

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 ($7.06 \pm 0.05 \times 10^5$ cfu/g), lactic acid bacterial count ($67.74 \pm 1.17 \times 10^7$ cfu/g) and fungal count ($0.81 \pm 0.16 \times 10^6$ sfu/g), while total viable bacterial, LAB and fungal in peeled samples were $30.40 \pm 2.00 \times 10^{10}$ cfu/g, $298.17 \pm 2.36 \times 10^7$ cfu/g and $133.30 \pm 0.15 \times 10^6$ 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 'emina', 'ewura-esi' and 'isu ahum' (Ghosh, 2015). The yam is native to Africa, Asia and northern Australia, however, over 600 varieties of yam exists and 95% of them are grown in African (Sanjeet *et al.*, 2017;

Omodamiro, 2015), for which Nigeria is one of the highest producers in Africa. 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), especially at the beginning of the rainy season in Nigeria.

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* (Kuate *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.

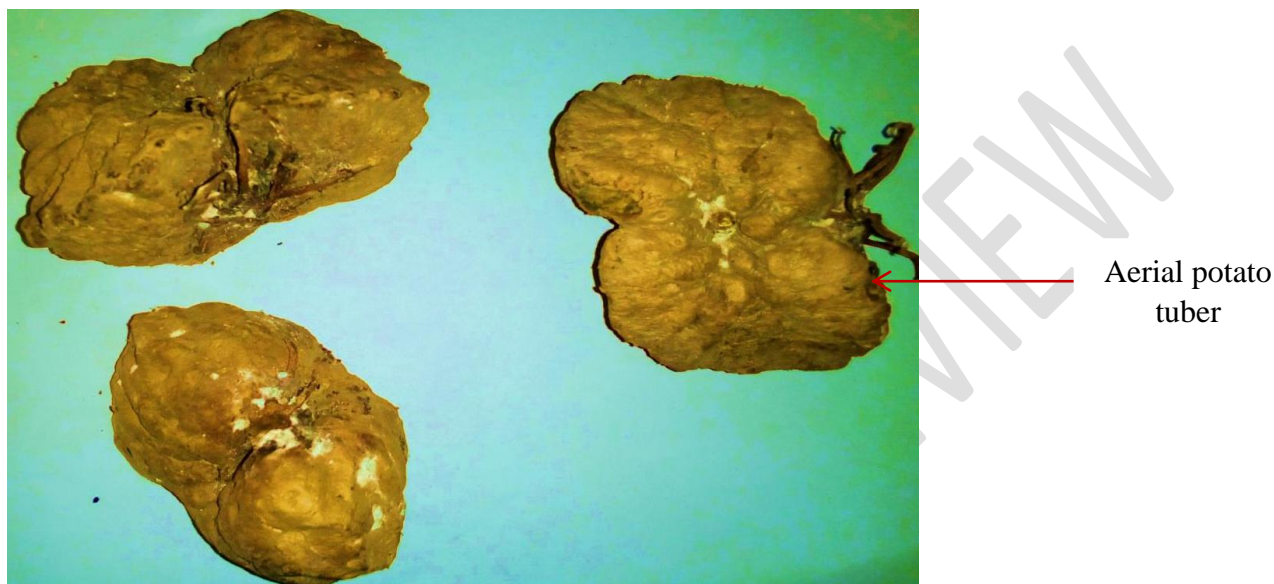


Plate 1: Tuber of Aerial potato

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 every 24 hours.**

Isolation and identification of microorganisms.

Isolation of total viable bacterial, yeast and mould were 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 ($30.40 \pm 2.00 \times 10^{10}$ cfu/g), peeled and parboiled ($1.93 \pm 1.51 \times 10^{10}$ cfu/g) and peeled boiled ($8.22 \pm 1.83 \times 10^{10}$ cfu/g) than the corresponding unpeeled samples. However, the bacterial load reduced at the end of fermentation period (168 hours) where unpeeled parboiled ($9.40 \pm 1.33 \times 10^5$ cfu/g) had the highest bacterial counts, followed by peeled ($7.50 \pm 0.17 \times 10^5$ cfu/g) and peeled boiled ($2.58 \pm 0.01 \times 10^5$ 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 ($203.00 \pm 0.77 \times 10^3$ cfu/g); peeled parboiled ($101.00 \pm 0.51 \times 10^3$ cfu/g); peeled boiled ($544.00 \pm 3.57 \times 10^3$ 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 ($44.13 \pm 0.16 \times 10^5$ 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 ($526.70 \pm 2.08 \times 10^6$ cfu/g) at 72 hour, unpeeled ($79.40 \pm 10.61 \times 10^6$ cfu/g), peeled parboiled ($824.00 \pm 1.55 \times 10^6$ cfu/g) at 48 hour, unpeeled parboiled ($456.00 \pm 0.77 \times 10^6$ cfu/g), peeled boiled ($392.30 \pm 2.98 \times 10^6$ 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 $7330.00 \pm 0.58 \times 10^4$ cfu/g in peeled sample. The least value was observed in unpeeled boiled ($17.00 \pm 0.00 \times 10^4$ 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 ($7.80 \pm 0.32 \times 10^7$ cfu/g) had the highest LAB count followed by peeled boiled ($5.44 \pm 3.57 \times 10^7$ cfu/g) and unpeeled parboiled ($2.43 \pm 0.12 \times 10^7$ 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 until 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 ($380.00 \pm 0.20 \times 10^4$ sfu/g) had the highest fungal counts followed by unpeeled boiled ($32.00 \pm 0.00 \times 10^4$ 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 ($93.42 \pm 0.11 \times 10^5$ sfu/g) and unpeeled ($86.11 \pm 0.03 \times 10^5$ 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 backslipping and starter culture fermented samples.

