

Short Review

The Microbiological Quality of Commercial Fruit Juices-Current perspectives

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The purpose of this review article is to introduce the importance of fruit juices for human health living in the country and in a broad, and to develop awareness among the people about the diseases caused by pathogens associated with fruit juice. Health benefits of juices have been included in this article and how the same juice can cause problems among people of different ages have been discussed. Contamination sources and the ways to prevent them is very important issue in protecting public health. Some future recommendations for fruit juices have also been added in this article. Different diseases caused by various microbial agents and the associated symptoms after consuming contaminated fruit juices worldwide are discussed in this review. This review was aimed at the possible sources of microbial contamination, disease caused by them and determining some ways to avoid such phenomena. From the information provided here, it was noticeable that commercial fruit juice can also harbor pathogenic microorganisms which can cause serious disease outbreaks. The contamination can also be initiated during in house consumption if lack of awareness prevails among the consumers. Manufacturing process should be much more strict in this regard to assure the public health safety. Commercially available fruit juices are consumed worldwide among different ages of people and if not processed properly, this healthy drink may be hazardous for human health.

Keywords: Fruit juice, Contamination, Microbial spoilage, Public health safety, Good manufacturing practice (GMP).

Introduction to fruit juices and the nutritional values

Fruit juice is a popular soft drink made of the pulp of different types of fresh fruits¹⁻⁴. Fruit imparts natural flavour to fruit. Fruit juices contain many components which are beneficial for our health. Though the actual components varies from fruits to fruits, in general they contain flavonoid glycosides, dietary fiber, calcium, vitamin C, carotenoids, lutein, lycopene, β -carotene, phenolic acids, stilbenes, ellagic acid, amino acids, aroma compounds, anthocyanin, flavonols, polyphenols, potassium, vitamin D, low amount of sodium, cholesterol, fat etc. Components present in fruit juices has been proved to help in preventing heart disease, certain cancers, diabetes, cataracts, Alzheimer's disease, asthma and helps in the formation of collagen, cartilage, blood vessels and muscles⁵⁻²³. Considering those beneficial impacts on human health, fruit juices become popular worldwide.

Global availability of packed juices and the consumers

People of all ages like to drink fruit juices. Young children who drinks fresh fruits or juices regularly, can maintain the habit till the age of adolescence. Regular fruit juice drinkers have been shown to suffer less chronic illnesses^{23,24}. Due to worldwide available transportation systems commercially produced fruit juices have been transported from country to country for making the juice products available everywhere. Fruit juices are more

popular among children, but adults used to drink other carbonated soft drinks and/or other energy drinks rather than fruit juices, though most of the cases they have no benefit on health. People who drink more fruit juices have better health conditions, better immune system comparing those who don't drink fruit juices. Fresh fruit juices without additives and extra sugar are more healthy and have no harmful effects on health. Juice which contains other added ingredients and high sugar contents may damage our health.

High earning and educated people like to drink fruit juice as a supplement of vitamins and other essential nutrients for health, but low earning people unable to afford money to buy fruit juices. School going children also prefer juices due to their attractive freshness and many flavors as well as the attractive packaging specially manufactured for them²⁵⁻³².

Microbiological quality perspective of packed juice

Commercial fruit juices can be prepared either by pasteurization or by adding chemical preservatives. Processed fruit juices rather than pasteurization are more popular due to their fresh tastes. In the industry fruit juice is processed by automatic machine (collection, cleaning, extraction of juices and packaging). There is an every possibility of contamination of processed fruit juice at any stage of processing. Contamination may be occurred by spoilage organisms and/or by food borne pathogens. Food borne

