The article brings an introduction that allows the reader to understand the importance of the work. The methodology was able to produce reliable results. The conclusions are in accordance with the objectives of the work and are based on the data and discussions presented. Therefore, I accept with minor corrections.

Original Research Article

MICROBIAL CHANGES DURING THE FERMENTATION OF AERIAL POTATO (*DISCOREA BULBIFERA* LINN)

ABSTRACT

Dioscorea bulbifera is one of the under-utilized tubers in Nigeria both for food and medical purposes. Microbial changes during the fermentation of aerial potato after being subjected to different treatment were monitored using standard methods, the changes in microbial load and type of microorganisms was reported. It was observed that unpeeled backslope fermented samples had the highest total viable bacterial count ($7.06\pm0.05 \times 10^5$ cfu/g), lactic acid bacterial count ($67.74\pm1.17 \times 10^7$ cfu/g) and fungal count ($0.81\pm0.16 \times 10^6$ sfu/g), while total viable bacterial, LAB and fungal in peeled samples were $30.40\pm2.00 \times 10^{10}$ cfu/g, $298.17\pm2.36 \times 10^7$ cfu/g and $133.30\pm0.15 \times 10^6$ sfu/g at 120 hour of fermentation respectively. Some of the bacteria isolated include *Shigella flexneri*, *Escherichia coli*, *Staphylococcus aureus*, *Lactobacillus delbrueckii*, *Lactobacillus fermentum*, *Lactobacillus plantarum*, *Lactococcus lactis*, while the fungal isolates were *Fusarium oxysporum*, *Geomyces pannorum*, *Geotrichum candidum*, *Penicillium brevicompactum*, *Penicillium corylophilum*, *Saccharomyces cerevisiae*, *Candida tropicalis* and others species. The treatment methods employed had a significant effects on the microbial load of fermented aerial potato. The fermentation methods employed have significant effects on the microbial load and type of microorganisms in the fermented aerial potato. Fermentation can be used as a food processing method to eliminate unwanted microorganisms in fermented food, which will enhance the food shelf life.

Keywords: Aerial potato, fermentation, microorganisms, and mixed cultures.

INTRODUCTION

Dioscorea bulbifera commonly known as the aerial potato, air potato, air yam, aerial yam, bitter yam, cheeky yam and parsnip yam is a species of true yam in the yam family, Dioscoreaceae. In Nigeria, *Hausas* called it 'dóóya', *Igbos 'Agukwu'* and *Yorubas* call it 'ẹmina', 'ẹwura-esi' and 'isu ahum' (Ghosh, 2015). The yam is native to Africa, Asia and northern Australia, however, over 600 varieties of yam exits and 95% of them are grown in African (Sanjeet *et al.,* 2017; Omodamiro, 2015) I suggest citing the three largest producers in the world and the latest data on production in Nigeria.. Aerial yam is a perennial vine with broad, alternate leaves, and two types of storage organs. It typically climbs to the tops of trees and has a tendency to take over native plants. New plants develop from bulbils that form on the plant, and these bulbils serve as a means of dispersal. The aerial stems of air potato die back in winter, but re-sprouting occurs from bulbils and underground tubers (Odugbemi, 2008). Is there a period in the year when production is higher?

D. bulbifera has been found to possess profound therapeutic potential. It is commonly used in traditional Indian, African and Chinese medicine in the treatment of sore throat (Sharma and Bastakoti, 2009), breast cancer (Anandpara and Tirgar, 2017), and type II diabetes mellitus (Ghosh *et al*., 2011, 2014; Ghosh, 2015). *D. bulbifera* has proved effective in the treatment of sub-acute thyroiditis (Nam *et al.,* 2006). Also, *D. bulbifera* could significantly induce apoptosis of HCT116 human colorectal carcinoma cells (Hidayat *et al.,* 2018), and also has shown anti-helminthic activity against *Fasciola gigantica* and *Pheritima posthuma* (Adeniran and Sonibare, 2013). More so, *D. bulbifera* has been reported to have Anti-HIV-1 integrase compounds (Chaniad *et al.*, 2016; Nabatanzi, 2016). The plant also possesses antibacterial effects against multi-drug resistant bacteria *Enterobacter aerogenes* EA289, *Klebsiella pneumoniae* KP63, *Pseudomonas aeruginosa* PA124, *Mycobacteria* strain and *Staphylococcus aureus* (Kuete *et al.*, 2012). It also possesses antioxidant activity against free radicals (Araghiniknam *et al.*, 1996).

The tuber is rich in some phytochemicals such as saponins, tannins, flavonoids, sterols, polyphenols, glycosides (Ghosh, 2015) and steroidal saponins (Tapondjou *et al.*, 2013). The composition may vary according to the geographical locations (Trimanto and Hapsari 2015). Despite the numerous uses of this plant as stated, aerial potato is one of the under-utilized tubers in Nigeria both for food and medical purposes (Kwong-Niding and Misai, 2002; Tewodros and

Getachew, 2013). For better utilization, the yam is subjected to fermentation in order to remove the toxins, better preservation, round the year availability and improved safety for consumers. This study therefore aimed at presenting the microbial changes during the fermentation and processing of aerial potato.

MATERIALS AND METHODS

Collection of Aerial Potato Samples

Aerial potato tubers (Plate 1) were purchased from Kogi State, Nigeria in a sterile bag and transported to the Laboratory, Department of Microbiology, Federal University of Technology, Akure for laboratory examination. The samples were sorted, separated to remove tubers that are spoilt by rodent attack or physical injuries and sand.

