

POST-HARVEST SPOILAGE OF INDIAN BLACKBERRY AND CONTROL STRATEGIES

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Syzygium cumini (Indian blackberry) belongs to family *Myrtaceae*. It is also known as black plum, jamboo or jamun. Many years ago, it has been identified for its valuable properties for traditional medicine. There is a huge diversity in Indian flora. Chemical diversity shows one of the important vital factors that make natural products outstanding candidates for screening (Jamal, 2011). Black plum flowers and leaves contain about 0.7% of essential oil and due to its pharmacological properties it is used in the cosmetic and pharmaceutical industries. These chemical properties are due to presence of trans caryophyllene, germacrene D, L-dodecene, and spathulenol and spilanthol. Having these kinds of chemical properties, different plant species evoke the interest of pharmaceutical and cosmetic companies, which use them as raw materials for many products including cosmetic cream to relax micro-tension of facial skin, preventing wrinkles and smoothing. (Borges, 2015).

Syzygium cumini is good source of iron, vitamin C and other vital nutrients. It is also useful in making post-harvest products like jam, jelly, squash and powder from jamoon seeds, which have great medicinal properties for diabetic patients. Black plum fruits play key role in food industries; they can be used to produce excellent quality products such as vinegar, cider, squash and non-fermented ready to serve beverages. Jamun pulp has sharp and beautiful color due to presence of anthocyanin pigment, which is responsible for providing an attractive appearance to the beverages prepared from it. Indian blackberry fruits are also rich source of glucose and fructose which are the major sugars in the ripened fruit besides minerals which provide more calories compared to other fruits. The Jamun seed has good nutrition value like protein, carbohydrate, calcium, iron, vitamin C, folate, vitamin B, carotene, photochemicals (purple pigment anthocyanin), magnesium, potassium and fibre. Jamboline is a name of glucose present in jamun seeds; which converts starch into sugar in case of increased production of glucose that is responsible for high sugar level in human body (Sagar, 2019).

Indian black plum or jamun fruits are very short

lived. Approximated 20-30% of jamun fruits were lost in harvest and post-harvest time. If proper care is taken from harvesting to final marketing to main consumer, farmers will get profitable prices (Joshi, 2011). Another factor is transporting equipment used for harvesting such as sac, basins and baskets which can serve as major sources of transmission of the pathogens. Impure water used in washing the fruits maybe contaminated with huge number of microorganisms and that could be transferring them directly to the fruits due to the high sugar content. Also, it serves as a fertile ground for microbes especially fungi (Awoite, 2013). Handling and transport are main causes of spoiling fruits and vegetables. Air is also responsible for spoilage of fruits during their post-harvest period as it contains fungal spores (Holtmeyer and Wallin, 1981). Indian blackberry has excellent medicinal property. It is a herbaceous plant species presenting high moisture content and short shelf life, thus it requires long term prevention technology (Barбора, 2015).

Sample collection

Samples were collected from SGVP (Shree Swaminarayan Gurukul Vishwavidya Pratishthanam) near Nirma University Ahmedabad, on 24 June 2019. Total 100 samples were collected. SGVP is very big campus; where organic crops are grown by using organic fertilizer. After collecting fruits, they were washed and cleaned in abundant flow of clean water to remove plant debris, trash, latex and pathogen inoculum which are responsible for causing diseases in transit and them are dried.

Postharvest treatment

After drying, fruits are ready for some post-harvest treatments. Total ten treatments (Fig. 1) were given:

Hot water treatment: Hot water treatment is promising and has been used with success in removing or suppressing the development of fungi on the fruit surface as well as those situated just below the surface as a result of pre harvest infection.

Heated forced air treat/aerated steam/hot air: Forced air or hot air treatment has gained some importance in post-harvest treatments in some fruits and vegetables.

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Steam or hot air can reduce mycological infection.

Fruit coating with vegetable cooking oil: We can apply some edible oil on the surface of fruits and veggies and store them in air jar or container. It has been effective in reducing microbial infection.

Chilling treatment: In this technique, fruits and vegetables are placed in deep refrigerator. In chilled condition all activity (like ripening, pathogenic) will stop in present form.

Natural plant products: The study of some natural products like Neem (*Azadirachta indica*) of their antimicrobial activity has received little attention though such activity was known since ancient times (Rahul, 2015).

