Original Research Article

PERSISTENT MICROBIAL CONTAMINANTS IN HAWKED 'OGI' AND PUBLIC HEALTH CONCERNS IN COVID-19 ERA

ABSTRACT

Aim: The guarantee of quality and safety of foods and all the agents involved in the processes of the food chain in the covid times is of public health concern. This study aimed to evaluate the safety quality of street vended 'Ogi' from selected Street hawkers in Iwo, Nigeria in light of the present COVID-19 pandemic.
Study design: The experimental design used is completely randomized.
Methodology: Vendors from five locations were randomly selected to procure samples. pH, total titratable acidity (TTA), microbial loads, identification of isolates, and storability studies were carried out using standard methods.
Results: pH ranged from (4.1 to 6.3); TTA (0.6 to 0.75 %) for raw 'Ogi' slurry. All the 'Ogi' samples were contaminated. Counts ranged from ($2.6x10^7$ to $1.3x10^8$ CFU/g); ($5.6x10^6$ to $2.0x10^7$ CFU/g); (5.2 to $7.2x10^7$ CFU/g); ($6.2x10^6$ to $6.1x10^7$ CFU/g); and ($1.2x10^5$ to $4.4x10^6$ CFU/g) for total viable (TVC); *Staphylococcal*; *Salmonella-Shigella*; *Lactobacillus* and fungal respectively. pH of cooked 'Ogi' ranged from (4.2 to 6.1); TVC and *Salmonella-Shigella* count ranged from (2.3to 8.5x 10^6 CFU/g), (1.7 to 3.3x 10^6 CFU/g); ($5.8x10^6$ to $1.5x10^7$ CFU/g), (3.1 to $7.9x10^6$ CFU/g); and ($6.6x10^6$ to $1.6x10^7$ CFU/g), ($4.0x10^6$ to $1.0x10^7$ CFU/g) for days 1, 2 and 3 respectively.
Conclusion: Even after 'Ogi' is cooked, there is still a high probability of survival of some pathogens in this functional food, and consumption could result in gastro-intestinal disorder, thereby creating a food safety concern for consumers who may have other health challenges.

Keywords: *Contaminants, 'Ogi', Hawked foods, Consumer safety, COVID-19pandemic*

1. INTRODUCTION

COVID-19 pandemic has caught the world by surprise, including African nations. Although vaccines have been developed, the effect of the pandemic on food security is observable [1]. Furthermore, there are concerns of safe food handling and personal hygiene of food workers.According to [2], the aggressive spread of COVID-19 has raised many questions about the safety of workers in the food sectors, and even more dire in countries where food

safety regulations are neither strictly enforced nor adhered to. In Nigeria for example there is in-discriminate preparation of food on the roadside and hawking. Individuals with health challenges should not have to worry about if food purchased from a street vendor is safe for consumption.

Many people young and old alike consume 'Ogi' in Nigeria and other African countries because it is easily digested. For example, cooked 'Ogi' is used as a weaning food for babies and young children, while some nursing mothers consume it to stimulate breast milk production. It is also consumed by individuals who are sick [3]. Furthermore, the uncooked 'Ogi' has been documented to relieve stomach discomfort and reduce the frequency of stooling [4]. The physical and biochemical qualities of 'Ogi' are influenced by the type of cereal grain used, duration of fermentation, and the milling method. During the processing of maize to 'Ogi', there are nutrient losses such as protein and minerals [5,6,7].

'Ogi' being a fermented food product is likely to have a relatively high microbial population than most foods. According to several studies, fermenting organisms include *Lactobacillus*, *Saccharomyces* and *Candida* species [8,9].*Lactobacillus* and *Candida planetarium* are the predominant microorganism while bacteria such as *Corynebacterium* hydrolyzes the corn starch and then yeasts of the *Saccharomyces* species also contribute to the flavor development [8]. These microorganisms are probiotics, which contribute nutritionally to the end product and also add unique taste, aroma, and flavour to the product.