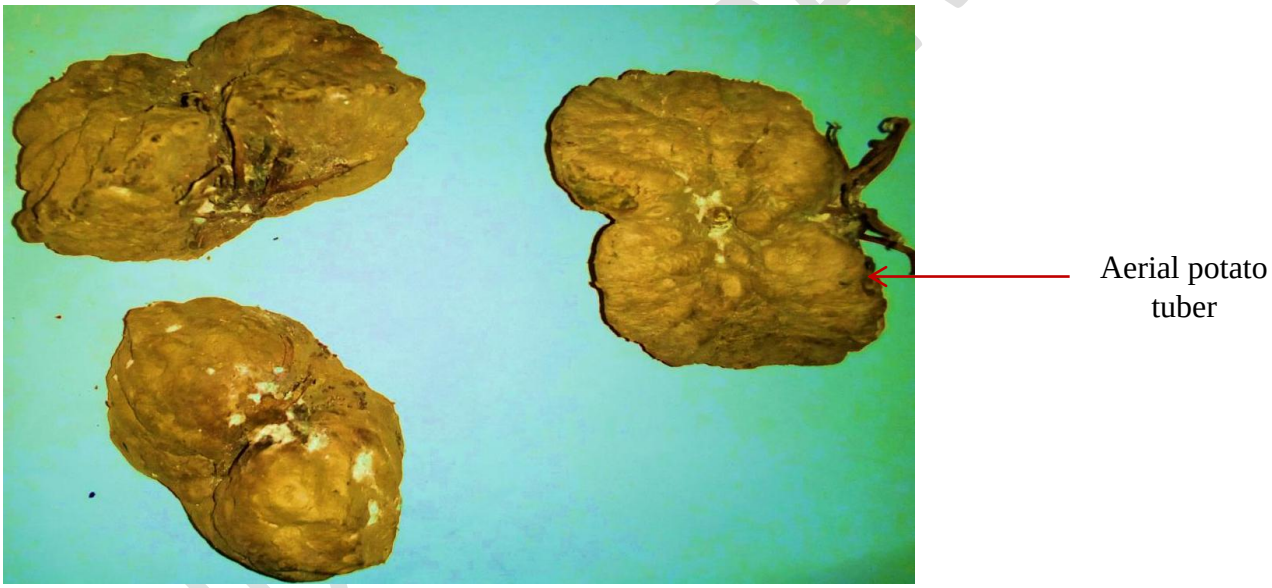

Plate 1: Tuber of Aerial potato

Fermentation of Aerial Potato

Five hundred grams (500 g) of aerial potato tubers labeled as samples A to F were diced and soaked in 1500 ml of water in 2 litres plastic container at room temperature (27 °C) and allowed to undergo natural fermentation for 7 days. For backslopping fermentation, Fifty grams (50 g) of previously fermented samples (A to F) were added to 450 g of raw samples A to F in a respective manner, and submerged in 1500 ml of water in 2 litre plastic container at room temperature (27 °C) for 7 days. Five hundred grams (500 g) of aerial potato samples A to F were inoculated with starter cultures of dominant microorganisms and submerged in 1500 ml tap water inside 2 litre

plastic container at room temperature (27 °C) for 7 days. During the fermentation, microbial load of aerial potato in backslopping, sample fermented with starter and mixed culture were monitored. What interval were the collections performed?

Isolation and identification of microorganisms.

Isolation of total viable bacterial, yeast and mould was carried out during fermentation using the methods of Olutiola *et al.* (2018). The cultural, morphological and microscopic examination of the isolated bacteria, yeast and mould were done according to Hunter and Bamett (2000) and Fawole and Oso (2004).

Statistical analysis

Data obtained was statistically analysed using SPSS version 20, means of values were separated by new Duncan's Multiple Range test and significant difference was value at $p \leq 0.05$.

RESULTS

Microbial load in Fermented Aerial Potato with different methods

Table 1 shows the total viable bacterial counts in aerial potato fermented with mixed culture, backslopping fermented aerial potato and aerial potato fermented with starter culture. The result revealed that the bacterial counts increased as the fermentation period increased, the highest bacterial counts were observed in all the treatments at 120 hours was higher in peeled ($30.40\pm2.00 \times 10^{10}$ cfu/g), peeled and parboiled ($1.93\pm1.51 \times 10^{10}$ cfu/g) and peeled boiled ($8.22\pm1.83 \times 10^{10}$ cfu/g) than the corresponding unpeeled samples. However, the bacterial load reduced at the end of fermentation period (168 hours) where unpeeled parboiled ($9.40\pm1.33 \times 10^{5}$ cfu/g) had the highest bacterial counts, followed by peeled ($7.50\pm0.17 \times 10^{5}$ cfu/g) and peeled boiled ($2.58\pm0.01 \times 10^{5}$ cfu/g) samples. In backslopping fermented aerial potato, it was observed that the bacterial count increases as the fermentation period increased until 120 and 144 hours. At the end of fermentation (168 hours), all the peeled samples (peeled ($203.00\pm0.77 \times 10^{3}$ cfu/g); peeled parboiled ($101.00\pm0.51 \times 10^{3}$ cfu/g); peeled boiled ($544.00\pm3.57 \times 10^{3}$ cfu/g)) had the highest bacterial load compared with the corresponding unpeeled samples. In aerial potato fermented with starter culture, it was noted that bacterial count increases as fermentation period progressed. At the end of fermentation (168 hour), the highest bacterial count were noted in peeled

