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Microbiological Assessment of Air Contamination of Vended Foods Sold in the Main Market in Lokoja, Kogi State, Nigeria

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Abstract: The microbiological evaluation of the air microflora as it affects vended foods sold in the main market in Lokoja, Kogi State, Nigeria was investigated. A total of 40 samples comprising of 24 samples of vended food and 16 air samples were screened for total bacterial and fungal count. A total of 8 bacterial species were isolated, characterized and identified from the vended food samples; they were *Bacillus subtilis*, *Micrococcus* sp., *Salmonella* sp., *Shigella* sp., *Staphylococcus aureus*, *Escherichia coli*, *Proteus* sp., *Pseudomonas* sp., while 6 bacterial species were isolated from the air samples including *Bacillus subtilis*, *Micrococcus* sp., *Staphylococcus aureus*, *Salmonella* sp., *Shigella* sp., *Escherichia coli.* A number of 3 fungal species were isolated from the vended food samples comprising of *Aspergillus* sp., *Penicillium* sp. and *Mucor* sp., while 2 fungal species were isolated from the air samples, namely: *Aspergillus* sp. and *Penicillium* sp. The total aerobic plate count ranged from $1.8\text{-}3.0\times10^4$ cfu mL^{-1} with date palm having the lowest count and carrot having the highest count; while, the total fungal count ranged from $1.5\text{-}2.3\times10^4$ cfu mL^{-1} with carrot having the lowest count and watermelon having the highest count. The mean total viable count of microbial isolates in air samples indicated that *S. aureus* had the highest mean microbial count (210 cfu/dm^2/h) with *Micrococcus* sp., having the least mean microbial count (54 cfu/dm^2/h) for the densely populated site. *Bacillus subtilis* had the highest mean microbial count (254 cfu/dm^2/h) in air sample from the refuse dump site opposite the market; while, Micrococcus had the lowest mean microbial count (63 cfu/dm^2/h) in air sample. Some of the organisms incident in air were found in the vended food samples and this shows that, air serves as a conveyor of these microbes. The isolated microorganisms from the air and vended food samples are of public health significance. The importance of air as a major source of microbial contamination cannot be underemphasized and the need to encourage sanitary practices around the market should be encouraged. Adequate training programs for food vendors and the public should be implemented in order to maintain high standard of personal and environmental hygiene which will help reduce the level of contamination in vended foods.

Key words: Vended foods, air microflora, microbial load, pathogens, air contamination

INTRODUCTION

Foods continue to remain the major source of deriving nourishment to man. The sustainability of life depends to a large extent on food consumed. The consumption of food could either have beneficial or detrimental effect on man. Consumption of contaminated food could have harmful effect which can result into a food infection and can be in the form of food infection or food intoxication. According to WHO (2007), food borne illnesses are diseases usually infectious or toxic in nature caused by agents that enter the body through the ingestion of food. Foodborne illness is a major international health problem with consequent economic reduction (Duff *et al*., 2003). Research has shown that bacteria; such as Salmonella, *Staphylococcus aureus*, *Escherichia coli* (Pathogenic strains), *Bacillus* sp., *Listeria monocytogenes* and *Clostridium botulinium*; viruses; such as Hepatitis A and E, Norovirus; molds, fungi and yeasts are implicated as microbial agents responsible for food infections (CDC, 2010). Vended foods are foods sold by vendors in streets or other public places for immediate consumption at a later time without further processing or preparation. Vended foods range from pastries like meat pie, sausage rolls, burger, moin moin, salad or coleslaw, fried meat, fried chicken, milk and milk products (Caserani and Kinston, 1974). Other examples include fruits, vegetables, all kinds of snacks and drinks. A general trend which shows that a social pattern characterized by increased mobility, large number of itinery workers and less family or home centered activities and this has led to the consumption of more vended foods (Clarence *et al*., 2009). Other reasons for the high consumption rate of vended foods include convenience, modern lifestyle, industrialization, economic downturn, quest for more wealth, materialism, lack of time to prepare proper meal, low purchasing power (Nielsen, 2006). Thus, food vendor services are on the increase and the responsibility for good manufacturing practices of food; such as good sanitary measures and proper food handling have been transferred from individuals or families to food vendors who rarely enforce such practices (Musa and Akande, 2002). In Nigeria, a large number of foods have been reported to have high occurrences of bacteria (Adesiyun, 1995; Okonko *et al*., 2009; Oluwafemi and Simisaye, 2005; Angela *et al*., 2010). Even though, epidemiological evidence on outbreak of food borne disease is scarce, there are indicators that foods could be contaminated to unsafe levels at the point of consumption with air flora and other organisms from handlers, equipment or utensils and the raw food materials (Edema *et al*., 2008). In Nigeria, the sale of vended foods is likened with practices; such as display of food products in wheel barrows, on tables, trays and mats at point of sale and the use of bare hands during handling and sales. These unhygienic practices may lead to microbial contamination due to deposition of bioaerosols on exposed products, transfer of microbes from dirty hands and utensils (Ogugbue *et al*., 2011). This study was aimed at investigation the role of air borne contaminants on vended foods sold in the most patronized market in Lokoja, Kogi State with a view of proffering food safety advice.

