A review on the consumption of vended fruits: microbial assessment, risk, and its control

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Abstract

Fruits are very beneficial to health and their consumption has been recommended in daily diets. However, when fresh fruits are harvested and processed into sliced ready-to-eat or vended forms for sale, hygienic procedures are neglected. Thus, they are easily infested by pathogens. In addition, uneducated vendors who sell these fruits often display or hawk them on the streets in contaminated containers, utensils, or dirty environments. This poses a great threat to the health of consumers. In the light of this realization, some microbial assessments have been carried out to ascertain the safety of these vended fruits, thus making it a necessity to exploit the outcomes of some of these microbial assessments on vended fruits in order to sensitize the consumers on the effect of their consumption and mitigate risk by improving their quality. This will assist to lower certain health concerns, an outbreak of diseases, and death.

Key words: vended fruits; microbial assessment; risk; control and consumption.

Introduction

Fruits have been greatly recommended in foods due to their health-promoting attributes. They are very essential in dietary guidance since they contain high levels of minerals particularly electrolytes, vitamins such as vitamin C, and phytochemicals which act as antioxidants and fibres (Slavin and Lloyd, 2012). Therefore, the consumption of fresh fruits or their juices is crucial to healthy living (Bhat et al., 2011). In addition, it is expected that a rich balanced diet should consist of fruits due to their numerous functions. Some of which include the ability to develop a blood lipid profile, detoxify the human body, and prevent vitamin deficiencies (Minich and Bland, 2007; Slavin and Lloyd, 2012). Also, the consumption of sufficient amounts of fruits lowers blood cholesterol levels, controls blood pressure, reduces the risk of some heart diseases, and prevents some kinds of cancer (Hung et al., 2004). When fruits are harvested or during post-harvest processing, they come in contact with water, soil, dust, and handling. Consequentially, they harbour a lot of microorganisms including pathogens (Ogofure et al., 2017). Also, harvested fruits are commonly sold as cut or sliced fruits to entice the consumers. These types of fruit are referred to as vended fruits or ready-to-eat fruits, some of which include watermelons, pineapples, cucumbers, mangoes, oranges, pawpaws, etc. They are usually displayed at strategic places or carried around by hawkers to be sold to buyers for immediate consumption without necessarily rinsing or washing them because they have already been prepared and packed in small polythene bags as illustrated in Figure 1 (Kalia and Gupta, 2006).