Some other plant extracts that also have been studied with a view to managing post-harvest losses of veggies include garlic (*Allium sativum*), ginger (*Zingiberofficinale*), turmeric (*Curcuma longa*). It has been used for eradicating the development of fungal growth (Chuku *et al.*, 2010).

Chemical treatment: CaCl_2 extends the storage life of fruits by keeping their durability and minimizing the rate of respiration, protein breakdown and rotting incidence (Ayar, 2011).

Bioactive reagent: Bioactive compounds such as potassium bicarbonate (KHCO_3) have been reported to effectively control mycelia growth of *Botrytis cinera* and *Alternaria alternata* for two weeks at a concentration of 1-2%, thereby maintaining fruit and vegetable quality. The trade off, however, was that the firmness or tenacity of the fruits dipped in 1-2% KHCO_3 was significantly not compromised in the process. (Etebu, 2013).

Media preparation

It was first step for identification of fungal strains. PDA is commonly used medium for fungal growth. Each and every type of fungal isolate was grown on Potato Dextrose Agar Medium (PDA). For pure culture, Rose Bengal media was used.

Isolation of associated fungi

Fungi were inoculated on Potato Dextrose Agar (PDA) medium. This was done for all the samples collected from SGVP. The petri plates were incubated at room temperature. Fungal growth was observed daily. After five-six days of incubation, plates were ready with fungal colonies. For pure culture, a small portion of mycelium from each fungal colony was transferred aseptically into fresh plates containing the Rose Bengal

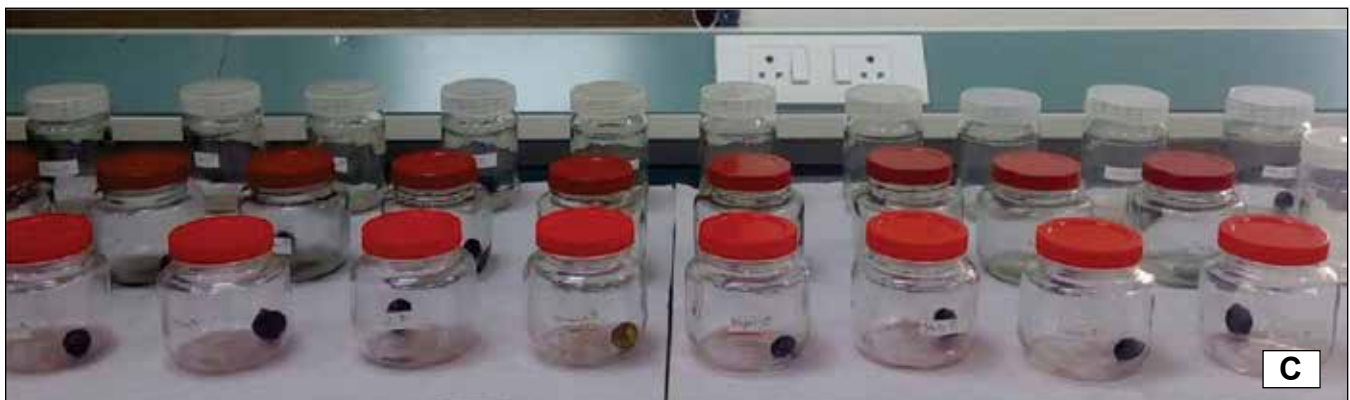


Fig. 1. (A) A fruiting tree of *Syzygium cumini*, (B) the fruits, (C) treated jamun in bottles.

medium. The fungal species were purified by repeated sub-culturing.

Slide preparation

In the preparation of slide, Lacto-phenol Cotton Blue was used as stain. It was prepared by 3 components: phenol, which will kill any living organisms, lactic acid, which preserves the fungal structure and cotton blue which stains the chitin in the fungal cell wall. A minute portion of each organism was aseptically taken by using sterile inoculating needle and teased at the center of clean glass microscopic slides containing drop of lacto phenol cotton-blue stain and then covered with cover slips. Slide was observed in light microscope (Oza, 2017).

Characterization and identification of the isolates

The pure cultures of the fungi were identified on the basis of their colony growth pattern, conidial morphology and pigmentation using the microscopic examination. The identification of isolated fungi up to the genus and species was done on the basis of macro and micro morphological characteristics, using Manual of soil fungi (Gilman,1998). Genetic level identification was based on literature, standard textbook and identification keys.

