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## Microbial spoilage of fruits: Reasons and preservation

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### Abstract

Fruits provide sufficient condition for the growth of several bacteria and fungi. Microorganism spoils the fruits and changes the texture, taste, odor, flavor etc. and makes them non edible. By the growth of microorganisms there is heavy loss of fruits. Other reasons such as during handling and transportation, there is a greater risk to get damaged in fruits. By spoilage of fruits, farmers suffered from a great loss.

**Keywords:** Spoilage, bacteria, fungi, post-harvest, shelf life

### Introduction

#### Fruits

Fruits are sweet and fleshy products of trees and other plants that contain seeds and they are typically eaten as food. There are various sizes, shapes, color and flavors of fruits. Fruits are main component of healthy diet because of their nutritional value. A Fruits provides the ideal environment for the growth of many types of microorganisms. Specifically for bacteria fruits gives good environment for growth and viability. Fruits are essential source of nutrients to human being which gives supplement to body with necessary vitamins, fats, minerals, and oil in right proportion for human growth. The fruit tissues composed of high concentration of various types of minerals, sugars, vitamins and amino acids <sup>[1]</sup>. India is the second largest producer of fruits and vegetables after china. According to Kumar (2011) <sup>[5]</sup>, Food and Agricultural organization (FAO) data shows that India has produced about 76424.2 tons of fruits in 2011. Fruits are delicious, and an essential part of a balanced diet. They are not only providing essential nutrients but also enhance the flavor and texture of various dishes. People can use fruits in their regular diet as snacking as a healthy snack between meals. Also fruits can add as salads for a sweet combination. Fruits can blend into smoothies for a nutrient-dense drink.

Various culinary fruits provide significant amount of fiber and water, and many are generally high in vitamin C <sup>[2]</sup>. The dietary fiber consumed in eating fruit promotes satiety, and may help to control body weight and aid reduction of blood cholesterol, a risk factor for cardiovascular diseases <sup>[3]</sup>.

#### Health benefit of fruits

Fruits are universally noted as healthy. Fruits supply dietary fiber which intake is connected to lower incidence of cardiovascular disease and obesity <sup>[4]</sup>. Fruits and vegetables also provide minerals and vitamins to the diet and are good source of phytochemicals that function as anti-inflammatory, antioxidants and phytoestrogens agents and other protective mechanisms. All parts of Banana plant have pharmaceutical application. The flowers used in bronchitis and dysentery, cooked flowers are given to diabetics, young leaves are placed as poultices on burns and other skin afflictions. The roots of banana are applicable in digestive disorders and dysentery <sup>[5]</sup>. Banana seed mucilage is given in cases of diarrhea in India <sup>[6]</sup>. Bananas contain 27%, 12% and 8% daily volume of Vitamin B6, Vitamin C, and Magnesium respectively. Fruits are very poor source of protein and fat. Avocado is the exception containing 28 % fat. Avocado contains high amounts of potassium, fiber, vitamin B6, E, K and two carotenoids known as lutein and zeaxanthin, which support eye health. Generally fruits are poor source of iron but Seethaphal is good source of iron. Guavas, Citrus fruits and cashew are rich in vitamin C, but quantity of vitamin is varies from fruit to fruit. Fruits like Apple, pears, grapes, and some citrus fruits contain flavonoids which act as antioxidants.

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Mangoes are good source of carotenes, while Alphonso type of Mango was found to be the richest source of  $\beta$ - carotene. Oranges are moderately good source of  $\beta$ - carotene. Mangoes are excellent source of potassium, folate, fiber, and vitamin A, C, B6, K and E, also high in mangiferin a potent antioxidant. Studies have shown that mango may protect the body from chronic diseases, such as type 2 diabetes, heart disease, Parkinson's, and Alzheimer's and some forms of cancer. Amla is also a wealthy source of vitamin C. Ripen fruit contains a higher percentage of sugar than unripe fruit. Sucrose, fructose and glucose are main form of sugars that can find in fruits. Strawberries are a juicy red fruit which have high water content, and seeds provide plenty of dietary fiber. Strawberries also contain flavonoid called quercetin, which is a natural anti-inflammatory compound. Lime has antibacterial and antioxidant properties. The flavonoid in Grapefruits helps protect against some cancer, obesity and inflammation [7]. Lychee is rich source of vitamin C, potassium, fiber and many polyphenols with anti-inflammatory and antioxidant properties. Cherries are a great source of fiber and potassium both of which are important for heart and gut health, also good source of serotonin, melatonin; which support good mood and sleep [8].