sample (44.13±0.16 x 10^5 cfu/g) followed by unpeeled>peeled parboiled >unpeeled boiled>unpeeled parboiled >peeled boiled. Lactic acid bacterial (LAB) count of aerial potato fermented with different methods are shown in Table 2. In aerial potato fermented with mixed culture, the highest LAB count was observed in different samples at different period of fermentation, the highest LAB counts was observed in peeled (526.70±2.08 x 10^6 cfu/g) at 72 hour, unpeeled (79.40±10.61 x 10^6 cfu/g), peeled parboiled (824.00±1.55 x 10^6 cfu/g) at 48 hour, unpeeled parboiled (456.00±0.77 x 10^6 cfu/g), peeled boiled 392.30±2.98 x 10^6 cfu/g) at 96 hour. Lactic acid bacterial (LAB) count in backslopping fermenting aerial potato had the highest LAB counts at the end of fermentation period (168 hour) as 7330.00±0.58 x 10^4 cfu/g in peeled sample. The least value was observed in unpeeled boiled (17.00±0.00 x 10^4 cfu/g). Lactic acid bacterial (LAB) count in aerial potato fermented with starter culture was increased till 120 hours during fermentation and a gradual decrease at 144 and 168 hour. At the end of fermentation period, it was observed that peeled (7.80±0.32 x 10^7 cfu/g) had the highest LAB count followed by peeled boiled (5.44±3.57 x 10^7 cfu/g) and unpeeled parboiled (2.43±0.12 x 10^7 cfu/g). There was no significant ($p<0.05$) difference in the LAB counts of unpeeled, peeled parboiled and unpeeled boiled.

Fungal counts in Fermented Aerial Potato

Fungal counts of aerial potato fermented with different methods and hours is shown in Table 3. In aerial potato fermented with mixed cultures, there was gradual increase in fungal counts untill 72 hours when the fungal counts began to decrease. Fungal counts in backslopping fermented aerial potato had the highest fungal counts at 120 hour, unpeeled at 96 hour, peeled parboiled 144 hour, unpeeled parboiled 72 hour, peeled boiled 48 hour, and unpeeled boiled 168 hour. At the end of fermentation (168 hour), peeled (380.00±0.20 x 10^4 sfu/g) had the highest fungal counts followed by unpeeled boiled (32.00±0.00 x 10^4 sfu/g). In aerial potato fermented with starter culture, it was noted that peeled and unpeeled samples had the highest fungal counts at 144 hour. At the end of fermentation period (168 hour), fungal counts of peeled (93.42±0.11 x 10^5 sfu/g) and unpeeled (86.11±0.03 x 10^5 sfu/g) samples were higher than what was observed in other samples while the least fungal count was observed in boiled samples.

Occurrence of Microorganisms in Fermented Aerial Potato

Occurrence of bacteria in fermented aerial potato is shown in Table 4. The most frequent bacterial isolate were *Bacillus subtilis* and *Lactococcus lactis* 15(12.71%), followed closely by *Lactobacillus plantarum* 13(11.02%) while the least are *Dickeya chrysantheni* 2(1.69%) and *Citrobacter freundii, Moraxella*

caprae, Shigella flexneri and *Yersinia massiliensis* 3(2.54%). The frequency of bacterial isolates were higher in peeled (11) and unpeeled (10) mixed culture fermentation compared with others. It was observed that, the genus *Lactobacillus* and *Lactococcus* were present in all the starter culture fermented samples, *Escherichia coli* was present in peeled and unpeeled mixed culture fermentation and in peeled and unpeeled parboiled mixed culture, *Bacillus subtilis* was present in all the fermented samples except unpeeled, peeled boiled and unpeeled boiled starter culture fermented samples. Occurrence of fungal isolates in fermented aerial potato is shown in Table 5. The most frequent fungi are *Candida tropicalis*18(36.00%) which is present in all the samples followed by *Saccharomyces cerevisiae* 12(24.00%) while the least frequent fungal isolates were *Aspergillus fumigatus, Aspergillus terreus, Geomyces pannorum, Penicillium brevicompactum* and *Penicillium corylophilum,* they are mostly isolated from mixed culture fermentation. *Aspergillus parasiticus* was isolated from mixed culture fermented peeled and unpeeled aerial potato only, *Fusarium oxysporum* was isolated from all the fermentation processes in unpeeled parboiled samples. Also, there was no presence of *Aspergillus* in all the peeled backslopping and starter culture fermented samples.

Table 1: Total viable bacterial count (cfu/g) in aerial potato fermented with different methods and hours