MATERIALS AND METHODS

Study area: The study area is the main market in Lokoja town, Kogi State. This study area was chosen as a result of cow dung, refuse dump in and around the market and the high level of patronage the market enjoys.

Chemical and reagents: All the chemicals and reagents used were of analytical grade obtained from LAB M, London.

Collection of samples: A total of 24 vended food samples comprising of date palm, carrot, kunu and sliced watermelon were collected in duplicates from 3 different vendors. A total of 16 Petri plates containing; Nutrient agar, Salmonella-Shigella agar, Mannitol salt agar and Potato dextrose agar were exposed in duplicates at two different locations in the market (One close to the dump site and the other where there is high human traffic).

Isolation of microorganisms from vended food samples: About 10 g of each food sample was weighed and homogenized in 100 mL of sterile 0.1% w/v peptone water using a stomacher. Ten fold dilutions of the homogenates was made; 0.1 mL of 10^{-4} dilutions of the homogenate was plated in duplicate on Potato Dextrose Agar (PDA), Nutrient Agar (NA) Mannitol Salt Agar (MSA), Salmonella-Shigella Agar (SSA) and MacConkey agar using Pour Plate Method. The plates were then incubated at 37°C for 24 h. For PDA, the plates were incubated at 25°C for 5 days. Nutrient agar was used for the enumeration of total bacterial count. MacConkey agar was used for coliform enumeration, Mannitol salt agar was used for *Staphylococcus aureus* and Salmonella-Shigella for isolation and enumeration of Salmonella and Shigella. At the end of the incubation period, the colonies were counted using a colony counter (Gallenkamp, England). The count for each plate was expressed as, colony forming unit per mL of the suspension (cfu mL^{-1}).

Determination of index of microbial air contamination in the market: The index of microbial air contamination of the markets was measured thrice a week for a period of 1 month employing the method of Pasquerella *et al*. (2000). This was carried out by exposing a standard Petri dish (9 cm in diameter) containing 20 mL of Nutrient agar, Salmonella-Shigella agar, MacConkey agar, Mannitol salt agar to air according to the 1/1/1 scheme (1 h, 1 m from the floor and at least 1 m from walls or any physical obstacle). Thereafter, the plates were closed, transferred to the laboratory and incubated at their respective temperatures described. After incubation, the colony forming units were counted and expressed as CFU/dm^2/h.

Identification of isolates: Distinct colonies on Nutrient and Potato dextrose agar were carefully examined microscopically for cultural characteristics like shape, colour, size, edge, consistency, elevation, optical characteristics. Gram staining and other biochemical tests were carried out employing the method of Speck (1976) and Cheesbrough (2004). Fungi that developed on PDA plates were stained with malachite green to examine the type and number of hyphae and the production of spores (Watanabe, 2002).

RESULTS AND DISCUSSION

Table 1 shows the mean microbial load of vended food samples. The result indicates that carrot had the highest bacterial count (3.0×10^4 cfu mL^{-1}) while date palm had the lowest bacterial count (1.8×10^4 cfu mL^{-1}). Watermelon had the highest total fungal count (2.3×10^4 cfu mL^{-1}) and carrot had the lowest fungal count (1.5×10^4 cfu mL^{-1}).

The mean microbial load of vended food samples from the vending sites is shown in Table 1. The result showed that carrot followed by watermelon had the significant higher count for total bacterial count (1.8-3.0×10^4 cfu mL^{-1}) compared to other samples; while watermelon and date palm had the highest total fungal count (1.5-2.3×10^4 cfu mL^{-1}). Table 2 delineates that a total of 11 organisms were isolated from the vended samples and they were *E. coli*, *Proteus* sp., *Salmonella* sp., *Shigella* sp., *Staphylococcus aureus*, *Bacillus subtilis*, *Micrococcus* sp., *Pseudomonas* sp., *Aspergillus* sp., *Mucor* sp. and *Penicillium* sp.

