Microbial Profile of Dawadawa Vended in Tamale Central Market

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Abstract

Background: Dawadawa is a common spice used in most rural homes across West Africa to spike the protein source in meals. This study assessed the handling practices of vendors and the microbial load of dawadawa vended in the Tamale Central Market.

Methods: A total of 15 samples were collected from 5 sections of the market using the random stratified sampling technique.

Results: Out of the 15 samples collected, 8 samples (53.33%) had *Salmonella* spp, 1 sample (6.67%) had *E. coli* and all 15 samples (100%) had *Staphylococcus aureus*.

Conclusions: Samples covered recorded no count of *Salmonella* spp and *E. coli* but high counts for *Staphylococcus aureus*. Factors accounting for the high prevalence of *Staphylococcus aureus* might be cross-contamination associated with improper handling practices as the human skin is known to be a reservoir of *Staphylococcus aureus*. Hence, the need for vendors to package dawadawa in neat disposal packs to reduce direct contact.

Introduction

In recent times, consumers have become inclined towards nutritious and hygienic natural products containing herbs or spices in the composition of foods. Spice is an edible part of a plant that is either whole, powdered, or crushed gotten from plant bark, seed or roots used for flavouring and preservation of food (Bedada et al. 2019). Traditionally, spices may be used to speed-up the recovery process, enhance uterine contraction after childbirth as well as relieve pain such as rheumatic pains.

Dawadawa is a local spice made from *Parkia biglobosa* mainly known as Africa locust bean tree. It is used in the seasoning of soups, stews, and other dishes. Dawadawa is widely known to enhance the meatiness of dishes and is considered to be a good source of protein especially for the poor (Esenwah and Ikenebomeh, 2008). However, spices can be contaminated through numerous means with a host of toxic and pathogenic bacteria (Székács et al. 2018). Microbes exist in diverse forms which include fungi, bacteria, viruses among others. Several microbes cause harm to plants and animals (Sattley and Madigan 2015).

Worldwide, it is estimated that about 93.8 million people suffer from illness associated with gastroenteritis, with 155 thousand deaths and a mean occurrence of 1.14 episodes per 100,000 persons. These statistics are associated with infection from *Salmonella* spp (Harb et al. 2019). The contributory factors associated with food contamination could be chemical or biological. *Vibrio cholera*, *Shigella* spp, and *Salmonella* spp are examples of biological contaminants (Hussain 2016). Among the hurdles that the health sector faces, food contamination issues that primarily arise from poor hygienic conditions are top on the list. Cooking equipment and utensils may be means of pathogen transfer to food (Akanele et al. 2016). Dawadawa from the production site, salespersons through to the consumers goes through

various handling and storage processes that can cause microbial contamination. Hence the need to determine the occurrence of pathogenic bacteria (i.e. *Salmonella* spp., *E. coli* and *Staphylococcus aureus*) which are of public health concern in this product.

Materials And Methods

Study area

The study was conducted at the Tamale Central Market, which is the main market located in the heart of the Central Business District of the Tamale Metropolis in the Northern region. Tamale is estimated to have a land size of about 646.90180 km^2, at longitude 0^0 36 and 0^0 57 West and latitude 9^0 16 and 9^0 34 North. The Metropolis shares boundaries with Central-Gonja to the South-West, Sagnarigu West and North, Mion District to the East and East-Gonja to the South (Ghana Statistical Service 2014).

Sampling Technique And Data Collection

Stratified random sampling was used to collect the dawadawa samples. The central market was sectioned into five to ensure the representativeness of the samples in the area. A total of 15 samples were collected into sterile bags which were well labelled. The samples were placed in a thermo-flask containing ice cubes and transported to the Council for Scientific and Industrial Research – Water Research Institute, Tamale laboratory for analysis.

A questionnaire was administered to 15 vendors from whom the samples were brought. The primary objective of the questionnaire was to find out if the vendors produced the product themselves and the duration it stays on the market. Personal observations such as the mode of product display, whether covered or uncovered were also taken into consideration.