Aerial Potato Fermented with mixed cultures	Initial (x 10^5)	24 (x 10^5)	48 (x 10^6)	72 (x 10^8)	96 (x 10^{10})	120 (x 10^{10})	144 (x 10^8)	168 (x 10^5)
Peeled	0.06^{a}±0.00	2.69^{a}±0.17	2.47^{a}±0.32	5.87^{b}±0.12	4.63^{b}±0.21	30.40^{d}±2.00	20.73^{b}±0.12	7.50^{b}±0.17
Unpeeled	4.80^{b}±5.86	1.57^{a}±0.12	4.99^{a}±0.18	4.79^{b}±0.30	2.32^{b}±0.37	10.79^{c}±2.22	20.28^{b}±3.24	1.07^{a}±0.00
Peeled parboiled	0.00^{a}±0.00	0.50^{a}±0.01	0.70^{a}±0.18	0.55^{a}±0.81	0.77^{a}±1.00	1.93^{a}±1.51	0.05^{a}±0.30	1.58^{a}±2.27
Unpeeled parboiled	0.14^{a}±0.15	2.82^{a}±0.31	3.29^{a}±0.31	9.95^{b}±1.33	4.54^{b}±0.90	1.18^{a}±1.59	5.07^{a}±0.92	9.40^{b}±1.33
Peeled boiled	0.10^{a}±0.00	0.75^{a}±0.73	0.75^{a}±0.73	3.27^{a}±0.31	3.13^{b}±2.08	8.22^{b}±1.83	4.46^{a}±0.49	2.58^{a}±0.01
Unpeeled boiled	0.00^{a}±0.00	0.00^{a}±0.00	1.20^{a}±0.00	2.10^{a}±0.00	0.07^{a}±0.01	4.60^{a}±0.00	1.63^{a}±0.00	0.04^{a}±0.00
Aerial Potato in back slope Fermentation								
Peeled	9.00^{a}±0.00	113.00^{b}±0.12	106.30^{b}±0.03	443.00^{c}±0.40	943.0^{c}±0.15	109.70^{c}±0.15	204.30^{d}±0.40	203.00^{c}±0.77
Unpeeled	706.00^{b}±0.05	383.00^{c}±0.21	20.30^{a}±0.59	579.00^{d}±0.18	41.00^{b}±0.31	18.40^{ab}±1.32	144.50^{c}±1.04	231.00^{c}±1.37
Peeled parboiled	2.00^{a}±0.00	100.00^{b}±0.00	10.10^{a}±0.68	222.00^{c}±1.52	51.00^{b}±0.59	30.50^{b}±0.04	15.10^{b}±1.02	101.00^{c}±0.51
Unpeeled parboiled	23.00^{a}±0.21	39.00^{b}±0.02	4.30^{a}±0.30	8.00^{a}±0.03	17.00^{b}±0.05	5.70^{a}±0.39	2.30^{a}±0.13	43.00^{b}±0.12
Peeled boiled	13.00^{a}±0.09	492.00^{c}±0.19	16.30^{a}±0.98	155.00^{b}±1.10	24.00^{b}±0.07	67.20^{b}±0.47	23.40^{b}±1.48	544.00^{d}±3.57
Unpeeled boiled	5.00^{a}±0.00	2.00^{a}±0.00	18.70^{a}±0.00	233.00^{c}±0.00	1.00^{a}±0.00	21.30^{b}±0.00	16.30^{b}±0.00	2.00^{a}±0.00
Aerial Potato Fermented with starter culture								
Peeled	9.04±0.00^{a}	6.31±0.06^{c}	27.04±0.11^{b}	12.15±0.14^{b}	20.73±0.12^{c}	29.67±0.02^{c}	54.82±0.21^{d}	44.13±0.16^{c}
Unpeeled	12.11±0.86^{a}	5.22±0.53^{c}	21.31±0.32^{b}	15.41±0.36^{b}	20.28±3.24^{c}	28.44±0.26^{c}	41.44±0.03^{c}	31.06±0.07^{b}
Peeled parboiled	9.43±0.06^{a}	3.14±0.07^{b}	17.44±0.06^{a}	9.70±0.70^{a}	1.05±0.30^{a}	9.11±0.18^{a}	36.08±0.47^{b}	30.05±0.50^{b}
Unpeeled parboiled	10.66±0.13^{a}	1.86±0.11^{a}	11.76±0.16^{a}	10.06±0.03^{a}	5.07±0.92^{ab}	11.35±0.33^{ab}	33.19±0.10^{a}	27.33±0.11^{b}
Peeled boiled	10.81±0.07^{a}	2.41±0.02^{a}	11.54±0.54^{a}	8.59±0.33^{a}	4.46±0.49^{a}	12.42±0.16^{ab}	37.06±0.30^{b}	20.41±0.13^{a}
Unpeeled boiled	9.42±0.31^{a}	1.55±0.01^{a}	10.31±0.07^{a}	7.37±0.57^{a}	1.63±0.00^{a}	9.55±0.11^{a}	29.11±0.42^{a}	29.16±0.42^{b}

Values are presented as mean±SE, values in the same column carrying same superscript are not different significantly according to new Duncan's Multiple Range test at $p<0.05$

Table 2: Lactic Acid Bacterial (LAB) count in Aerial Potato Fermented with different methods and hours