Vended apple was highly predominated with *Proteus* sp., (5.0×10^4 cfu mL^{-1}) while, *E.coli* had the least microbial count (1.0×10^4 cfu mL^{-1}) in apple. For carrot, *Pseudomonas* sp. and *E. coli* was prevalent (3.5×10^4 cfu mL^{-1}) and Micrococcus had the least occurrence of 0.4×10^4 cfu mL^{-1}, date palm had high incidence of *S. aureus* (6.0×10^4 cfu mL^{-1}) and Aspergillus (1.8×10^4 cfu mL^{-1}) having the least occurrence; watermelon had Shigella (7.7×10^4 cfu mL^{-1}) highly predominant as compared to other samples and the least occurrence was with *Penicillium* sp. and *Mucor* sp., (1.0×10^4 cfu mL^{-1}) as shown in Table 3.

Table 1: Mean microbial load of vended food samples (cfu mL^{-1})

Vended food samples	Total Aerobic Plate Count (TAPC)	Total Fungal Count (TFC)
Date palm	1.8×10^4	1.8×10^4
Watermelon	2.6×10^4	2.3×10^4
Apple	2.1×10^4	1.6×10^4
Carrot	3.0×10^4	1.5×10^4

Table 2: Microbial isolates from vended food samples

Vended food samples	Organisms isolated
Date palm	*Proteus* sp., *E. coli*, *Aspergillus* sp., *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas* sp.
Watermelon (sliced)	*E. coli*, *Salmonella* sp., *Staphylococcus aureus*, *Shigella*, *Aspergillus* sp. and *Penicillium* sp.
Apple	*E. coli*, *Salmonella* sp., *Shigella* sp., *Mucor* sp., *Proteus* sp.
Carrot	*E. coli*, *Salmonella* sp., *Shigella* sp., *Pseudomonas* sp., *Staphylococcus aureus*, *Aspergillus* sp., *Mucor* sp.

Table 4 shows the index of air contamination in the market. The total aerobic count for the refuse dump site opposite the market was higher than the densely populated site. For the densely populated site, *S. aureus* had the highest mean microbial count (210 cfu/dm^2/h) with *Micrococcus* sp., having the least mean microbial count (54 cfu/dm^2/h). *Bacillus subtilis* had the highest mean microbial count (254 cfu/dm^2/h) in air sample from the refuse dump site opposite the market; while Micrococcus had the lowest mean microbial count (63 cfu/dm^2/h) in air sample. Staphylococcus, Salmonella and Shigella, *Bacillus subtilis* and *E. coli* were more prevalent in the refuse dump site as shown in Fig. 1.

The effect of contaminated or polluted air on vended foods is enormous. The consumption of vended foods that have been exposed to microbial contamination from air increases the risk of food-borne diseases which are caused by diverse pathogens incident in air. The sanitary conditions and hygiene of vendors could also be a contributory factor to high microbial load in vended foods.

The high microbial load in carrot and watermelon can be attributed to the direct exposure to air. In the market,

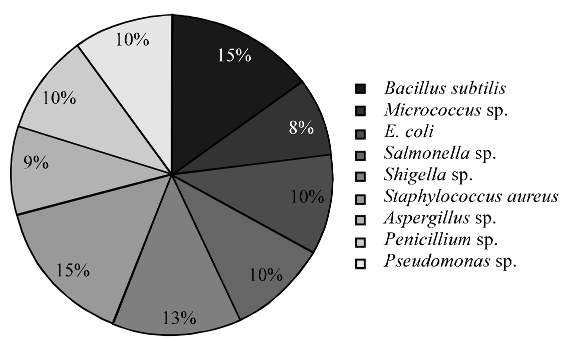

Fig. 1: Percentage occurrence of organisms isolated from air samples

Table 3: Mean total colony forming unit of microbial isolates from vended samples

Isolates vended food samples	Bacterial isolates *E. coli*	*Proteus* sp.	*Salmonella* sp.	*Shigella* sp.	*Staphylococcus aureus*	*Bacillus subtilis*	*Micrococcus* sp.	*Pseudomonas* sp.	Fungal isolates *Penicillium* sp.	*Mucor* sp.	*Aspergillus* sp.
Apple	1.0×10^4	5.0×10^4	4.0×10^4	ND	ND	ND	ND	ND	ND	1.6×10^4	ND
Carrot	3.5×10^4	ND	1.0×10^4	1.1×10^4	1.0×10^4	ND	0.4×10^4	3.5×10^4	ND	0.8×10^4	0.7×10^4
Date palm	5.0×10^4	2.0×10^4	ND	ND	6.0×10^4	3.2×10^4	ND	2.1×10^4	ND	ND	1.8×10^4
Watermelon	6.0×10^4	ND	1.2×10^4	7.7×10^4	5.0×10^4	ND	ND	1.6×10^4	1.0×10^4	1.0×10^4	1.3×10^4