'Ogi' is usually produced by small to medium scale establishments, rural, and mostly uneducated women. After the fermentation process, the finished product is packaged in leaves or polyethylene bags and hawked. Since 'Ogi' is mainly produced by local means its' operations are not usually standardized thus leading to contamination by harmful microorganisms that may sometimes lead to foodborne diseases. The contamination level usually varies with the technique of production and the personal hygiene of the producers. Further, the safety of 'Ogi' may not be guaranteed as it may be contaminated with microorganisms from water, soil, dust, handler's hands, environment, utensils, and equipment during production, packaging, sales, and storage. All these factors make consumption of 'Ogi' a public health concern particularly if the immunity status of the individual is low because of other health-related challenges. Consumption of un-hygienically produced 'Ogi' exposes individuals who are vulnerable such as young, old, pregnant, and immune-compromised, to various types of foodborne diseases. In this era of the COVID pandemic, 'Ogi' continues to be one of the most commonly consumed fermented foods, it is, therefore, important to investigate if hawked 'Ogi' could be a vehicle of foodborne pathogens, increasing the prevalence of foodborne diseases and complicating recovery of Nigerians.

2. MATERIAL AND METHODS

'Ogi' samples were purchased from five (5) different street food vendors and locations in Iwo, Osun State. Locations are: Koba-ope (KBO), MOT, Oke- Odo (OEO), Oke- Afo (OEA), and Oke- Ola (OEL) Areas. The samples were kept in containers with lids, labelled, transported, and stored in a refrigerator (4 - 7 degrees Celsius) in Food Science and Technology Laboratory at Bowen University, Iwo until used.

MICROBIAL LOAD OF STREET HAWKED 'OGI'

Sample preparation

About 10 g of each sample was weighed and homogenized with 90 mL sterile 0.85% saline solution, and further diluted up to (10^{-4}). About 1.0 mL of the last dilution was pipetted in duplicate into petri dishes and different media using the pour plate method was added [10]. Nutrient agar, *Salmonella-Shigella* agar, de Mann Ragossa and Sharpe (MRS), for Lactobacillus, Mannitol Salt, and potato dextrose (PDA) agars (Lab M) were inoculated. Petri

dishes were incubated at 37 degrees Celsius and observed for 24 h under aerobic conditions, while plates for fungi count were incubated at 28 degrees Celsius for 72 h. MRS agar plates were incubated at 35±2degrees Celsius for 48h under anaerobic conditions. All plates containing 30-300 colonies were enumerated.

Identification of Isolates

Colonies were isolated and purified by repeated sub-culturing on Nutrient broth and pure culturing on Nutrient agar. Gram staining and biochemical (MRVP, Indole, Catalase, motility, and carbohydrate fermentation) assays were performed in order to identify the bacterial isolates according to [11].

Preparation of Cooked 'Ogi' samples

About 250 g of raw 'Ogi' slurry was dissolved in 600 mL of potable water, and then heated to a boil to turn it into soft gel while constantly stirred. They were then packaged in light polyethylene wraps, clear bowls, or traditional leaves (*Tectona grandis*) to determine the safest package for cooked 'Ogi'. Microbial load of cooked 'Ogi' (Agidi) samples were also carried out during storage following previous method.

pH and Titratable Acidity (TTA)

The pH of samples was measured according to AOAC [12]. Briefly, 1 g of each sample was dissolved in 100 mL of distilled water and the slurry was mixed thoroughly for homogeneity. Then each sample was divided into three aliquots of 30 mL each and the pH was measured in triplicate with a pH meter (ATC pH meter, Hanna Inc., China). Total titratable acidity was determined by the standard titration procedure for TTA according to [10]. Approximately 2 g of sample was weighed into 20 mL of distilled water and shaken thoroughly to form a suspension. The suspension was then titrated against 0.1M of sodium hydroxide (NaOH) after the addition of 3 drops of phenolphthalein as indicator, until the reaction mixture turned pink. Total titratable acidity was expressed as percentage of lactic acid.