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disease outbreaks have been documented in different countries³³⁻³⁷. Specially Yeast and molds are the dominant microorganisms in juice because they can thrive the high acidic conditions of the juice. Some examples of them are species of the genera *Cladosporium*, *Candida*, *Dekkera*, *Pichia*, *Saccharomyces*, *Aspergillus*, *Zygosaccharomyces*, *Penicillium*, *Byssochlamys*, *Hanseniaspora*, *Paecilomyces*, *Mucor*, *Fusarium*, *Botrytis*, and *Neosartorya Talaromyces* etc. Some lactic acid and acetic acid bacteria may be present in fruit juices. Some pathogenic bacteria like *Escherichia coli* O157, *Salmonella*, and *Cryptosporidium*, fecal *Streptococci* and some spore formers like *Clostridium pasteurianum* and *Bacillus coagulans* may be present in fruit juice if the juice is not processed adequately.³⁸⁻⁵¹

Bacterial growth in fruit juice depends on pH, storage temperature, types of packaging material, humidity, water activity, concentration of preservatives, application of UV treatments during production, sugar contents, quality of water used in juice, quality of the machines used in the juice industries, raw materials, quality of fruits etc. Mainly improper washing of fruits with poor quality water used in the juice preparation are the major source of contaminating microbes found in the fruit juices⁵²⁻⁵⁹. Some fruit juice spoiling organisms are listed in Table 1.

Fruit juices are stored in cold temperature and/or in normal temperatures. When packed juices are kept in humid condition and at ambient temperatures (for example during summer seasons), spoiling microorganisms often get stimulated to grow

and cause spoilage and change in odor, taste, visual change etc. If the packaging is not enough protective, they may invite the spoilage causing microbes to get entrance and spoil the drinks. Smaller packages are consumed instantly after opening and have less chance of contamination during consumption. But in case of larger packages, juice pack is often stored in normal temperature or refrigerators depending on the users, which may be more vulnerable for contamination.

High pressure, UV radiation, Gamma radiation, ozonization, electron beam radiation, pasteurization, pulsed electric field processing etc. and chemical preservatives such as organic acids, hydrogen peroxide, dimethyl dicarbonate, vanillin, monocaprylin, essential oils, vanillic acid, nisin and cinnamon etc are to be applied to preserve fruit juice⁶⁵⁻⁶⁸.

Fruit juice associated disease outbreaks

Food borne pathogens if present at sufficient number in fruit juice may cause illness in the consumers. Some microbes only survive in the juice and multiply within the host after consumption and start the disease. Some microbes which can multiply within the juice may yield off odor in juice and make juice unfit for human consumption. *Clostridium perfringens*, *Staphylococcus aureus*, *Bacillus cereus*, *Clostridium botulinum* able to produce toxins in fruit juice and after drinking the juice can cause food poisoning. Fruit juice contaminating pathogens and symptom caused by them are listed in Table 2.