Aerial Potato Fermented with mixed cultures	LAB counts (cfu/g x 10^6)							
	Initial	**24**	**48**	**72**	**96**	**120**	**144**	**168**
Peeled	$0.00^{a}\pm0.00$	$276.70^{d}\pm0.58$	$173.30^{c}\pm1.53$	$526.70^{c}\pm2.08$	$46.70^{b}\pm2.08$	$41.70^{b}\pm2.08$	$61.60^{b}\pm2.08$	$100.00^{c}\pm1.00$
Unpeeled	$0.00^{a}\pm0.00$	$3.60^{a}\pm0.00$	$79.40^{b}\pm10.61$	$1.10^{a}\pm0.16$	$11.00^{a}\pm1.42$	$39.00^{b}\pm5.32$	$11.30^{a}\pm1.63$	$49.00^{b}\pm0.00$
Peeled parboiled	$0.00^{a}\pm0.00$	$487.90^{e}\pm1.82$	$824.00^{e}\pm1.55$	$105.90^{b}\pm1.48$	$21.00^{a}\pm0.17$	$1.90^{a}\pm0.01$	$33.00^{b}\pm0.41$	$76.00^{b}\pm0.00$
Unpeeled parboiled	$7.00^{b}\pm0.04$	$191.80^{c}\pm2.19$	$308.60^{d}\pm3.82$	$111.90^{b}\pm1.18$	$456.00^{c}\pm0.77$	$22.70^{a}\pm1.55$	$92.00^{b}\pm7.93$	$77.00^{b}\pm1.20$
Peeled boiled	$0.00^{a}\pm0.00$	$29.30^{b}\pm4.00$	$56.10^{b}\pm4.83$	$19.80^{a}\pm2.79$	$392.30^{c}\pm2.98$	$298.17^{c}\pm2.36$	$298.17^{c}\pm4.36$	$38.80^{b}\pm0.00$
Unpeeled boiled	$0.00^{a}\pm0.00$	$9.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$5.00^{a}\pm0.00$	$6.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$1.00^{a}\pm0.00$
Aerial Potato in back slope Fermentation				**LAB counts (cfu/g x 10^4)**				
Peeled	$30.00^{c}\pm0.00$	$160.00^{c}\pm0.00$	$470.00^{c}\pm0.58$	$730.00^{c}\pm1.53$	$600.00^{b}\pm1.00$	$1067.00^{c}\pm0.58$	$4330.00^{d}\pm0.12$	$7330.00^{c}\pm0.58$
Unpeeled	$50.00^{c}\pm0.04$	$668.00^{d}\pm11.54$	$3335.00^{d}\pm2.84$	$180.00^{b}\pm0.04$	$1320.00^{c}\pm0.66$	$1900.00^{c}\pm1.39$	$800.00^{b}\pm0.51$	$390.00^{b}\pm0.19$
Peeled parboiled	$50.00^{c}\pm0.01$	$0.00^{a}\pm0.00$	$220.00^{b}\pm0.14$	$1860.00^{d}\pm1.28$	$2450.00^{d}\pm1.65$	$570.00^{b}\pm0.54$	$8190.00^{e}\pm0.55$	$1444.00^{d}\pm0.32$
Unpeeled parboiled	$0.00^{a}\pm0.00$	$10.00^{a}\pm0.02$	$2140.00^{d}\pm2.39$	$2520.00^{d}\pm1.52$	$1130.00^{c}\pm0.81$	$1847.00^{c}\pm1.30$	$10520.00^{f}\pm0.76$	$420.00^{b}\pm0.14$
Peeled boiled	$40.00^{c}\pm1.17$	$6774.00^{e}\pm1.14$	$3250.00^{d}\pm2.17$	$2140.00^{d}\pm3.04$	$6160.00^{e}\pm4.41$	$530.00^{b}\pm0.17$	$2130.00^{c}\pm1.51$	$630.00^{b}\pm0.58$
Unpeeled boiled	$10.00^{b}\pm0.00$	$84.0^{b}\pm0.00$	$1.00^{a}\pm0.00$	$7.00^{a}\pm0.00$	$5.00^{a}\pm0.00$	$8.00^{a}\pm0.00$	$18.00^{a}\pm0.00$	$17.00^{a}\pm0.00$
Aerial Potato Fermented with starter culture				**LAB counts (cfu/g x 10^7)**				
Peeled	1.06 ± 0.00^{a}	2.69 ± 0.17^{bc}	2.47 ± 0.32^{a}	5.87 ± 0.12^{bc}	4.63 ± 0.21^{b}	33.40 ± 1.06^{f}	25.13 ± 0.11^{c}	7.80 ± 0.32^{d}
Unpeeled	2.80 ± 5.86^{b}	1.57 ± 0.12^{b}	4.99 ± 0.18^{b}	4.79 ± 0.30^{b}	6.32 ± 0.37^{c}	10.79 ± 2.22^{e}	20.28 ± 3.24^{c}	1.07 ± 0.00^{a}
Peeled parboiled	1.02 ± 0.00^{a}	0.50 ± 0.01^{a}	1.70 ± 0.18^{a}	1.55 ± 0.81^{a}	1.77 ± 1.00^{a}	1.93 ± 1.51^{a}	1.05 ± 0.30^{a}	1.58 ± 2.27^{a}
Unpeeled parboiled	1.23 ± 0.21^{a}	0.39 ± 0.02^{a}	1.43 ± 0.30^{a}	1.08 ± 0.03^{a}	2.17 ± 0.05^{a}	2.57 ± 0.39^{b}	2.23 ± 0.13^{b}	2.43 ± 0.12^{b}
Peeled boiled	1.13 ± 0.09^{a}	4.92 ± 0.19^{c}	1.63 ± 0.98^{a}	1.55 ± 1.10^{a}	2.24 ± 0.07^{a}	6.72 ± 0.47^{d}	2.34 ± 1.48^{b}	5.44 ± 3.57^{c}
Unpeeled boiled	1.00 ± 0.01^{a}	1.33 ± 0.31^{b}	1.20 ± 0.00^{a}	2.10 ± 0.00^{a}	2.07 ± 0.01^{a}	4.60 ± 0.00^{c}	1.63 ± 0.00^{a}	1.04 ± 0.00^{a}

Values are presented as mean±SE, values in the same column carrying same superscript are not different significantly according to new Duncan's Multiple Range test at $p<0.05$.