Mineral Content Determination

The samples were pre-ashed according to [12], with slight modification. Briefly, 80 g of each sample was weighed into clean previously weighed ceramic crucibles and placed in a muffle furnace (Vecster ECF3, UK) at 585 °C overnight. Calcium (Ca), magnesium (Mg), Iron (Fe) and Phosphorus (P) were determined using the Atomic Absorption Spectrometer (PG 990, United Kingdom).

3. RESULTS AND DISCUSSION

MICROBIAL LOAD OF RAW 'OGI' SLURRY SAMPLES

All the 'Ogi' samples had microbial contaminants, with total viable count (TVC) ranging from ($2.6x10^7$ to $1.3x10^8$ CFU/g). Staphylococcal count ranged from ($5.6x10^6$ to $2.0x10^7$ CFU/g). *Salmonella- Shigella* count ranged from (5.2to$7.2x10^7$ CFU/g). *Lactobacillus* count ranged from ($6.2x10^6$ to $6.1x10^7$ CFU/g) while the fungal count ranged from ($1.2x10^5$ to $4.4x10^6$ CFU/g) (Table 1). Sample from Oke-Ola (OEL) had highest count for total viable, Staphylococcal and *Salmonella-Shigella*.

Table 1: Microbial load (CFU/g) of raw 'Ogi' samples

Location of Sample	Microbial load (CFU/g) TVC	Staphylococcal	*Salmonella-Shigella*	*Lactobacillus*	Fungal
KBO	$2.6\pm0.07^{d}x10^{7}$	$1.6\pm0.7^{b}x10^{7}$	$5.4\pm0.7^{d}x10^{7}$	$7.5\pm0.3^{d}x10^{6}$	$4.4\pm0.7^{a}x10^{6}$
MOT	$4.8\pm0.0^{c}x10^{7}$	$5.6\pm0.07^{e}x10^{6}$	$5.2\pm0.7^{e}x10^{7}$	$6.2\pm0.0^{e}x10^{6}$	$1.2\pm0.07^{d}x10^{5}$
OEO	$9.7\pm0.7^{b}x10^{7}$	$8.5\pm0.7^{d}x10^{6}$	$5.5\pm0.0^{c}x10^{7}$	$9.2\pm0.2^{c}x10^{6}$	$1.3\pm0.7^{c}x10^{6}$
OEA	$9.6\pm0.7^{b}x10^{7}$	$1.5\pm0.0^{c}x10^{7}$	$6.6\pm0.0^{b}x10^{7}$	$6.1\pm0.7^{a}x10^{7}$	$1.5\pm0.7^{b}x10^{6}$
OEL	$1.3\pm0.0^{a}x10^{8}$	$2.0\pm0.7^{a}x10^{7}$	$7.2\pm0.2^{a}x10^{7}$	$3.3\pm0.07^{b}x10^{7}$	$1.3\pm0.02^{c}x10^{6}$

[1]Values are mean ± SD of duplicate;Duncan separation ofmeans with same alphabets are not different ($p<0.05$) in each column; KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke- Ola.

Identification of Isolates

Morphological, biochemical, and sugar fermentation analyses carried out on pure cultures from all the raw 'Ogi' samples, revealed the presence of the following bacterial species: *Enterobacter aerogenes; Shigella* spp.; *Salmonellae* spp.*; Klebsiella* spp.; *Pseudomonas, Staphylococcus aureus; Staphylococcus epidermidis; and Lactobacillus* as presented in Table 2. According to previous works, organisms responsible for 'Ogi' fermentation are *Lactobacillus* spp; *Aerobacter*; *Corynebacterium*; yeast, and moulds [7,13]. All the microorganisms identified in this study except Lactobacillus are contaminants either from the raw material, processing water, or hands of handlers. Furthermore, these organisms are known foodborne or opportunistic pathogens that have been implicated in foodborne disease outbreaks [14]. According to several researchers [15,16], the occurrence of bacterial pathogens in fermented foods suggests a need for caution in the use of these foods for infant feeding. This study in agreement with others [17,18] has shown that there is a possibility for foodborne pathogens to survive, grow and persist in fermented foods. Since Akamu is a traditional food for weaning infants, convalescing, and older people, constant consumption is a health risk and should be of public health concern.