Peptone Water Preparation

The peptone water was prepared according to the manufacture`s protocol, thus 20 g of peptone powder into 1000 ml of distilled water. Peptone powder of 67.5 g was measured using an electric scale and transferred into a beaker (American Public Health Association (APHA) 2017). Distilled water 3375 ml was poured into a beaker containing the peptone powder and stirred continually to dissolve suspended particles. The peptone solution was then poured into glass bottles and sterilised using at a pressure of 103.4 Kpa, cooled and stored in the refrigerator (APHA 2017).

Sample Preparation

After the collection of samples, they were taken to the laboratory for analysis. Each sample was grounded into a powdery form and weighed using an electric balance to a weight of 25 g and poured into sterile zip lock bags which were earlier labelled in ascending order. The zip lock bags containing the measured samples were then sent to the laminar flow hood. Peptone water of 225 ml was added to each sample

under the Ultraviolet (UV) light chamber in accordance with APHA (2017) procedure. The mixture was manually massaged until homogenisation was achieved.

Preparation of Salmonella-Shigella agar, Chromo cult agar and Mannitol salt agar

Salmonella-Shigella (SS) Agar and Chromo cult agar of 63 g and 17.25 g were respectively measured into a 500 ml beaker each. Distilled water of 1000 ml was poured into the beaker containing each of the measured agar and stirred. The mixture was heated to completely dissolve suspended particles using a hot plate with stirrer and then kept to cool to room temperature in the lamina flow hood disinfected with 70% alcohol in accordance with APHA (2017) procedure. The media was poured into sterilised petri-dishes and allowed to solidify.

Mannitol salt agar was weighed in to a beaker and 100 ml of distilled water added and stirred. The mixture was allowed to boil with continual stirring to dissolve properly. The homogenised media was then sterilised at 102.4 Kpa at temperature of 121°C using the pressure heat steriliser in accordance with APHA (2017) procedure. The solution was cooled in a lamina hood to about 48°C.

Statistical analysis

Analysis of variance (ANOVA) was done using version 16.0 of the microsoft excel at a significance level of $P< 0.05$ for the microbes, location and sources and mode of packaging.

Results And Discussion

Occurrence of microbial isolates in dawadawa

The occurrence of *Salmonella* spp, *E. coli* and *Staphylococcus aureus* are shown in Table 1. The detection of these bacteria may be as a result of poor food handling practices and storage procedures that are mostly observed in small-scale processing units in rural developing countries (Oloo et al. 2018). Developing countries are faced with the struggle of poor, disintegrated, and uncoordinated food safety systems that poses immense danger to the health of consumers. This menace is on the rise as a result of weak implementation of food safety regulation (Oloo et al. 2018). Most food processing sites are set up in backyards or squalid areas. Some are managed by persons with no expertise in food technology hence their inability to adhere to food safety standards (Oloo et al. 2018). Dawadawa preparation goes through various processes of preparation before it reaches the consumer. These processes, if not handled according to safety standards will expose the product to microbial contamination (Ajayi 2014).

Table 1
Bacterial count of dawadawa samples from various sections of the market

Site	Sample	Ss (cfu/g)	E. coli (cfu/g)	Sa (cfu/g)	Ss	E. coli	Sa
						OCCURRENCE	
Section 1	A1	0	0	26	⬚	⬚	⬚
Section 1	A2	0	0	108	⬚	⬚	⬚
Section 1	A3	0	0	141	⬚	⬚	⬚
Section 2	B1	14	0	101	⬚	⬚	⬚
Section 2	B2	2	0	141	⬚	⬚	⬚
Section 2	B3	221	0	132	⬚	⬚	⬚
Section 3	C1	151	0	30	⬚	⬚	⬚
Section 3	C2	207	0	55	⬚	⬚	⬚
Section 3	C3	4	18	14	⬚	⬚	⬚
Section 4	D1	209	0	98	⬚	⬚	⬚
Section 4	D2	0	0	98	⬚	⬚	⬚
Section 4	D3	0	0	110	⬚	⬚	⬚
Section 5	E1	0	0	91	⬚	⬚	⬚
Section 5	E2	11	0	48	⬚	⬚	⬚
Section 5	E3	0	0	74	⬚	⬚	⬚
Note: Ss: Salmonella spp count, E. coli; E. coli count, and Sa: Staphylococcus aureus count							

The mean count of *Staphylococcus aureus* was 85.21 cfu/g and *E. coli* had the least mean count of 12.29 cfu/g (Table 2). *Staphylococcus aureus* was significantly higher in numbers than *E. coli* (Table 2).