### Spoilage of Fruits

Spoilage can be defined by various ways. Simply spoilage means fruits are no longer acceptable to the consumer. Spoilage of fruits means that condition of food or fruits that causes undesirable changes which is unacceptable for human consumption [9]. The worst case of spoilage; when it becomes a food safety issue, where the food or their product may cause the consumer illness or death. According to a Department of Statistic data, 18.9 billion pounds of fresh fruits were lost annually due to spoilage, which was contributed to 19.6% of edible food losses of Malaysia for that particular year [10]. High concentration of amino acids, sugars, minerals, vitamins also gives good platform for the successful growth and survival of various bacteria and saprophytic fungi. Fruits are highly perishable and maintain the active metabolism during the storage period. During post-harvest period various diseases can affect quality of fruits. Post-harvest deterioration of fruits may take place at any stages such as storage, trans-shipment, handling process, transport or move the crop from the grower to dealer, to retailer and finally to consumer [11]. In every year major loss in yield is caused due to fungal diseases. Post-harvest diseases of fruits are most severe cause of loss of production, and diseases are responsible for bio deterioration of fruits. In Assam, actual availability of fruits and vegetables in the market goes down by 35% to 40% due to post harvest losses.

Spoilage of bacteria can causes softening of tissues as pectins are degraded, whole fruit may ultimately deteriorate into a slimy mass. Starch and sugars are metabolized which cause unpleasant smell and flavors may develop along with lactic acid and ethanol [12]. Some spoilage microbes are competent of colonizing and creating lesions on undamaged and healthy plant tissue [13]. Microbial fruit infection may occur during the growth season, harvesting, handling, transport, post- harvest storage and marketing conditions. Spoilage will because fruits become even toxic to consumers. Several studies have been reported that occurrence of bacteria in spoiled fruits includes

*Pseudomonas*, *Xantomonas*, *Enterobacter*, *Bacillus*, *Clostridium* and *Lactobacillus* etc. [14]. The difference in the presence or absence of microbes could be due to various factors which can be due to resident microflora in the soil, presence of any non- resident microflora through animal manures [15]. Microorganisms spoil fruits which lead to a great loss to mankind [16].

It can be challenging to ensure microbial integrity of fresh fruits throughout the commercial and distribution process. During processing and storage time several compositional and physiological changes occur making fresh fruits a suitable component for microbial spoilage. When the cells of fruits are damaged, enzyme catalyzes the oxidation compounds, resulting in browning the fruits flesh. This process is increases by air exposure. Some fruits develop ethylene gas as they ripen, this gas can help other fruits to ripen and also fasten the process of spoilage if they are stored together which can cause over-ripening and decay. There are many factors which effects of spoilage of fruits such as pH, temperature, oxygen, moisture, certain human tendency and misconception can contribute to spoilage of fruits. Sometimes, consumers buy more produce commodities than required which is also one of the reason for spoilage. Studies have shown correlation between increased incidence of non-communicable diseases and diets rich in fats, sugars and salt, and low in fruit and vegetables [17].

Consumption of fruits has increased exponentially all over the world due to increased awareness of the health benefits [18]. Spoilage of fruits is an important food issue that has taken much less research attention compared to other produce related food borne illness.

### Reasons for spoilage of fruits

Even due to enormous production of fruits and vegetables, during transportation, handling, storage heavy losses of fruits and vegetables are reported [19-20]. The chances that microbial spoilage agents will be established at any point along these stages depends on certain factors such as surface morphology, topography, plant surface exudates and post-harvest handling. As the fruits are cut off from their natural nutrient source, their quality begins to diminish but the period of greatest susceptibility to decay onset is during ripening and senescence [21].

One of the reasons for spoiled fruit is via the farm environment, post- harvest handling and processing. Furth more, soils typically are teeming with life and the possibility of contamination exists [22]. Second reason for spoilage is pre- harvest sources such as seed, agricultural water, soil, manure, other biological amendments, and humans. Spoilage microorganism can enter through this route into plant tissue, from where it becomes virtually impossible to sanitizers or other decontamination process to reach them and eliminate it [23]. Some fruits develop ethylene gas as they ripen; this gas can stimulate ripening in other fruits, and can also speed up spoilage if fruits are stored together, leading to over-ripening and decay. Improper packaging can expose fruits to air, moisture, and contaminants, speeding up the spoilage process. Over time, fruits naturally decaying due to enzymatic processes and microbial activity, even under optimal storage conditions [24].