MICROBIAL CONTENT OF COOKED 'OGI'

The TVC, *Salmonella- Shigella* count, and the fungal load of the cooked 'Ogi' samples were evaluated for three days as indicated in Table 3. On day 1, TVC ranged from (2.3 to 8.5 x 10^6 CFU/g); *Salmonella- Shigella* count ranged from (1.7 to 3.3 x 10^6 CFU/g). There was no fungal growth on all the samples on the first and second days. However, on the third day of storage, the fungal count ranged from (8.5 x 10^5 to 1.5 x 10^6 CFU/g). Overall, there was a consistent increase in microbial content with each passing day of storage.

Table 2. Biochemical characteristics of isolates from 'Ogi' samples

Parameter	Isolates 1	2	3	4	5	6	7	8
G+Sh	-R	-R	-R	+C	+C	-R	-R	+R
Catalase	+	+	+	+	+	+	+	-
Citrate	+	-	+	+	-	+	-	-
Motility	+	-	-	-	-	+	+	-
SH	+	-	+	+	-	+	-	-
MR	-	+	-	+	-	-	+	-
VP	+	-	+	+	+	-	-	-
Indole	-	+	+	-	-	-	-	+
Glucose	A/G	A/G	A/G	A/G	A/G	-/-	A/G	A/G
Sucrose	A/G	-/-	A/G	A/G	A/G	-/-	-/-	A/G
Lactose	A/G	-/-	A/G	A/G	A/G	-/-	-/-	A/G
Xylose	A/G	-/-	A/G	-/-	-/-	-/-	A/G	-/-
Tentative Organism	*E. aerogenes*	*Shigella* spp	*Klebsiella* spp	*Staph. aureus*	*Staph. epidermidis*	*Pseudomonas aeruginosa*	*Salmonella* spp	*Lactobacillus* spp

G+Sh= Gram + shape; SH= Starch hydrolysis; MR=Methyl red; VP=Voges Proskaurer; A/G = Acid/gas; -/- =Negative acid/no gas

STORABILITY OF COOKED 'OGI'

The package also appears to protect/preserve cooked 'Ogi'. It was observed that leaves were less effective compared to polyethylene wraps. There was no visible change in the colour and taste of all the samples in the first two days of storage, but it was observed that the stiff gel became thicker each day. However, visible signs of spoilage such as slime and mould growth were observed and since the majority of the samples were slimy to the touch, taste analysis was not performed on day 3 (Table 4).

Table 3. **Microbial load (CFU/g) of cooked 'Ogi' (Agidi) during storage at ambient temperature**

