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Enumeration of Salmonella Species Isolated in Ready–to–Eat Fruits Vended in Bukuru Market, Jos South, Plateau State

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Authors' contributions

This work was carried out in collaboration among all authors. Author MSCR designed the study, wrote the protocol and the first draft of this manuscript. Authors EBA and AFU proof read and reviewed the manuscript. Authors MSCR and TOO performed the experiment, statistical analysis and managed the analyses of the study. Authors APB and CSSB monitored the progress of the study design and protocol. Author MSCR also managed the literature search, retrieval and review. All authors read and approved the final manuscript.

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ABSTRACT

Background: Despite control measures to curtailed salmonella fruit contamination over the years, pathogenic disease outbreaks caused by the ingestion of Salmonella contaminated fresh-cut-fruits pose a significant problem to human health by the consumption of fresh and minimally processed

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fruits. This study aimed to enumerate and determine the prevalence of Salmonella species isolated in ready-to-eat fruits vended in Bukuru Market Jos South, Plateau state.

Methodology: A total of seventy-eight ready-to-eat vended fruit samples were purchased and cultured for the enumeration of bacterial isolates according to National Food Safety Standard for Microbiological Examination. Pulp pH value of each fruit was obtained by immersing litmus paper into the pulp and results recorded.

Results: Of the 78 fruits specimen, 22 (28.2%) were Salmonella positive. The prevalence rates of salmonella isolated were found to be higher (22.7%) in both coconut and avocado followed by watermelon (18.2%) and sweetmelon (13.6%) as compared with other fruits in the study area. Lower rates of 4.5% were found in banana, pawpaw, and dates with a rise in apple with 9.1% respectively.

Conclusion: The study showed a high $p<0.05$ (7.811) prevalence of pathogenic Salmonella species isolated in ready-to-eat fruits in the study area revealing that the spread of salmonella is not independent of fruits thereby suggestive of contamination made available by fruit vendors in this part of the world. Thus, epidemiological traceability and significant measures must be taken to check the safety of these vended products before consumption.

Keywords: Enumeration; ready-to-eat fruits; Salmonella spp; isolation; Bukuru-Market; Salmonella contamination.

1. INTRODUCTION

Disease outbreaks caused by the ingestion of contaminated fresh cut fruits pose a significant problem to human health as source of contamination of these food products is linked to Salmonellosis [1,2], however, in some cases the higher incidence is attributed to vegetables than other food products [3,4]. Fruits comprise an essential part of human diet as one of the major sources of dietary nutrients of great importance. However, over the years, fruit has a dramatic increase in outbreaks of food-borne illness caused primarily due to salmonella by the consumption of fresh and minimally processed fruits accounting for 130 outbreaks in the United states [5-8]. *Salmonella* contamination is mostly associated with produce such as poultry, cattle and their feeds but other products such as dried foods, infant formula, fruit and vegetable products and pets have become important [9]. The consumption of street foods has been suggested to potentially increase the risk of foodborne diseases as street foods are readily contaminated from different sources as there is no proper safety, quality and hygiene practices during preparation [10,11]. In Nigeria, mostly the North – Central Nigeria and at different parts of the world have indicated the pollution and contamination of common fruits and vegetables by salmonella species where small-scale farmers cultivate vegetables and fruits generally marketed at different markets within the respective local communities [12]. Thus, informed the enumeration and prevalence determination of *Salmonella* species isolated in ready-to-eat vended fruits in Bukuru market of Jos south, Plateau state.