Table 2
The mean count of bacteria in dawadawa samples

Microbe	Mean ± SD	P-value
Salmonella spp	59.21 ± 9.53	0.034
E. coli	12.29 ± 4.81	0.336
Staphylococcus aureus	85.21 ± 43.04	0.001

Bacterial counts obtained from all the 15 samples collected showed a greater percentage of *Staphylococcus aureus* i.e 63%, than *Salmonella* spp and *E. coli* (Fig. 1).

Bacteria Count Based On Duration On Market

According to key informants, dawadawa products remain on the market within a space of one week after production. From data collected, 10 (66.67%) vendors asserted to the sales of their product below a week (daily) whilst 5 (33.33%) asserted that it takes a maximum of week (weekly) for a batch to be sold (Fig. 2). This could be attributed to the exposure to the atmosphere as the days go by. The duration of products on market increases the risk of contamination if not stored properly (Svobodová and Tůmová, 2015). The more a product is exposed to environmental factors the more highly its prone to microbial contamination (Temitope and Igbokwe 2014). *Staphylococcus aureus* has the highest occurrence in all time durations whilst *E. coli* had the least (Fig. 2).

Bacteria isolation based on mode of packaging of dawadawa for sales

This distribution was based on the state of packaging of the dawadawa samples from the market. Covered samples recorded no count of *Salmonella* spp and *E. coli* but higher counts of *Staphylococcus aureus*. Covered products recorded a low count for microbial presence in all isolates due to reduced contact with houseflies and the atmosphere. The higher counts of isolates for uncovered samples could be associated with exposure to environmental factors (microbial spores in the air). Microbial spores are present in the atmosphere and can multiply when attached to favourable surfaces/ substances/ media (Majeed 2017).

Distribution of the bacteria based on sections of the market

Bacterial prevalence varied based on sample collection points (Fig. 3). Samples collected around highly polluted environments like samples from B3, C1, C2, and D1 recorded the presence of *Salmonella* spp whilst A2, A3, B1, B2, B3 and D3 had higher counts of *Staphylococcus aureus*. *E. coli* isolates were from samples collected from location (C3) near to the public toilet. *E. coli* presence indicated a fresh faecal matter contamination of the dawadawa. *E. coli* is known to be associated with faecal matter contaminations (FAO 2016).

Distribution of bacteria based on the product chain

The classification along the product chain, from processors to wholesale and/or retailers showed bacterial contamination resulting from their activities (Fig. 4). The wholesale packaging (moulding into balls) and remoulding by retailers and repackaging to consumers; with hands, containers, water used in sprinkling to mould are major sources of bacterial contact with the processed dawadawa. All these chain processes of handling could contribute to the varying bacterial counts of all the three isolates. Observation from the study indicated that samples obtained from producers were relatively high in the three isolates especially *Staphylococcus aureus* due to compromise in food safety standards. This result

is similar to reports on prevalence of microbes associated with production, environment and persons involved with production of food (Adu-Gyamfi et al. 2012; Biranjia-Hurdoyal and Latouche 2016).

Dawadawa is a common alkaline fermented spice or condiment and like all other spice it is dried in an open area under the sun with the intension of reducing microbial load and sold with no further treatment done to them. It comes as no surprise as studies revealed the inclusion of micro flora species in spices hence the isolation of *Salmonella* spp, *E. coli* and *Staphylococcus aureus* (Banerjee and Sarkar 2003).

Bacterial count variation observed in the spices could be as a result of factors such as mode of presentation on the market, duration on the market, source of product and product chain transfer from producers to retailers. Generally, all the processes involved in the preparation of dawadawa poses a threat of potential food contamination; bare feet, sand, mortar and pestle are employed in the de-hulling process, water used in the preparation process, fermentation, drying and moulding and finally plastic bags employed in packaging could all be sources of contact contamination of the product (Ajayi, 2014).