	Microbial load (CFU/g)		
Location of 'Ogi' sample	**TVC**	***Salmonella- Shigella***	**Fungal**
Cooked 'Ogi' (Day 1)			
KBO	$2.3\pm0.07^{e}x10^{6}$	$2.3\pm0.03^{d}x10^{6}$	NG
MOT	$5.8\pm0.7^{b}\ x10^{6}$	$3.3\pm0.01^{a}\ x10^{6}$	NG
OEO	$8.5\pm0.7^{a}\ x\ 10^{6}$	$1.7\pm0.02^{e}x10^{6}$	NG
OEA	$4.3\pm0.5^{d}\ x10^{6}$	$3.2\pm0.3^{b}x10^{6}$	NG
OEL	$4.8\pm0.3^{c}x10^{6}$	$2.4\pm0.07^{c}x10^{6}$	NG
Cooked 'Ogi' (Day 2)			
KBO	$1.5\pm0.07^{a}x10^{7}$	$4.2\pm0.0^{b}x10^{6}$	NG
MOT	$1.4\pm0.0^{b}\ x\ 10^{7}$	$7.9\pm0.7^{a}x10^{6}$	NG
OEO	$1.1\pm0.03^{c}x10^{7}$	$3.1\pm0.7^{d}x10^{6}$	NG
OEA	$5.8\pm0.01^{e}x10^{6}$	$4.1\pm0.03^{c}x10^{6}$	NG
OEL	$6.8\pm0.7^{d}x\ 10^{6}$	$3.1\pm0.07^{d}x10^{6}$	NG
Cooked 'Ogi' (Day 3)			
KBO	$1.4\pm0.7^{b}x10^{7}$	$4.1\pm0.02^{d}x10^{6}$	$5.0\pm0.07^{d}x10^{5}$
MOT	$1.6\pm0.7^{a}x10^{7}$	$1.0\pm0.7^{a}x10^{7}$	$2.0\pm0.5^{e}x10^{5}$
OEO	$1.4\pm0.5x^{b}10^{7}$	$5.5\pm0.07^{b}x10^{6}$	$9.5\pm0.02^{b}x10^{5}$
OEA	$6.6\pm0.01^{d}x10^{6}$	$5.0\pm0.03^{c}x10^{6}$	$1.5\pm0.01^{a}x10^{6}$
OEL	$1.3\pm0.07^{c}x10^{7}$	$4.0\pm0.05^{d}x10^{6}$	$8.5\pm0.07^{c}x10^{5}$

[1]Values are mean ± SD of duplicate;Duncan separation ofmeans with same alphabets are not different ($p<0.05$) in each column; KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke- Ola; NG= No growth

Table 4. Organoleptic quality of cooked 'Ogi' stored at ambient temperature

Parameter	Storage temp /Package	Colour	Taste	Texture	Odour
Cooked 'Ogi' (Day 1)	(32 ± 2^{0}C)				
KBO	Polyethylene	Yellow	Sour	Smooth/Thin	Normal
MOT	Leaves	White	Not sour	Smooth/Thin	Normal
OEO	Leaves	White	Not sour	Smooth/Thin	Normal
OEA	Polyethylene	White	Not sour	Smooth/Thin	Normal
OEL	Clear bowl	White	Not sour	Smooth/Thin	Normal
(Day 2)					
KBO	Polyethylene	Yellow	Sour	Smooth/Stiff gel	Normal
MOT	Leaves	White	Not sour	Smooth/Stiff gel	Normal
OEO	Leaves	White	Not sour	Smooth/Stiff gel	Normal
OEA	Polyethylene	White	Not sour	Smooth/Stiff gel	Normal
OEL	Clear bowl	White	Not sour	Smooth/Stiff gel	Normal
(Day 3)					
KBO	Polyethylene	YNF	ND	Not slimy	Normal
MOT	Leaves	Fungal growth	ND	Slimy	Normal
OEO	Leaves	Fungal growth	ND	Slimy	Normal
OEA	Polyethylene	WNF	ND	Not slimy	Normal
OEL	Clear bowl	WNF	ND	Slimy	Normal

KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke- Ola;
ND= Not determined; YNF= Yellow no visible fungal growth; WNF= White no visible fungal growth.

pH and TTA

The pH of the raw 'Ogi' slurry samples ranged from (4.1±0.0[b] to 6.3±0.06[a]) with sample from Kobaope (KBO) area being more acidic. There were statistically significant differences ($p<0.05$) between the samples. The total titratable acidity of raw 'Ogi' slurry ranged from (0.21 to 0.75 %), with sample from OEL (Oke-Ola) having the least percentage of TTA (Figure 1). Values obtained were within the (0.65 %) reported by [19] for 'Ogi' stored at ambient temperature.