2. MATERIALS AND METHODS

A stratified sampling technique was adopted where samples were divided into homogeneous population based on specific characteristics. The selected stratum was then sample using a 5.3% probability sampling method of randomization in accordance to Adesetan *et* al. [13] as calculated with 5% desired absolute precision and 95% confidence interval using the Cochran's (1963) formula recommended by Thrusfield, [14] as stated $N_0=z^2pq/e^2$ thereby, a total of seventy-eight (78) ready-to-eat vended fruit samples from 13 different fruits (apple, avocado, sweetmelon, coconuts, sliced watermelon, pawpaw, orange, mango, African cherry, dates, banana, pineapple and cashew) comprising of six (6) samples each were purchased from the Bukuru market and packaged in polyethene bags then transported to the Bingham University Multipurpose Laboratory Jos campus for enumeration of bacterial isolates within 30 minutes in cold box. In the laboratory, 25g of each sample was weight, blended and homogenized with agitation for 3 minutes and pre-enriched in 225ml of buffered peptone water (BPW) incubated at 37^oC for 18 hours according to National Food Safety Standard for Microbiological Examination thereafter a 10µl was streaked on a section of xylose lysin deoxycholate (XLD) medium for 24hrs at 37^oC and second isolation was done on SSA medium for 24 hrs at 37^oC respectively. For the enumeration of Salmonella specie in food

myriads and products, the method by Luo et al. [1] was followed while the microscopic investigation for Gram reaction and morphological features of suspected colony was determined using standard method of Grams staining and biochemical test by Cheesbrough, [15]. Pulp pH value of each fruit was obtained by immersing the litmus paper into the pulp and results recorded.

3. RESULTS AND DISCUSSION

The results showed that out of the 78 fruits specimen collected, 22 (28.2%) specimens were Salmonella positive. In this, only 8 fruits group had Salmonella spp. (38.6%) and 5 fruits group had (61.4%) growth of other gram-negative bacteria isolated in the study area. This concurs with a study conducted by Lukasz et al. [16] in Poland who reported a 25% prevalence rate of salmonella isolated in samples of plant origin such as fruits, vegetables and spices and Iveren et al. [12] in Makurdi revealed that all the sampled fruits and vegetables sold in the markets were contaminated with pathogenic bacteria. However, high prevalence (66.7%) rate of Salmonella spp. was reported by Orji *et* al. [17] in Ebonyi revealed that isolated organisms from the vended fruits contamination occurred due to poor hygiene and environmental factors like contaminated air. In Gram's staining, the organism appeared as Gram negative, short rod-shaped bacteria, arranged in single and paired under light microscope, these characteristics correspond to Salmonella spp. as described by Bae et al. [18].

In table 2, the prevalence rates of salmonella isolated were found to be higher (22.7%) in both coconut and avocado followed by watermelon (18.2%) and sweetmelon (13.6%) as compared with other fruits in the study area. Lower rates of 4.5% were found in banana, pawpaw, and dates with a rise in apple with 9.1% respectively. This implies that the acidic contain in other fruits could not permits the growth of salmonella isolates. This is in consonance with the findings of Pui et al. [19] who reported that the growth of salmonella is completely inhibited at pH <3.8, the water activity of <0.94 and temperatures of <7°C. Additionally, Keerthirathne et al. [20] revealed that Salmonella typhimurium has a regulated response to further protect itself from acid stress by the process called the acid tolerance response (ATR) that protects Salmonella spp. at pH levels of 3.0–4.0, but is activated when environmental pH values are between 5.5 to 6.0 (Table 1). Moreso, in the present study, the chi square test for the degree of association and hypothesis of Salmonella in the study area showed $p<0.05$ (7.811) indicative of the spread of Salmonella is not independent of fruits.

Table 1. Enumeration rates of Salmonella spp. from vended fruit samples in the study area

Samples	No. examined (N=78)	Pulp pH values of ready-to-eat fruits	No. of positive for Salmonella spp. (N=22)	Percentage (%)
B	6	3.0	1	4.5
M	6	6.0	0	0
A	6	5.0	2	9.1
Av	6	6.0	5	22.7
Pw	6	4.0	1	4.5
Wm	6	7.0	4	18.2
Sm	6	7.0	3	13.6
O	6	5.0	0	0
Ca	6	4.0	0	0
P	6	7.0	0	0
Ac	6	3.0	0	0
Cn	6	6.0	5	22.7
D	6	6.0	1	4.5
		28.2%	**100**	