ND = Not Detected

Table 4: Mean total viable count of microbial isolates in air samples (cfu/dm^2/h)

Sampling sites	*Micrococcus* sp.	*E. coli*	*B.subtilis*	*Salmonella* sp.	*Pseudomonas* sp.	*Shigella* sp.	*Staphylococcus aureus*	*Penicillium* sp.	*Mucor* sp.	*Aspergillus* sp.
Densely populated area in the market	54	87	206	78	94	196	210	81	0	68
Refuse dump site opposite the market	63	198	254	150	132	201	218	95	0	84

products are opened as often as the customers demand, open display of products to attract the customers encourage sporadic visits by flies. The dusty, unhygienic environment coupled with the poor handling by vendors are factors contributing to the high microbial load (Oranusi and Olorunfemi, 2011). The use of trays, tables, make-shift, stalls and wheel barrows constantly used by vendors also increases the chances of having food contamination. Pathogens can invade the interior surfaces of the produce during peeling, slicing, trimming and other processes like packaging, handling and marketing (CDC, 1979).

The chances of contamination is heightened by the fact that food vending is done without adequate storage conditions, thereby exposing the foods to flies harbouring microbes and also ensuring that the food kept at ambient temperature that favours the proliferation of microbial contaminants, pathogenic mesophiles and other disease causing agents (Bryan *et al*., 1992; Muinde and Kuria, 2005; Barro *et al*., 2006).

The presence of *E. coli* in the vended food samples is critical. This organism is found in the normal intestinal flora of humans and animals but can also be an important cause of enteric illness and they constitute the major etiologic agent of sporadic and epidemic diarrhea both in children and adults (Nweze, 2010; WHO, 1985). It has also been described as an environmental organism (Sagoo *et al*., 2001). The incidence of *E. coli* could have been as a result of poor sanitary practices.

Salmonella, *Staphylococcus aureus*, *Pseudomonas* sp. and *Aspergillus* sp., had 75% occurrence in the sample. The presence of Salmonella is of importance because it is known as a pathogen that causes typhoid fever and food poisoning (Parry *et al*., 2002; Ekperigin and Nagaraja, 1998). *S. aureus* is a common organism found in all individuals and expelled from the respiratory tract, nose, mouth, clothing, hand and skin. Aboloma (2008) and Wada-Kura *et al*. (2009) have reported that the incidence of *S.aureus* in food is an indication of environmental and human contamination. It has also been noted that sneezing, talking and coughing may produce droplets that is carried by air as vectors (Hobbs and Golbert, 1982). *S. aureus* is a pathogen of public health importance (Adak *et al*., 2005). *Pseudomonas* sp., is an opportunistic pathogen that causes bacteremia and gastrointestinal infections (Kim *et al*., 2009).

The presence of Micrococcus could be attributed to their presence in air. Shigella is a pathogen and its presence has been attributed to unhygienic practices related to feacal contamination (Fredlund *et al*., 1987; Beuchat, 1996). *Proteus* sp., is an environmental contaminant (Oranusi and Olorunfemi, 2011).

The incidence of Aspergillus, Penicillium could be attributed to the surrounding air (Aboloma, 2008). They are known as environmental contaminants and have also been implicated as food borne pathogens (Aboloma, 2008; Katherine *et al*., 2006; Oluwafemi and Simisaye, 2005).

Salmonella, Staphylococcus had the highest percentage occurrence in the air sample and this can be attributed to the unhygienic practices and poor sanitation in and around the market. The refuse dump site adjacent to the market is a breeding place for flies which still come to perch on vended foods. The food handlers are also contaminated because they also defecate around the market and use the same hands to hawk foods. All these unhygienic practices contribute immensely to the sub-standard state of vended foods.

The presence of the possible pathogenic organisms in the analyzed food samples should be of immense importance to vendors, consumers and concerned arms of government.

CONCLUSION

In conclusion, the result from this study has shown that air borne contaminants in the market contribute to the microbial load of vended foods sold in the main market in Lokoja town. This is exacerbated by the poor sanitary practices around the market. Consequently, attention should be given by the government to this market to ensure that the dump site opposite the market is cleared up and poor sanitation highly discouraged. Focus should be directed at eliminating microbial air contamination during marketing by packaging of products for sale as safety is of particular concern with vended foods. To prevent the occurrence of food borne illness, it is therefore, important to ensure that foods sold are safe and hygienic, public awareness programs should be employed to educate personnels involved in food processing and food vending (Taulo *et al*., 2008; Okonko *et al*., 2008a, b).

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