Table 1. List of microorganisms responsible for spoilage⁶⁰⁻⁶⁴

Yeast		Mold	Bacteria
Heat sensitive: <i>Pichia</i> , <i>Candida</i> , <i>Saccharomyces</i> , <i>Rhodotorula</i> , <i>Pichia membranifaciens</i> , <i>Candida maltosa</i> , <i>C. sake</i> , <i>Saccharomyces bailii</i> , <i>S. bisporus</i> , <i>S. cerevisiae</i> , <i>S. rouxii</i> , <i>S. bayanus</i> , <i>Brettanomyces intermedius</i> , <i>Schizosaccharomyces pombe</i> , <i>Torulopsis holmii</i> , <i>Hanseniaspora guilliermondii</i> , <i>Schwanniomyces occidentalis</i> , <i>Dekkera bruxellensis</i> , <i>D. naardenensis</i> <i>Torulaspora delbrueckii</i> , <i>Zygosaccharomyces microellipoides</i> , <i>Candida parapsilosis</i> , <i>C. stellata</i> , <i>Torulaspora delbrueckii</i> , <i>Zygosaccharomyces rouxii</i> .	Resistant to preservatives: <i>Zygosaccharomyces bailli</i> , <i>Candida krusei</i> , <i>Saccharomyces bisporus</i> , <i>Schizosaccharomyces pombe</i> , <i>Pichia membranifaciens</i> Resistant to heat: <i>P. membranifaciens</i>	Heat resistant: <i>Byssochlamys fulva</i> , <i>Neosartorya ficheri</i> , <i>Talaromyces spp.</i> , <i>Paecilomyces variotii</i> , <i>Aspergillus tamari</i> , <i>A. flavus</i> , <i>A. ochraceus</i> , <i>B. nivea</i> . Mycotoxin producers: Byssochlamic acid (<i>Byssochlamys fulva</i> , <i>B. nivea</i>), patulin (<i>B. fulva</i> , <i>B. nivea</i> , <i>P. expansum</i>), ochratoxin (<i>Aspergillus carbonarius</i>), citrinin (<i>Penicillium expansum</i> , <i>P. citrinum</i>)	Lactic acid bacteria: <i>L. mesenteroides</i> ssp. <i>cremoris</i> , <i>Leuconostoc paramesenteroides</i> , <i>Leuconostoc dextranicum</i> Acetic acid bacteria: <i>Acetobacter</i> , <i>Gluconobacter</i> , and <i>Gluconacetobacter</i> Alicyclobacilli: <i>Bacillus acidocaldarius</i> , <i>B. acidoterrestris</i> , <i>Alicyclobacillus acidocaldarius</i> , <i>A. hesperidium</i> , <i>A. acidophilus</i> , <i>A. cyclohexanicus</i> , <i>A. fastidiosus</i> , <i>A. pomorum</i> Others: <i>Propionibacterium cyclohexanicum</i> , <i>Streptomyces spp.</i> , <i>Bacillus coagulans</i> , <i>B. marcescens</i> <i>C. pasteurianum</i> and <i>C. butyricum</i> . Pathogenic bacteria: <i>Escherichia coli</i> , <i>Salmonella spp.</i> , <i>Shigella spp.</i> , <i>Staphylococcus spp.</i>

Table 2. Disease symptoms caused by contaminating microbes found in fruit juices^{69,70}.

Microorganisms	Examples	Disease symptoms
Bacteria	<i>Salmonella</i> spp.	Abdominal pain, diarrhea, chills, fever, nausea
	<i>Shigella</i> spp.	Abdominal pain, diarrhea, fever, nausea
	<i>Clostridium botulinum</i>	Nausea, vomiting, fatigue, dizziness, dryness of mouth and throat, muscle paralysis, difficulty swallowing, double or blurred vision.
	<i>Escherichia coli</i> O157:H7	Bloody diarrhea, abdominal pain, hemolytic uremic syndrome (HUS), kidney failure.
	<i>Listeria monocytogenes</i>	Gastroenteritis, childbirth in pregnant women, septicemia, meningitis.
Virus	Hepatitis A	Fever, malaise, anorexia, nausea, abdominal pain, jaundice, dark urine
	Norwalk virus	Vomiting diarrhea, malaise, fever, nausea, abdominal cramps
Parasites	<i>Cyclospora</i> spp.	Watery diarrhea, nausea, anorexia, abdominal pain
	<i>Cryptosporidium</i> spp.	Profuse watery diarrhea, abdominal pain, anorexia, vomiting

Listeria monocytogenes, a notorious food borne pathogen is found in unpasteurized apple juices. *Salmonella* spp., *Escherichia coli* O157:H7, and *Cryptosporidium* spp. were also found in unpasteurized juices. *Salmonella* spp. associated food borne disease outbreak occurred before the 20th century in Sarasota County, Florida and United States. Hepatitis A was occurred in Egypt in 2004 due to intake of fruit juice⁷¹.

Governing bodies selecting the criteria for quality of fruit juices

According to Fruit Juice and Fruit Nectars (FJFN) Regulations 2013 in England, freezing of fruits before juice production is prohibited, and addition of sugars in juice is also not permitted⁷². According to the opinion of the United State Department of Agriculture (USDA) people consuming 100% juice does not cause obesity in most cases but obese people may gain weight for drinking of 100% juice⁷³, whereas, the Academy of Nutrition and Dietetics Evidence Analysis Library (ANDEAL) concluded that in case of children there is no interrelation between weight gain and fruit juice consumption⁷⁴. In Ethiopian Public Health Institute (EPHI) Food Microbiology guideline, it has been suggested that people should not be sold or consumed spoiled, poor quality and harmful toxin containing juices. It is prohibited to manufacture, package, handle and store fruit juice in unhygienic condition⁷⁵. According to FDA, fruit juices should be rejected if it contains toxins, high microbial load and high pesticide residue⁷⁶. Microbial limit in fruit juice is listed in Table 3 according to the FDA standard. According to Food Safety and Standard Authority of India (FSSAI, 2011)⁷⁷, microbiological limits are listed in Table 4.