The consumption of these vended ready-to-eat fruits has become a global trend. This is due to their accessibility, convenience, and relatively cheaper prices than the whole fruits (Nwachukwu et al., 2008). Thus, they have gradually become staples due to the recent modernization, industrialization, economic downturn, materialism, and unavailability of ample time to prepare a proper meal in some
microbial assessment of vended ready-to-eat fruits to consumer health, some experiments have been carried out to ascertain the safety in consumption of these vended fruits. In Table 1, a summary of the microbial assessment on vended fruits is highlighted. For example, Orji et al. (2016) evaluated the microbial contamination of ready-to-eat vended fruits in the Abakpa main market, Abakaliki, the southeastern part of Nigeria. The assessment was carried out using standard microbiological methods. A total of 17 vended fruit samples that consisted of tiger nuts, sliced pineapple, carrot, watermelon, and cucumber were collected from fruit vendors. They were screened for the total bacterial and fungal counts. The analysis indicated that total aerobic plate count ranged from 3.5 × 10^2 to 1.03 × 10^6 CFU/ml with tiger nuts having the highest count and cucumber having the lowest count. The total fungal count ranged from 1.1 × 10^3 to 1.42 × 10^5 CFU/ml with carrot having the highest count and sliced pineapple having the lowest count while tiger nuts had no significant growth. The isolated organisms in all studies as well as their infections are illustrated in Table 2. The isolated organisms in this study were E. coli, Shigella sp., Salmonella sp., Pseudomonas sp., Staphylococcus aureus, and one fungal isolate, Mucor sp. from the tested vended fruits. The contamination could have occurred as a result of poor hygiene, faecal contamination, and environmental factors such as contaminated air (Orji et al., 2016). Thus, it was recommended that adequate awareness on sanitary practices by individuals to the environment should be encouraged by health officials to reduce the level of contamination in vended fruits. Another experiment on the bacteriological assessment of ready-to-eat pawpaw (Carica papaya) sold in the selected locations in Benin City, Nigeria was carried out by Ogochuru et al. (2017). In the study, 31 vended pawpaw samples were purchased and analysed. Standard bacteriological techniques using selective media were employed for the isolation, purification, and putative identification of selected bacterial isolates present in the vended pawpaw fruits. The susceptibility and resistance of these bacterial isolates to common antibiotics were also assessed. It was observed that total staphylococcal counts were between 8.2 × 10^3 and 8.21 × 10^5 CFU/g while coliform counts ranged from 0.8 × 10^3 to 1.68 × 10^4 CFU/g. Salmonella counts obtained from the pawpaw samples were in the range of 2.03 × 10^2 to 1.86 × 10^5 CFU/g with pineapple and watermelon showing the highest count and sliced pineapple having the lowest count. The total fungal count ranged from 1.3 × 10^3 to 1.7 × 10^5 CFU/g with pawpaw showing the highest count. Five bacterial pathogens ranged between 0.25 and 0.60 which indicated multiple antibiotic resistance (MAR) index greater than 0.2. MAR index is a tool used for health risk assessment to identify if the isolates are from a region of high or low antibiotic usage. A MAR index of 0.2 and above is indicative of ‘high-risk’ source of contamination (Davis and Brown, 2016). In the study, the MAR index of isolated bacterial pathogens ranged between 0.25 and 0.60 which indicated that the vended pawpaw posed a serious threat to public health. Another investigation on the microbial quality of ready-to-eat fruits sold in different markets of the Enugu metropolis, the southeastern part of Nigeria, was carried out by Ugwu and Edeh (2019). A total of 40 ready-to-eat fruit samples that consisted of pineapple, watermelon, pawpaw, and cucumber were collected from a fruit vendor and screened to ascertain the microbial counts. The results indicated that mean bacterial load of the samples ranged from 6.0 × 10^3 to 8.2 × 10^5 CFU/g with pineapple and watermelon showing the highest counts while the mean fungal load ranged from 1.3 × 10^3 to 1.7 × 10^5 CFU/g with pawpaw showing the highest count.

**Microbial Assessment of Some Vended Fruits**

Microbial risk assessment is a systematic approach to aid the understanding of complex food systems and to convert the potential presence of pathogens in the preparation environments, food processing, and production into reports of the likelihood and degree of a food safety risk defined in terms of adverse public health outcomes (Havelaar et al., 2010). Considering the importance of...
Table 1. A summary of the microbial assessment and identified organisms of some vended fruits.

| Vended fruits tested | Microbial assessment | Identified organisms | References |
|----------------------|----------------------|----------------------|------------|
| Tiger nuts, sliced pineapple, carrot, watermelon, and cucumber | Total bacterial and fungal counts | *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* sp., *Shigella* sp., *Pseudomonas* sp., and *Mucor* sp. | Orji et al. (2016) |
| Pawpaw (*Carica papaya*) | Total *staphylococcal* counts, coliform counts, *Salmonella* counts, and *Pseudomonas* counts | *E. coli*, *Salmonella enterica*, *Klebsiella oxytoca*, *Enterococcus faecalis*, *S. aureus*, and *Pseudomonas aeruginosa* | Ogoiture et al. (2017) |
| Pineapple, watermelon, pawpaw, and cucumber | Bacterial load and fungal load | *Staphylococcus aureus*, *Klebsiella* sp., *E. coli*, *Shigella* sp., *Salmonella* sp., *Candida* sp., and *Aspergillus* sp. | Ugwu and Edeh (2019) |
| Sliced watermelon, sliced pineapple, apple, sliced pawpaw, and packaged fruit salad | Total aerobic plate | *E. coli*, *Enterobacter*, *Salmonella*, *Klebsiella*, *Bacillus* sp., *Staphylococcus aureus*, *Penicillium* sp., *Mucor* sp., *Aspergillus niger*, *P. aeruginosa*, *Proteus*, *Micrococcus*, and *Lactobacillus* sp. | Oranusi and Olorunfemi (2011) |
| Fresh-squeezed juices of lime, carrot, and sugarcane | Total viable counts | Faecal coliforms, *Vibrio*, and *Staphylococcal* counts | Mahale et al. (2008) |
| Green mangoes, carrot, and cucumber | Bacterial load | *Klebsiella*, *Enterobacter*, *Salmonella paratyphi A*, *Hafnia*, *E. coli*, *Alcaligenes*, and *Proteus* | Ali et al. (2011) |
| Hog plum, guava, plum, and pineapple | Total bacterial count, total coliform count, and total *Salmonella–Shigella* counts | *E. coli*, *Bacillus*, *Staphylococcus aureus*, *Klebsiella*, and *Proteus* | Mahfuza et al. (2016) |