**Microorganism involved in spoiled fruits:** Presence of pathogenic fungi in fruits had been reported in apple, corn,

grapes, guava and mango [25], orange, tomato, pineapple, and watermelon [26]. The most frequent pathogenic fungi isolated from spoilt fruits are *Aspergillus*, *Rhizopus*, *Alternaria*, *Penicillium* and *fusarium*. Fungal spoilage were developed unpleasant odours and flavor, reduced quality and cause foodborne disease [27]. Gram positive bacteria, Gram negative bacteria, fungi, are common spoilage agent of fruits. It can be challenging to ensure the microbiological integrity of fresh fruit throughout the commercial and distribution chain. During this time several changes occur in fruit composition making them a suitable substrate for microbial infestation [28]. In addition to the possibility of triggering allergic responses to dry air borne spores produced by some spoilage microbes such as *P. italicum* and

*P. digitatum*, several spoilage molds including *Aspergillus spp.*, *Fusarium spp.*, *Penicillium spp.*, *Alternaria spp.* and so on produce toxic metabolites (mycotoxins), which are a well-established public health hazard [29]. Some spoilage microbes are opportunistic human pathogen, which have been implicated in foodborne outbreaks.

Some spoilage microbes may at times play beneficial roles for example *Botrytis cinerea*, a spoilage agent of grapes, which in certain situations could enhance the commercial value of the commodity [30]. Inappropriate harvesting practices may cause damage such as wounds, abrasion, bruising, puncture, or breakage to the cellular and tissue structure [31].

**Table 1:** Common microbial spoilage agents of fruits and vegetables

Causative agent	Infection caused	Produce affected
<i>Erwinia carotovora</i> subsp. <i>Carotovora</i>	Bacterial soft rot	Many vegetables including leafy crucifers, Lettuce, Endives, Parsley, Celery, Carrots, Onions
<i>Pseudomonas aeruginosa</i> , <i>Pseudomonas fluorescens</i>	Soft rot	Celery, tomatoes
<i>Pseudomonas gingeri</i>	Yellowed lesions	Ginger
<i>Bacillus spp.</i>	Spoilage	Tomatoes, potatoes, pepper
<i>Corynebacterium sepeidonicum</i>	Tuber rot	White potatoes
<i>Penicillium chrysogenum</i>	-	Grapes
<i>Penicillium funiculosum</i>	-	Onions
<i>Mucor piriformis</i>	Soft rot	Strawberries, Apples, Tomatoes, Apples, Pears
<i>Aspergillus Niger</i>	Bunch rot/ Black mold rot	Grapes, Citrus, Apples, Pears, Strawberries, Mangoes, Melons/Onion

[32-33]

### Factors affecting fruit spoilage

Most of the spoilage microorganisms, mainly bacteria can thrive best at near neutral pH  $\geq 4.5$ . Fruits generally have low pH for example lemons have pH 2.2 [34]. Fungi are much less sensitive to pH which can grow over a wide range within pH range 3-8 [35]. To survive in food, most of the spoilage microbes required water in an available form [36]. Microbes can survive harsh environmental conditions such as sub optimal temperature provided liquid water is available [37]. Temperature is the second most important factor that modulates the survival and growth of microbes. Psychotropic spoilage microorganisms are common and been associated with spoilage under refrigeration conditions. Many microbes which can cause spoilage in fruits require oxygen for survival and growth. Apart from biological factors, some non- biological factors such as intrinsic food parameters, climate and human tendencies contribute to large scale spoilage. Another factor is spoilage microbes may gain entry into plant tissues during fruit development, or through the calyx, stem scar [38].

### Preservation

One of the major risks for the preservation of fruits and vegetables is that they have a very short shelf life and they are exposed to the microbial contamination if contacted through soil and water. By this reason preservation of fruits are very much important for consumption for a longer duration. Many countries are engaged in the production of fruits to a larger extent. There are some common methods for fruit preservation such as Hot water, hot steams or sun drying treatment. Some physical methods like Ultrasound, High pressure, Irradiation. There are some chemical methods by using Hypochlorite, Preservatives [39]. Some of the antimicrobials, polypeptides and Organic acids can also be used as preservatives. Hermetic sealing in a modified

atmospheric packaging (MAP) system is used for protection against microorganisms or enzymes that can cause spoilage.

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