Table 4. Microbial limits in fruit juice

Microorganism	Maximum limit
Total bacterial count/ml	25
Total coliform count/ 100 ml	Absent
<i>Escherichia coli</i> / 100 ml	Absent
Yeast and mold/ ml	5

Table 4. Microbiological requirements of Fruit Juices as per FSSAI (2011) ⁷⁷

Count (cfu/ml)	Maximum Count Permitted
Total count	Not more than 50
Coliform	Absent in 100 ml
Yeasts	Not more than 2

FSSAI (Licensing and Registration of Food businesses) Regulation, 2011⁷⁸

Permitted ingredients for juice FSSAI⁷⁷ include sugar (less than 2% moisture), liquid sucrose/ invert sugar/ fructose syrup/ liquid cane sugar, lime/lemon juice, salts/spices/ aromatic herbs for tomato juices, vitamins and minerals.

Study carried out in Bangladesh

From an investigation on the commercially available nine fruit juices of mango and oranges in Bangladesh, it was found that pH range of the fruit juice samples studied was between 3.50 ± 0.10 and 4.70 ± 0.05. Vitamin C and protein content were higher in mango juices than orange juices⁴⁷. Heavy metals like arsenic, lead, copper and zinc were within the limits recommended by Bangladesh Standard and Testing Institute (BSTI). and the Gulf standards (the recommended Microbiological Standards for any fruit juice sold in the Gulf Region⁷⁸. In another study, several kinds of fruit juices showed pH, acidity, total aerobic plate count, yeast-mold count, heavy metal content within the standards recommended by Gulf standards, though the preservative content was higher⁷⁹. Both local and foreign packed and commercial juices are available in Bangladesh. Some local brand juices often contain total bacterial count and yeast-mold count above the range of the required limits. Such fruit juices can be responsible for the onset of public health hazards.

Future aspects of commercial fruit juice and recommendations

Fruit juice should not be given to infants less than six months old as this might cause allergies, dermatitis, perioral rash, carbohydrate malabsorption, and acute diarrhea. Over consumption of juices by old and children under 5 years old can cause diarrhea, over nutrition, and dental carries. Consuming fruit juice without added sugars is recommended for the people of all ages because of the nutritional values and beneficial effects to our health status. Naturally, fruit juices are good sources of nutrition imparting essential amino acids, vitamins and minerals. Juices can be enjoyed at any corner of the world and at any time upon individual's choice. Immune compromised patients with poor health condition can be given natural antimicrobials, vitamins, necessary amino acids, minerals enriched juices. Fruit juice is a source to get instant energy. Fruit juice is a source to get instant energy. Fruit juice should be made with fresh, washed, and selected fruits to avoid contaminants. During the juice processing, aseptic condition should be strictly maintained. Operators and workers should have the proper knowledge about the personal hygiene, good hygienic practice (GHP) and good manufacturing practice (GMP) and the risk of public health if pathogenic bacteria find their way into the juice.

Conclusion

Fruit juices are one of the most popular drinks which is beneficial for the people of all ages. They not only fulfill the requirements of our nutritional demands but protect us from a variety of diseases if consumed regularly starting from the early ages. The quality of the fruit juices should be maintained to avoid the chance of food borne disease outbreaks. Though fruit juices make our immune status strong, but it can cause damage if over consumed and/or it is contaminated with food borne pathogens. Quality test should be started from the fruits selected for making juice, harvesting, peeling, processing, and use of additives, packaging materials and storage conditions. Consumer handling is an important factor to reduce the complications of fruit juice consumption.

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Conflict of interest

Authors have no potential conflict of interest.

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