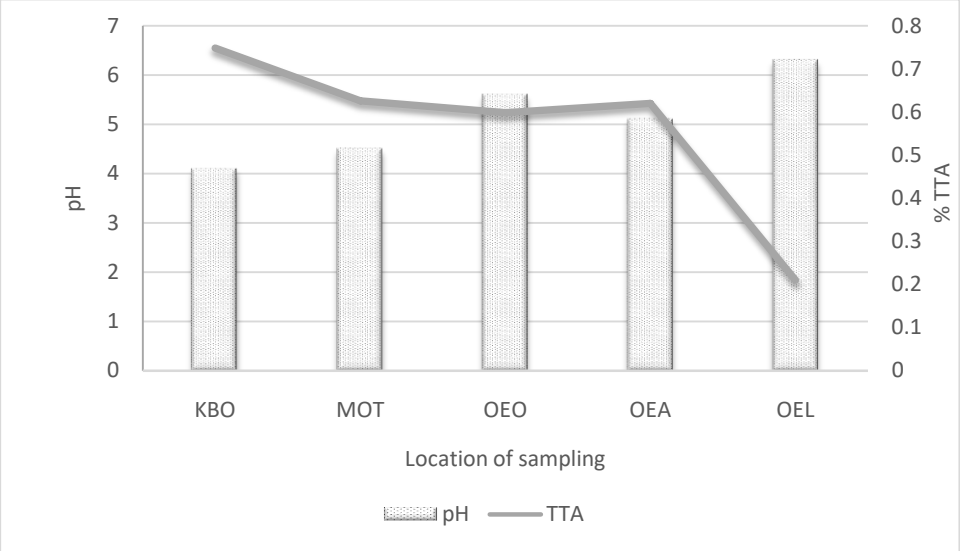

Figure 1: pH and Total titratable acid values of raw 'Ogi' slurry from selected locations. KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke-Ola

pH of the cooked 'Ogi' ranged from (4.2[c]±0.01 to 6.1[a]±0.0); (5.8[d]±0.01 to 6.1[a]±0.01); and (5.7±0.6 to 6.1±0.06) for days 1, 2 and 3 after production (Figure 2).

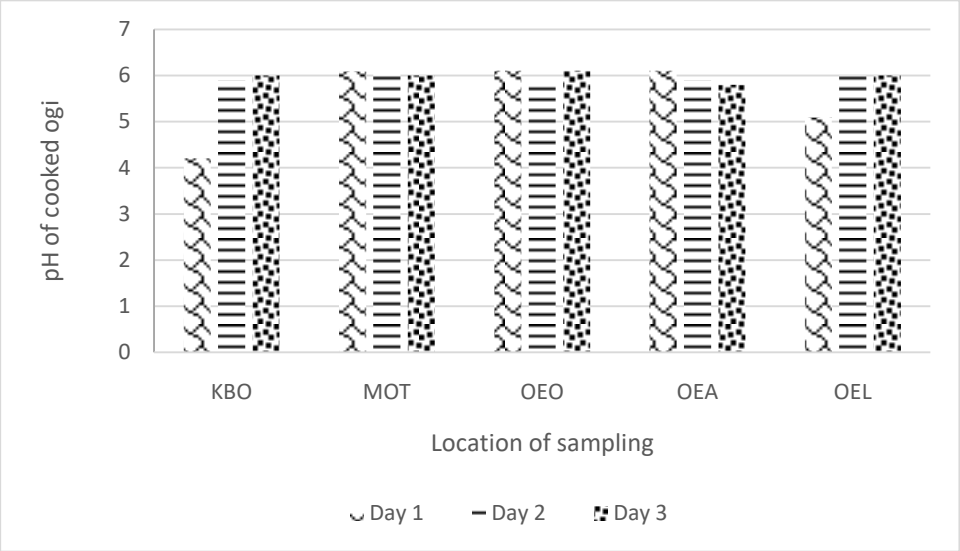

Figure 2: pH of cooked 'Ogi' samples during 1-3 days of storage at room temperature. KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke-Ola