Table 2. Identified microorganisms in vended fruits, infections, and diseases.

| Identified organisms in vended fruit | Infections and diseases | References |
|------------------------------------|-------------------------|------------|
| *Escherichia coli*                  | Diarrhea, pneumonia, and intestinal lining damage | Wendorf et al. (2015) |
| *Staphylococcus aureus*             | Skin and respiratory infections, food poisoning | Halablab et al. (2010) |
| *Salmonella* sp.                    | Paratyphoid fever        | Viera-Pinto et al. (2011) |
| *Shigella* sp.                      | Indigestion and dysentery | Rooney et al. (2004) |
| *Pseudomonas* sp.                   | Necrotizing inflammation  | Ouzari et al. (2008) |
| *Mucor* sp.                         | Nasal or sinus congestion | Thiyam and Sharma (2013) |
| *Klebsiella* sp.                    | Pneumonia, urinary tract infection, sepsis, and meningitis | Turton et al. (2008) |
| *Candida* sp.                       | Damage of the immune system | Hirata et al. (2017) |
| *Aspergillus* sp.                   | Pulmonary infection, asthma, cystic fibrosis | Panackal et al. (2003) |
| *Penicillium* sp.                   | Allergic pulmonary disease | Barcus et al. (2005) |
| *Proteus*                           | Wound infections, urinary and septic infection | Cao et al. (2014) |
| *Micrococcus*                       | Skin contaminant         | Jayaprakash et al. (2005) |
| *Lactobacillus*                     | Urinary tract infection  | Matsumoto et al. (2005) |
| *Vibrio* sp.                        | Foodborne infection such as cholera | Sweet et al. (2013) |
| *Hafnia*                            | Intestinal infection     | Abbott et al. (2011) |
| *Alcaligenes* sp.                   | Immune infection         | Tan et al. (2002) |

and two fungal species were isolated: *S. aureus*, *Klebsiella* sp., *E. coli*, *Shigella* sp., *Salmonella* sp., *Candida* sp., and *Aspergillus* sp. *Staphylococcus aureus* (70%) had the highest occurrence followed by *E. coli* (62.5%), *Salmonella* sp. (50%), *Klebsiella* sp. (40%), *Shigella* sp. (37.5%), *Candida* sp. (37.5%), and *Aspergillus* sp. (17.5%) which had the lowest occurrence. Ugwu and Edeh (2019) claimed that the presence of these organisms in the screened fruits was an indication of poor sanitary practices during the processing of the vended fruits. In Ota, the southwestern part of Nigeria, a study was carried out by Oranusi and Olorunfemi (2011) on microbiological safety evaluation of street sliced ready-to-eat fruits that were sold. Sixty samples of vended fruits such as sliced watermelon, sliced pineapple, apple, sliced pawpaw, and packaged fruit salad were obtained from vendors in a university cafeteria and a local market. Thereafter, they were subjected to microbial count. The mean total aerobic plate count ranges from 2.0 × 10⁶ to 8.2 × 10⁶ CFU/g on pineapple and watermelon obtained from the local market and from 6.0 × 10⁶ to 2.7 × 10⁸ CFU/g on apple and fruit salads from the cafeteria of the University. The samples were all contaminated with coliform and fungi with counts ranging from 2.2 × 10⁵ to 4.2 × 10⁶ CFU/g and 2.0 × 10⁵ to 1.0 × 10⁶ CFU/g in the samples from the cafeteria and 2.0 × 10⁵ to 3.5 × 10⁶ CFU/g and 2.0 × 10⁵ to 1.1 × 10⁷ CFU/g in the samples from the local market. Organisms identified were *E. coli*, *Enterobacter*, *Salmonella*, *Klebsiella*, *Bacillus* sp., *Aspergillus niger*, *P. aeruginosa*, *Proteus*, *Micrococcus*, and *Lactobacillus* sp. The study concluded that the coliforms present with a count of at least 10⁵ in most of the samples reflected the sanitary quality of the processing of the produce. Thus, the consumption of ready-to-eat fruits was declared unsafe.