Conclusion

From the study, all samples tested positive for *Staphylococcus aureus*. Factors accounting for the prevalence of *Staphylococcus aureus* might be cross-contamination associated with improper handling practices as the human skin is noted to be the largest reservoir for *Staphylococcus aureus*. The microbial count for *E. coli* may be associated to fresh faecal contamination. Bacterial count variation was attributed to factors such as mode of presentation on the market, duration on market, source of product and product chain transfer from processors to retailers. Generally, the processes involved in preparation of dawadawa is also a potential source of contamination and that could be investigated in further studies.

Abbreviations

APHA: American Public Health Association; *UV: Ultraviolet;* SS: Salmonella-Shigella; ANOVA: Analysis of variance; *Ss: Salmonella* spp; *Sa: Staphylococcus aureus*

Declarations

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Authors 'contributions

All the authors made significant contributions to the document and agree to its publication. The contributions were performed in the following order: Conceived and designed the experiments: DMH, ABD,

AZI, ZN and the research was performed by DMH. Analysed the data: DMH, ZN, GQ and NB. Contributed drafting of the manuscript; critical revision of the manuscript for important intellectual content; statistical analysis: DMH, ABD, ZN, AZI, GQ and NB. The authors read and approved the final manuscript.

Availability of data and materials

All data generated or analyzed during this study are included in this article.

Competing interests

Authors have no conflicting interest.

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References

Adu-Gyamfi A, Torgby-Tetteh W, Appiah V (2012) Microbiological quality of chicken sold in Accra and determination of D_{10}-Value of E. coli. Food and Nutrition Sciences, 03(05):693–698.

Ajayi OA (2014) Bacteriology and qualitative study of African locust bean (Parkia biglobosa). Open Journal of Social Sciences, 02(11):73–78.

Akanele E, Mgbo S, Chukwu O, Ahudie CM (2016) Microbiological contamination of food: the mechanisms, impacts and prevention. International Journal of Scientific & Technology Research, 5(3):65–78.

American Public Health Association (APHA) (2017) Standard methods for the examination of water and wastewater, 23rd edn. American Public Health Association (APHA), Washington, D. C.

Bedada TL, Derra FA, Gebre SG, Sima WG, Edicho RM, Maheder RF, Negassi TY, Asefa YB (2019) Microbial evaluation of spices in ethiopia. The Open Microbiology Journal 12(1): 422 - 429.

Banerjee M, Sarkar PK (2003) Microbiological quality of some retail spices in India. Food Research International, 36(5); 469–474.

Biranjia-Hurdoyal S, Latouche MC (2016) Factors affecting microbial load and profile of potential pathogens and food spoilage bacteria from household kitchen tables. Canadian Journal of Infectious Diseases and Medical Microbiology, 2016: 1–6.

Esenwah CN, Ikenebomeh MJ (2008) Processing effects on the nutritional and anti-nutritional contents of African locust bean (Parkia biglobosa, Benth.) seed. Pakistan Journal of Nutrition, 7:214 - 217.

FAO (2016) Food in Urban.

Ghana Statistical Service (2014) 2010 Population and housing census report.

Harb A, O'Dea M, Abraham S, Habib I (2019) Childhood diarrhoea in the Eastern Mediterranean Region with special emphasis on non-typhoidal Salmonella at the human - food interface. Pathogens, 8(2): 60. https://doi.org/10.3390/pathogens8020060

Hussain M (2016) Food contamination: major challenges of the future. Foods, 5(4): 21. https://doi.org/10.3390/foods5020021

Majeed A (2017) Food toxicity : contamination sources, health implications and prevention. Journal of Food Science and Toxicology, 1: 1 - 2.

Oloo B, Daisy L, Oniang'o R (2018) Food safety legislation in some developing countries. In Food Safety - Some Global Trends. https://doi.org/10.5772/intechopen.75587

Sattley WM, Madigan MT (2015) Microbiology. In eLS (pp. 1–10). https://doi.org/10.1002/9780470015902.a0000459.pub2

Svobodová J, Tůmová E (2015) Factors affecting microbial contamination of market eggs: a review. Scientia Agriculturae Bohemica, 45(4): 226 - 237.

Székács A, Wilkinson MG, Mader A, Appel B (2018) Environmental and food safety of spices and herbs along global food chains. Food Control, 83: 1–6.