Table 3: Fungal counts of mixed culture of Fermenting Aerial Potato

Aerial Potato Fermented with mixed cultures	Fungal counts (sfu/g x 10^4)							
	Initial	**24**	**48**	**72**	**96**	**120**	**144**	**168**
Peeled	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$17.03^{b}\pm0.06$	$30.90^{c}\pm0.06$	$14.01^{b}\pm2.08$	$2.30^{a}\pm0.58$	$0.34^{a}\pm0.59$	$4.17^{b}\pm0.08$
Unpeeled	$3.30^{b}\pm0.00$	$8.01^{b}\pm0.11$	$49.04^{c}\pm0.06$	$95.02^{d}\pm0.13$	$14.04^{b}\pm0.23$	$1.30^{a}\pm0.23$	$0.09^{a}\pm0.10$	$0.00^{a}\pm0.00$
Peeled parboiled	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$14.03^{b}\pm0.15$	$0.71^{a}\pm0.01$	$0.19^{a}\pm0.27$	$0.04^{a}\pm0.00$
Unpeeled parboiled	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$2.60^{a}\pm0.26$	$0.42^{a}\pm0.00$	$0.02^{a}\pm0.03$	$0.01^{a}\pm0.01$
Peeled boiled	$1.10^{b}\pm0.01$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$1.10^{a}\pm0.01$	$43.4^{b}\pm0.63$	$4.34^{b}\pm0.60$	$0.39^{a}\pm0.00$
Unpeeled boiled	$2.00^{b}\pm0.00$	$1.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$3.01^{b}\pm0.00$	$7.41^{b}\pm0.00$	$2.02^{a}\pm0.00$	$0.06^{a}\pm0.00$	$0.03^{a}\pm0.00$
Aerial Potato in back slope Fermentation (sfu/g x 10^4)								
Peeled	$0.00^{a}\pm0.00$	$43.000^{b}\pm1.53$	$17.00^{b}\pm0.52$	$400.70^{c}\pm0.12$	$467.00^{c}\pm1.53$	$1333.00^{b}\pm0.15$	$900.00^{b}\pm2.00$	$380.00^{c}\pm0.20$
Unpeeled	$80.10^{b}\pm0.16$	$6.000^{a}\pm0.04$	$12.00^{a}\pm0.01$	$34.00^{b}\pm0.02$	$44.40^{b}\pm0.03$	$11.40^{a}\pm0.10$	$8.00^{a}\pm0.05$	$3.00^{a}\pm0.02$
Peeled parboiled	$14.00^{a}\pm0.00$	$1.000^{a}\pm0.00$	$2.00^{a}\pm0.01$	$2.00^{a}\pm0.01$	$5.00^{a}\pm0.03$	$4.00^{a}\pm0.00$	$7.00^{a}\pm0.01$	$4.00^{a}\pm0.00$
Unpeeled parboiled	$1.10^{a}\pm0.01$	$2.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$8.00^{a}\pm0.01$	$3.00^{a}\pm0.01$	$6.00^{a}\pm0.00$	$7.00^{a}\pm0.00$	$6.00^{a}\pm0.01$
Peeled boiled	$16.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$44.00^{b}\pm0.03$	$8.00^{a}\pm0.05$	$2.00^{a}\pm0.01$	$2.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$2.00^{a}\pm0.00$
Unpeeled boiled	$4.00^{a}\pm0.00$	$3.00^{a}\pm0.00$	$0.00^{a}\pm0.00$	$4.00^{a}\pm0.00$	$9.00^{a}\pm0.00$	$2.00^{a}\pm0.00$	$1.00^{a}\pm0.00$	$32.00^{b}\pm0.00$
Aerial Potato Fermented with starter culture (sfu/g x 10^5)								
Peeled	1.14 ± 2.08^{a}	7.64 ± 0.33^{b}	21.32 ± 0.77^{b}	77.68 ± 0.06^{c}	104.13 ± 0.15^{a}	207.31 ± 0.21^{d}	293.10 ± 0.31^{e}	93.42 ± 0.11^{d}
Unpeeled	46.70 ± 1.53^{b}	24.11 ± 0.06^{c}	24.16 ± 0.34^{b}	31.44 ± 0.13^{b}	112.03 ± 0.51^{b}	153.16 ± 0.09^{c}	187.30 ± 0.90^{d}	86.11 ± 0.03^{c}
Peeled parboiled	1.14 ± 0.23^{a}	5.31 ± 0.41^{a}	11.59 ± 0.16^{a}	21.62 ± 0.33^{a}	94.13 ± 0.53^{a}	83.44 ± 0.31^{b}	27.14 ± 0.16^{b}	19.41 ± 0.33^{b}
Unpeeled parboiled	1.44 ± 0.03^{a}	11.11 ± 1.02^{b}	16.02 ± 0.02^{a}	34.11 ± 0.18^{b}	100.05 ± 0.16^{a}	72.16 ± 0.42^{b}	34.11 ± 1.31^{c}	21.17 ± 0.42^{b}
Peeled boiled	1.14 ± 0.15^{a}	9.42 ± 0.16^{b}	15.11 ± 0.11^{a}	21.08 ± 0.08^{a}	92.15 ± 0.03^{a}	55.41 ± 0.16^{a}	18.41 ± 0.41^{a}	10.14 ± 0.38^{a}
Unpeeled boiled	1.05 ± 0.03^{a}	3.31 ± 0.08^{a}	18.41 ± 0.07^{a}	36.41 ± 0.03^{b}	107.31 ± 0.01^{a}	61.22 ± 0.22^{b}	22.63 ± 0.17^{b}	15.05 ± 0.06^{a}

Values are presented as mean±SE, values in the same column carrying same superscript are not different significantly according to new Duncan's Multiple Range test at $p<0.05$