MINERAL CONTENT

Phosphorus (P) content in the samples ranged from (1.03 to 1.27 mg/g). Magnesium (Mg) content ranged from (1.62 to 2.01 mg/g). Calcium (Ca) content ranged from (0.76 to 1.13 mg/g) and Iron (Fe) ranged from (0.0023 to 0.0044 mg/g). 'Ogi' sample OEA from (Oke-Afo) had the highest value in the mineral contents analyzed and was significantly different from others (Table 5). Although it has been previously established that there is nutrient loss during processing, other researchers reported higher mineral content Ca (35.96 mg/100 g); Mg (76.56 mg/100 g); and Fe (19.60 mg/100 g) [18]; Ca (12.89 mg/100 g); Mg (119.70 mg/100 g) and Fe (2.57 mg/100 g) of sample [21] for 'Ogi' than the values observed in this study. It could be that the samples purchased were not freshly produced because the longer 'Ogi' is stored, the daily replacement of sour water to prolong the shelf life leads to continuous loss of water-soluble nutrients [19,22].

Table 5: Mineral content of 'Ogi' slurry samples from various locations in Iwo

	Mineral Content of 'Ogi' sample (mg/100g)			
Location of sample	**Phosphorus**	**Magnesium**	**Calcium**	**Iron**
KBO	1.03±0.01^{d}	1.62±0.01^{d}	0.76±0.01^{d}	0.0023±0.00^{d}
MOT	1.08±0.01^{c}	1.69±0.00^{c}	0.88±0.00^{c}	0.0028±0.00^{c}
OEO	1.21±0.01^{b}	1.86±0.01^{b}	1.04±0.01^{b}	0.0037±0.00^{b}
OEA	1.27±0.01^{a}	2.01±0.00^{a}	1.13±0.00^{a}	0.0044±0.00^{a}
OEL	ND	ND	ND	ND

[1]Values are mean ± SD of duplicate;Duncan separation ofmeans with same alphabets are not different ($p<0.05$) in each row; KBO=Kobaope; MOT= Memorial Hospital; OEO= Oke-Odo; OEA= Oke-Afo; OEL= Oke- Ola; ND=Not determined

4. CONCLUSION

The street vended raw ‘Ogi’ from various locations in Iwo, Osun State were contaminated by different genera of bacteria and fungi, probably from various sources such as the maize, water, and utensils used in processing the ‘Ogi’, poor personal hygiene of preparers and unhygienic environments. Some of the microorganisms isolated and identified are not considered as part of the fermenting microorganisms but pathogenic and could lead to foodborne diseases in vulnerable individuals, complicating health challenges. Storability of ‘Ogi’ from this study shows that it is safer to consume cooked ‘Ogi’ the same day as the microbial population increased with time even when organoleptic quality appeared good.

COMPETING INTERESTS DISCLAIMER:

AUTHORS HAVE DECLARED THAT NO COMPETING INTERESTS EXIST. THE PRODUCTS USED FOR THIS RESEARCH ARE COMMONLY AND PREDOMINANTLY USE PRODUCTS IN OUR AREA OF RESEARCH AND COUNTRY. THERE IS ABSOLUTELY NO CONFLICT OF INTEREST BETWEEN THE AUTHORS AND PRODUCERS OF THE PRODUCTS BECAUSE WE DO NOT INTEND TO USE THESE PRODUCTS AS AN AVENUE FOR ANY LITIGATION BUT FOR THE ADVANCEMENT OF KNOWLEDGE. ALSO, THE RESEARCH WAS NOT FUNDED BY THE PRODUCING COMPANY RATHER IT WAS FUNDED BY PERSONAL EFFORTS OF THE AUTHORS.

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