Temitope PF, Igbokwe OE (2014) Impact of air pollution on the microbiological quality of ready to eat hawked foods sold around a cement factory in Lokoja, Nigeria. American Journal of Research
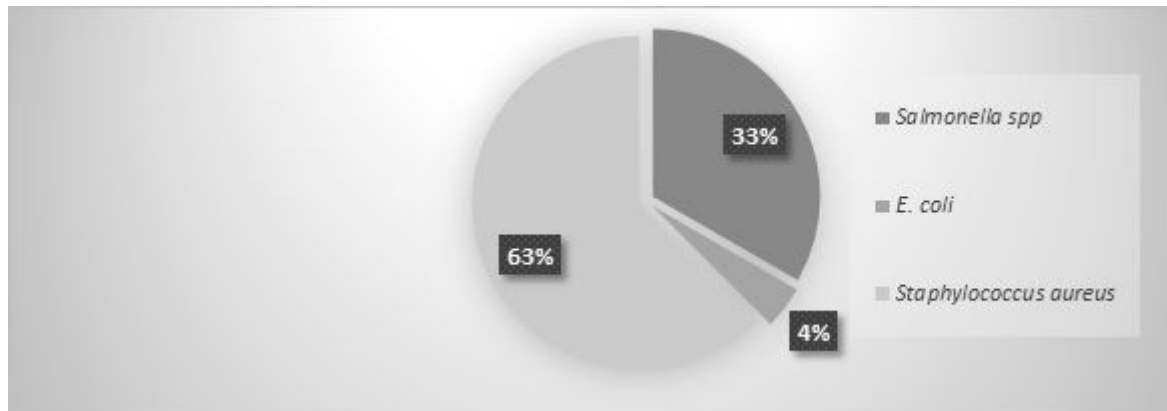
Communication, 2(11): 138–157.

Figures

Figure 1

Prevalence of bacteria isolates in the dawadawa samples collected
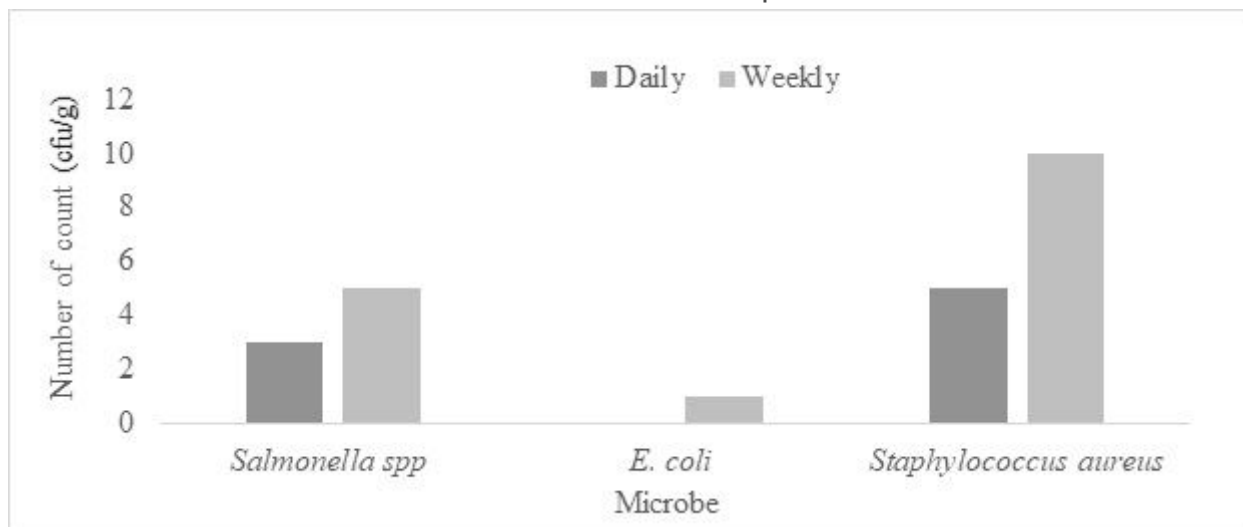