Table 4: Occurrence of bacteria in Fermented Aerial Potato

Bacterial isolates	Peeled			Unpeeled			Peeled parboiled			Unpeeled parboiled			Peeled boiled			Unpeeled boiled			Total (%)
	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	
Acinetobacter radioresistens	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	4(3.39)
Bacillus farraginis	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	+	+	4(3.39)
Bacillus subtilis	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	15(12.71)
Citrobacter freundii	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	3(2.54)
Citrobacter sedlakii	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	-	4(3.39)
Dickeya chrysantheni	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	2(1.69)
Escherichia coli	+	+	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	6(5.08)
Lactobacillus delbrueckii	+	+	+	+	+	+	-	-	+	-	-	+	-	-	+	-	-	+	10(8.47)
Lactobacillus fermentum	+	+	+	-	+	+	-	+	+	-	-	+	-	-	+	-	+	+	10(8.47)
Lactococcus lactis	+	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	15(12.71)
Lactobacillus plantarum	+	+	+	-	+	+	+	+	+	-	-	+	+	+	+	-	-	+	13(11.02)
Moraxella caprae	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	3(2.54)
Morganella morganii	-	+	+	-	-	+	+	-	+	-	+	+	+	-	-	-	-	-	8(6.78)
Pseudomonas aeruginosa	+	-	-	+	+	+	+	-	-	+	+	+	-	-	-	+	+	-	10(8.47)
Staphylococcus aureus	+	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	5(4.24)
Shigella flexneri	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	3(2.54)
Yersinia massiliensis	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-	3(2.54)
Total	11	8	6	10	9	7	6	4	6	8	5	7	4	5	5	6	6	5	118

Key: - = absent, + = present, MC = mixed culture fermentation, BS = backslopping fermentation, ST = starter culture fermentation

Table 5: Occurrence of fungi in Fermented Aerial Potato

Bacterial isolates	Peeled			Unpeeled			Peeled parboiled			Unpeeled parboiled			Peeled boiled			Unpeeled boiled			Total (%)
	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	MCF	BSF	STF	
Alternaria alternate	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	3(6.00)
Aspergillus fumigatus	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(2.00)
Aspergillus niger	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	3(6.00)
Aspergillus parasiticus	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(4.00)
Aspergillus terreus	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1(2.00)
Cladophialophora carrionii	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	2(4.00)
Candida tropicalis	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	18(36.00)
Fusarium oxysporum	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	3(6.00)
Geotrichum candidum	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	2(4.00)
Geomyces pannorum	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	1(2.00)
Penicillium brevicompactum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1(2.00)
Penicillium corylophilum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1(2.00)
Saccharomyces cerevisiae	+	-	+	-	-	+	+	+	+	+	-	+	+	+	+	-	-	+	12(24.00)
Total	3	1	2	4	3	3	4	4	3	4	2	3	2	2	2	5	1	2	50

Key: - = absent, + = present, MC = mixed culture fermentation, BS = backslopping fermentation, ST = starter culture fermentation

DISCUSSION

Initial increase in microbial load in all the samples of aerial yam observed in this study could be due to the fact that aerial potato is very rich in carbohydrate, We know that the composition can vary according to geographic location, but, on average, what is the percentage of carbohydrate in this tuber? which could sustain the growth of microorganisms. Bello and Akinyele (2007) and Sanjeet *et al.* (2017) reported that growth of some microorganisms are inhibited by the metabolic products of others in the growth medium thereby accounting for decrease recorded in microbial load of the aerial potato during fermentation. However, higher microbial counts in samples that was subjected to back-sloping fermentation agreed with the findings of Wirawati *et al.* (2019) who reported that back-sloping fermentation has been proven to accelerate the fermentation rate and improve food quality. Also, higher lactic acid bacterial counts observed in peeled backslopping fermented samples could increase the nutritional contents of the sample and as well reduce the presence of pathogenic microorganisms. The occurrence of *Shigella, Escherichia* and *Staphylococcus* which are potential pathogens in food could make aerial potato unfit for human consumption, however, the presence of *Lactobacillus* and *Lactococcus* Suggestion: Cite some previous studies that showed that a variety of different species of *Lactobacillus* and *Lactococcus* were isolated and identified in aerial potato.the lactic acid bacteria could increase the bioavailability of nutrients with a significant increase in the shelf life. The low occurrence of bacteria recorded in the backslopping and starter culture fermented samples could be as a result of suppression of other bacteria by the presence of lactic acid bacteria confirmed by the absence of *Escherichia coli* in backslopping and starter culture fermented samples respectively. Cite previous studies that can corroborate your results. However, presence of *Alternaria, Aspergillus, Cladophialophora, Fusarium, Geomyces* and *Geotrichum* which are either toxin producing or spoilage fungi could affect the safety of fermented aerial potato for human consumption, while presence of *Saccharomyces* and *Candida* species could improve the quality and shelf life of the final product. Backslopping and starter culture fermentation process was able to eliminate the presence of *Aspergillus* and this could be due to the presence of LAB that has been reported to produce some antimicrobial compounds.

In conclusion, presence of some potential pathogenic bacteria as well as toxin producing and spoilage fungi in fermented aerial potato is a challenge to public health. Backslopping and starter culture fermentation methods were able to eliminate majority of these microorganisms especially

in peeled and peeled boiled samples, therefore, these two methods can be employed in the processing of aerial potato for food.

