., Castagna, R., Ferrante, I., Frascella, F. and Luigi-Marasso, S. (2012). Development of a microcantil ever-based immunosensing method for mycotoxins detection. *Journal of Biosensors and Bioelectronics*, 40: 233- 239.
- Sani, N.M., Salihu Y., Saidu. A.Y., Yusuf S., Nuhu, D.Z. and Rabiu, G.A. (2018). Isolation of fungi associated with spoilage, *Journal of pure and applied sciences*, 4(2): 349-350
- Singh, D. and Abubakar, A. (2013). Study of Weed flora of Kebbi State, Nigeria, West tropical Africa. *Life Science Bulletin*, 10(2): 329-333.
- Singh, D. and Sharma, R.R. (2007). Postharvest diseases of fruit and vegetables and their management. In: Prasad, D., editor. *Sustainable Pest Management*. Daya Publishing House, New Delhi, India.
- Senjuti, J.D., Feroz, F., Tahera, J., Das, K.K. and Noor, R. (2014). Assessment of Microbiological Contamination and the Invitro Demonstration of the Anti-bacterial Traits of the commonly Available Local Fruit Blend within Dhaka Metropolis. *Journal of Pharmacognosy and Phytochemistry*, 3(1): 73-77
- Thiyam, B. and Sharma, G.D. (2013). Isolation and identification of fungi associated with local fruits of Barak Valley, Assam. *Current World Environment*, 8(2): 319-322.
- Tomassini, A., Sella, L., Raiola, A., Vidio, R. and Favaron, F. (2009). Characterization and expression of *Fusarium graminearum* endo polygalacturonases in vitro and during wheat infection. *Plant Pathology*, 58: 556-564.
- Zhu, S.J. (2006). Non-chemical approaches to decay control in postharvest fruit. In: oureddine, B. and Norio, S., editors. *Advances in Postharvest Technologies for Horticultural Crops Research Signpost*, Trivandrum, India. Pp.297-313.