Figure 2

Positive bacteria count in dawadawa samples based on duration on the market
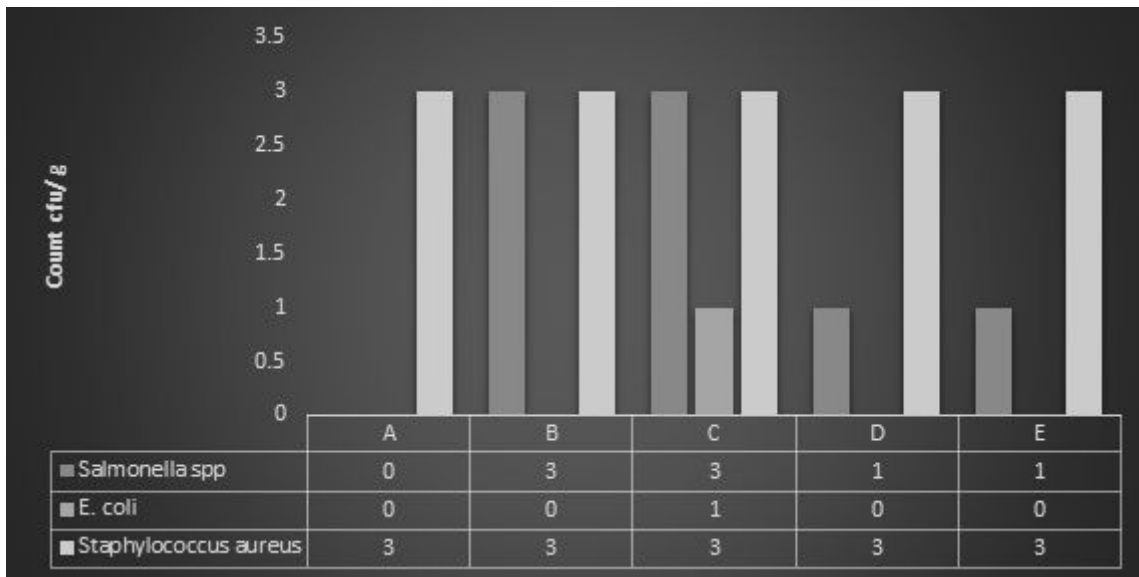
Figure 3

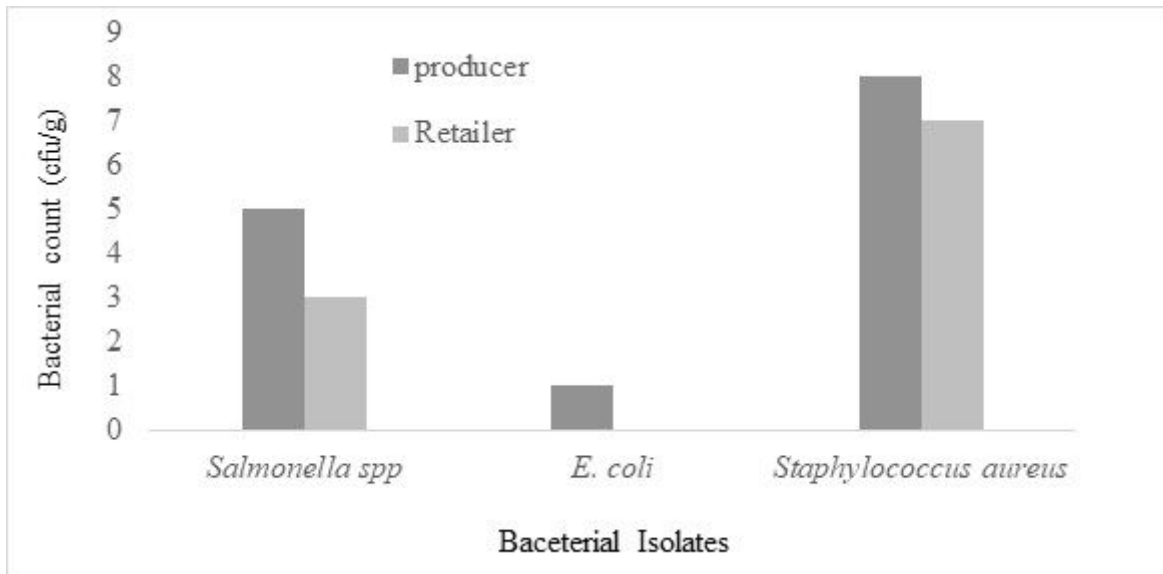Microbial isolates in dawadawa samples based on sections

Figure 4

Distribution of bacteria isolates base on the product chain