REFERENCES

Anandpara, R. C. and Tirgar, P. R. (2017). Investigation of therapeutics benefits of *Dioscorea bulbifera* in breast cancer. *Journal of Chemical and Pharmaceutical Research*, 9(6), 313–326.

Araghiniknam, M., Chung, S., Nelson-White, T., Eskelson, C and Watson, R.R. (1996). Antioxidant activity of *Dioscorea* and Dehydroepiandrosterone (DHEA) in older humans. *Life Sciences*, 59(11), 8795709

Chaniad, P., Wattanapiromsakul, C., & Pianwanit, S. (2016). Anti-HIV-1 integrase compounds from *Dioscorea bulbifera* and molecular docking study. *Pharmaceutical Biology, 54*, 0209.

Fawole, M. O. and Oso, B. A. (2004). Characterization of bacteria: *Laboratory Manual of Microbiology.* 4th Edition, Spectrum Book Ltd., Ibadan, Nigeria, 24-33

Ghosh S, More P, Nitnavare R, Jagtap S, and Chippalkatti R. (2015) Antidiabetic and antioxidant properties of copper nanoparticles synthesized by medicinal plant *Dioscorea bulbifera*. *J Nanomed Nanotechnol* S6: 007.

Ghosh, S. (2015). Phytochemsitry and therapeutic potential of medicinal plant: *Dioscorea bulbifera*. *Medicinal Chemistry,* 5(4), 160–172. doi:10.4172/2161-0444

Ghosh, S., Ahire, M., Patil, S., Jabgunde, A., Dusane, M. B., Bimba, N. and Dhavale, D. D. (2011). Antidiabetic activity of gnidia glauca and *Dioscorea bulbifera*: Potent amylase and glucosidase inihibitors. *Evidence-based Complementary and Alternative Medicine*, *2012*, 1–7.

Ghosh, S., More, P., Derle, A., Patil, A. B., Markad, P., Asok, A and Dhavale, D. D. (2014). Diosgenin from *Dioscorea bulbifera:* Novel hit for treatment of type ii diabetes mellitus with inhibitory activity against α -amylase and α -glucosidase. *PloS one, 9*(9), 2–13.

Hidayat, A., Fadhlurrahman, A., Chan, C. K., Mohamad, J., & Kadir, H. A. (2018). Dioscorea bulbifera induced apoptosis through inhibition of ERK 1/2 and activation of JNK

signaling pathways in HCT116 human colorectal carcinoma cells. *Biomedicine and Pharmacotherapy*, 104(04), 806–816.

Adeniran, A. A., & Sonibare, M. A. (2013). In vitro potential anthelmintic activity of bulbils of Dioscorea bulbifera L. on earthworms and liverflukes. *Journal of Pharmacognosy and Phytotherapy*, 5(12), 196–6.

Hunter, B. B. and Bamett, H. L. (2000). Deuteromycetes (Fungi Imperfecti). In: Handbook of Microbiology, Laskin, A. I. and H. A. Lechevalier (Eds.). 4th Edn., CRC Press, Boca Raton, FL., pp: 1-234.

Kuete, V., BetrandTeponno, R., Mbaveng, A. T., Tapondjou, L. A., Meyer, J. J. M., Barboni, L., & Lall, N. (2012). Antibacterial activities of the extracts, fractions and compounds from Dioscorea bulbifera. *BMC Complementary and Alternative Medicine*, 12, 1–12.

Nabatanzi, A. (2016). Wild food plants used by people living with hiv/aids in nakisunga sub-county, uganda. *African Journal of Food, Agriculture, Nutrition and Development*, *16*, 11310–11330.

Nam, H.-S., Cho, S.-S., & Kim, C.-J. (2006). The effects of Dioscorea bulbifera L. on hyperthyroidism of rats. *Journaol of Korean Oriental Medicine*, 27(3), 179–187.

Odugbemi, T (2008). *A Textbook of Medicinal Plants from Nigeria: Lagos, University of Lagos Pres*s, 45.

Olutiola, P. O., Famurewa, O. and Sonntag, H-G. (2018). An introduction to general microbiology; A practical approach. Second edition, Heidelberger, Germany, Measurement of microbial growth, 78 -101

Omodamiro OD (2015) Anti-inflammatory and diuretic activities of ethanol extract of *Dioscorea bulbifera* leaf. AJDDT 2(1): 029-038.

Sanjeet K, Gitishree D, Han-Seung S, Jayanta KP (2017) Dioscorea spp. (A wild edible tuber): A study on its ethnopharmacological potential and traditional use by the local people of Similipal biosphere reserve, India. Frontiers in Pharmacol 8(52): 1-17.

Sharma, L. N., & Bastakoti, R. (2009). Ethnobotany of Dioscorea L. with emphasis on food value in chepang communities in Dhading District, Central Nepal. *Journal of Plant Science*, 6(2009), 12–17.

Tapondjou, L. A., Jenett-Siems, K., Böttger, S., & Melzig, M. F. (2013). Steroidal saponins from the flowers of Dioscorea Bulbifera Var. Sativa. *Phytochemistry*, 95, 341–350.

Tewodros, M., and Getachew, W. M. (2013). Agronomical Evaluation of Aerial Yam / Dioscorea bulbifera / Accession collected from South and Southwest Ethiopia. *Greener Journal of Agricultural Sciences*, **3**(9): 693-704

Trimanto, T, and Lia Hapsari, L. (2015). Diversity and utilization of Dioscorea Spp. Tuber as alternative food source in nganjuk regency, East Java. *Agrivita*, 37(2), 97–107.