Keys: B=Banana, M=Mango, A=Apple, Av=Avocado, Pw=Pawpaw, Wm=Watermelon, O=Orange, Sm=Sweetmelon, Cn=Coconut, D=Dates, Ca=Cashew, P=Pineapple, and Ac=African cherry

Table 2. Gram-negative bacteria isolated from different fruits in the study area

Organisms	B	A	Av	M	Pw	Wm	Sm	Cn	D	O	Ca	P	Ac	Total (%) *	(X^2)
Salmonella spp.	1	2	5	0	1	4	3	5	1	0	0	0	0	22 (38.6)	7.81
E. coli	0	1	0	3	2	0	0	0	0	2	1	0	2	11 (19.3)	1.55
Shigella spp.	2	2	1	1	1	1	3	0	0	1	0	3	1	16 (28.1)	3.99
Proteus spp.	3	0	0	2	0	0	0	0	0	2	0	1	0	8 (14.0)	1
Total	**6**	**5**	**6**	**6**	**4**	**5**	**6**	**5**	**1**	**5**	**1**	**4**	**3**	**57 (100)**	(p<0.05)

*Key: B=Banana, M=Mango, A=Apple, Av=Avocado, Pw=Pawpaw, Wm=Watermelon, O=Orange, Sm=Sweetmelon, Ca=Cashew, P=Pineapple, and Ac=African cherry , *Percentages in parenthesis*

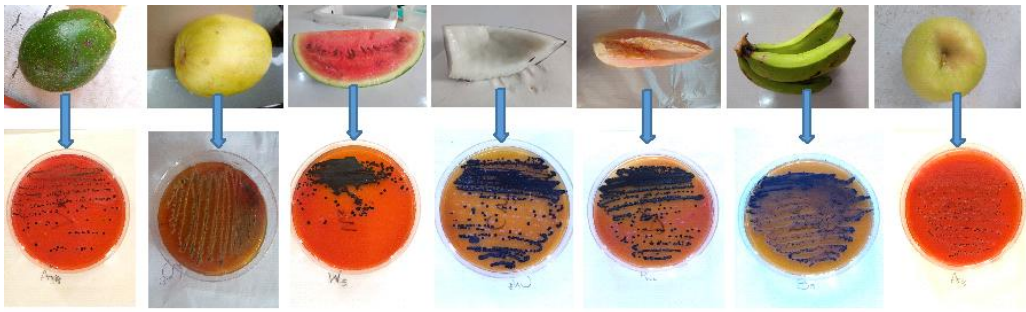

Fig. 1. Plates showing photograph and colonies of salmonella spp. Isolated from vended ready-to-eat fruits in the study area

Apart from Salmonella organisms isolated, several pathogenic bacterial species are primarily responsible for the contamination of ready-to-eat fruits and stand as a threat. Having been evidenced in this study by the isolation of these species from various fruits such as *E*. coli (19.3%), Shigella spp. (28.1%) and Proteus spp. (14.0%), this concurs with the report of Balali et al. [21], who revealed that sources of contamination and type of pathogenic agents isolated from fresh fruits and veggies are E. coli O157:H7, Listeria monocytogenes, Salmonella spp., Shigella etc. Moreso, researchers reported in their work that other isolates can be identified in ready-to-eat fruits as seen in studies conducted in Kwara state [22], in Ogun state [23], in Kogi state [24] and in India Tambeker et al. [25] as seen in Table 2.

4. CONCLUSION

The present study shows that p<0.05 (7.811) thus the spread of salmonella is not independent of fruits. This consequently suggests contamination of the ready-to-eat fruits made available by fruit vendors in this part of the world. Though, most ready-to-eat fruit contaminated with pathogens are either from the environment or vendors through processing and handling that could potentially cause diseases. Thus, epidemiological traceability is difficult for fruits as carriers of foodborne pathogens but significant measures must be taken to check the safety of these vended products before consumption**.** The need to explore routes of contamination involve in salmonella infection outbreaks is commendable in other to ensure fresh fruits safety.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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