Apart from case studies in Nigeria, various experiments on the quality of vended fruits have been carried out in some other countries. For instance, Mahale et al. (2008) reported the microbiological analysis of street vended fruit juices from Mumbai city, India. Thirty samples of fresh-squeezed juices of lime, carrot, and sugarcane obtained...
from vendors in Mumbai city were subjected to microbial count. The total viable counts of the samples were approximately log 6.5 CFU/100 ml with a major load of coliforms, fecal coliforms, Vibrio, and staphylococcal counts. Qualitative counts indicated the availability of coagulase-positive S. aureus in five samples of sugarcane and two samples of carrot juice. Almost 70% of the ice samples collected from the vendors indicated high microbial load that ranged from log 5 to 8.5 indicating the non-hygienic quality of the vended fruits. In another study, Ali et al. (2011) examined the bacterial isolate from vended fruits in Dhaka city, Bangladesh. Vended fruits like green mangoes, carrot, and cucumber and washing water for the fruits were collected from vendors and analysed for microbial quality. Lactose fermenter bacterial load of cucumber, carrot, mangoes, and washing water were found to be 4.3 × 10^3 to 9.45 × 10^3 CFU/g, 9.3 × 10^3 to 7.2 × 10^6 CFU/g, 28–305 CFU/g, and 8.5 × 10^2 to 1.57 × 10^7 CFU/ml, respectively. Several enteric bacteria such as Klebsiella, Enterobacter, Salmonella paratyphi A, Hafnia, E. coli, Alcaligenes, and Proteus were observed. Thus, consumption of the vended fruits was reported to be hazardous to health. Another study by Mahfuza et al. (2016) reported the microbial status of vended fruits such as hog plum, guava, plum, and pineapple. The fruits were obtained from vendors in Dhaka city in Bangladesh. Total bacterial count (TBC), total coliform count (TCC), and total Salmonella-Shigella (TSS) count in fresh-cut hog plum (Spondias mombin L.) were 3.5 × 10^4 CFU/g, 4.8 × 10^2 CFU/g, and 3.6 × 10^4 CFU/g, respectively. In guava (Psidium guajava), TBC, TCC, and TSS count were 1.5 × 10^4 CFU/g, 4.9 × 10^2 CFU/g, and 2.3 × 10^2 CFU/g, respectively. TBC and TCC were 4.6 × 10^4 CFU/g and 3.9 × 10^4 CFU/g respectively, in plum (Ziziphus mauritiana L.). The results indicated that hog plum had the least while plum possessed the highest microbial load among all the fruit samples. Organisms identified from the tested samples were E. coli (36%), Bacillus (25%), Staphylococcus (24%), Klebsiella (9%), and Proteus (6%). Hence, the vended fruits were declared risky consumption.

**Improving the Quality of Vended Fruits**

To tackle the menace of microbial contamination of vended fruits, enforcement of intense training on good manufacturing practices before, during, and after processing of ready-to-eat fruits and foods for fruit and food vendors should be done to maintain a high standard of personal and environmental hygiene. Thorough washing of fruits with clean water before consumption, routine washing of hands, and accurate application of hazard analysis critical control point should be implemented to control contamination of fresh fruit produce and its vended form.

**Conclusions**

The microbial assessment showed that vended ready-to-eat fruits pose great risks to consumer health. Thus, urgent steps including awareness of personal hygiene and environmental hygiene of the vendors and processing. This will improve the quality of the vended fruits as well as the lifespan and well-being of its consumers. By so doing, safe vended fruits could be propagated as a cheap source of nutrients that should be integrated daily in the diets.

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**Author’s Contributions**

OOF conceptualized the research idea and designed how the manuscript should be written. AEA provided details tailored to enhance the quality of the manuscript. ATI wrote the manuscript and provided the overall guidance.

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