Two fungal species, *Aspergillus flavus* and *Aspergillus sp.* were isolated from spoiled jamun fruits (Fig. 2). Both the fungal organisms were pathogenic, because they were able to produce the same spoilage

Table 1. Day wise data analysis during different treatments [C = Control, O = Oil, H= Hot water, S = Steam and Hot air, N = Neem, G = Ginger, GI= Garlic, T = Turmeric, CC = CaCl₂, K = KHCO₃, R = Refrigerator.]

Date	C	O	H	S	N	G	GI	T	CC	K	R
24/06/2019	-	-	-	-	-	-	-	-	-	-	-
25/06/2019	-	-	-	-	-	-	-	-	-	-	-
26/06/2019	-	-	-	-	-	-	-	-	-	-	-
27/06/2019	+	-	-	-	-	-	-	-	-	-	-
28/06/2019	+	-	+	+	-	-	-	-	-	+	-
29/06/2019	+	-	+	+	-	-	-	-	+	+	-
30/06/2019	+	-	+	+	-	-	-	-	-	-	-
01/07/2019	+	-	+	+	-	-	+	+	+	+	-
02/07/2019	+	-	+	+	+	-	+	+	+	+	-
03/07/2019	+	-	+	+	+	-	+	+	+	+	-
04/07/2019	+	-	+	+	+	-	+	+	+	+	-
05/07/2019	++	+	+	+	+	-	+	+	+	+	*
06/07/2019	++	+	+	+	+	-	+	+	++	+	*
07/07/2019	++	+	+	+	+	-	+	+	++	+	*
08/07/2019	++	++	++	++	++	+	++	++	++	++	*+

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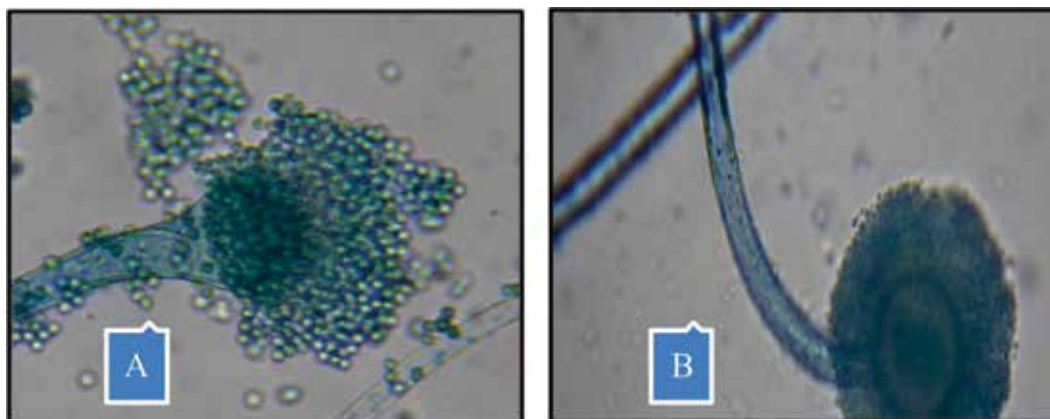


Fig. 2. Microscopic figure of (A) *Aspergillus flavus* and (B) *Aspergillus sp.*

symptoms in the healthy fruits if they were re-inoculated.

For control of fungal spoilage biological, chemical and physical treatments were given and day to day observation was reported as shown in Table 1. These treatment sources are easy available, cost effective and very economic for common person. In this Table 1 (-) symbol shows no fungal contamination. Ginger extract gives best result and hot water and steam treatments give poor results. The (+) symbol indicates that fungal contamination begins, (++) shows heavy contamination and (*) symbol shows that fruits become shrunk without contamination while (*+) symbol manifests that fruits become shrunk and contaminated too.

It can be concluded that Indian berry fruits have high dietary and nutrition qualities. Their spoilage by fungi results in loss of economic resources as well as food poisoning. The fruits are usually transported from areas of production to areas of consumption locally in baskets and sacs under conditions that encourage the growth of fungi. Good quality control measures must therefore be employed by the farmers, marketers and consumers during harvest, transportation, handling and processing of the fruits. This work will go a long way in preventing the consumption of contaminated black plum fruits, thereby reducing the health hazards posed by the mycotoxins produced by the fungi isolated in this study.

Authors' contribution

Conceptualization of research work and designing of experiments (KO, BKJ, BM); Execution of field/lab experiments and data collection (KO, BKJ, BM); Analysis of data and interpretation (KO, BKJ, BM); Preparation of manuscript (KO, BKJ, BM).

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