UNDER PEER REVIEW

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 10⁵)	24 (x 10⁵)	48 (x 10⁶)	72 (x 10⁸)	96 (x 10¹⁰)	120 (x 10¹⁰)	144 (x 10⁸)	168 (x 10⁵)
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 10⁶)							
	Initial	24	48	72	96	120	144	168
Peeled	0.00 ^a ±0.00	276.70 ^d ±0.58	173.30 ^c ±1.53	526.70 ^c ±2.08	46.70 ^b ±2.08	41.70 ^b ±2.08	61.60 ^b ±2.08	100.00 ^c ±1.00
Unpeeled	0.00 ^a ±0.00	3.60 ^a ±0.00	79.40 ^b ±10.61	1.10 ^a ±0.16	11.00 ^a ±1.42	39.00 ^b ±5.32	11.30 ^a ±1.63	49.00 ^b ±0.00
Peeled parboiled	0.00 ^a ±0.00	487.90 ^c ±1.82	824.00 ^c ±1.55	105.90 ^b ±1.48	21.00 ^a ±0.17	1.90 ^a ±0.01	33.00 ^b ±0.41	76.00 ^b ±0.00
Unpeeled parboiled	7.00 ^b ±0.04	191.80 ^c ±2.19	308.60 ^d ±3.82	111.90 ^b ±1.18	456.00 ^c ±0.77	22.70 ^a ±1.55	92.00 ^b ±7.93	77.00 ^b ±1.20
Peeled boiled	0.00 ^a ±0.00	29.30 ^b ±4.00	56.10 ^b ±4.83	19.80 ^a ±2.79	392.30 ^c ±2.98	298.17 ^c ±2.36	298.17 ^c ±4.36	38.80 ^b ±0.00
Unpeeled boiled	0.00 ^a ±0.00	9.00 ^a ±0.00	1.00 ^a ±0.00	4.00 ^a ±0.00	5.00 ^a ±0.00	6.00 ^a ±0.00	1.00 ^a ±0.00	1.00 ^a ±0.00
Aerial Potato Fermented with back slope Fermentation	LAB counts (cfu/g x 10⁴)							
Peeled	30.00 ^c ±0.00	160.00 ^c ±0.00	470.00 ^c ±0.58	730.00 ^c ±1.53	600.00 ^b ±1.00	1067.00 ^c ±0.58	4330.00 ^d ±0.12	7330.00 ^c ±0.58
Unpeeled	50.00 ^c ±0.04	668.00 ^d ±11.54	3335.00 ^d ±2.84	180.00 ^b ±0.04	1320.00 ^c ±0.66	1900.00 ^c ±1.39	800.00 ^b ±0.51	390.00 ^b ±0.19
Peeled parboiled	50.00 ^c ±0.01	0.00 ^a ±0.00	220.00 ^b ±0.14	1860.00 ^d ±1.28	2450.00 ^d ±1.65	570.00 ^b ±0.54	8190.00 ^c ±0.55	1444.00 ^d ±0.32
Unpeeled parboiled	0.00 ^a ±0.00	10.00 ^a ±0.02	2140.00 ^d ±2.39	2520.00 ^d ±1.52	1130.00 ^c ±0.81	1847.00 ^c ±1.30	10520.00 ^f ±0.76	420.00 ^b ±0.14
Peeled boiled	40.00 ^c ±1.17	6774.00 ^e ±1.14	3250.00 ^d ±2.17	2140.00 ^d ±3.04	6160.00 ^e ±4.41	530.00 ^b ±0.17	2130.00 ^c ±1.51	630.00 ^b ±0.58
Unpeeled boiled	10.00 ^b ±0.00	84.0 ^b ±0.00	1.00 ^a ±0.00	7.00 ^a ±0.00	5.00 ^a ±0.00	8.00 ^a ±0.00	18.00 ^a ±0.00	17.00 ^a ±0.00
Aerial Potato Fermented with starter culture	LAB counts (cfu/g x 10⁷)							
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 ±0.00	0.00 ^a ±0.00	17.03 ^b ±0.06	30.90 ^c ±0.06	14.01 ^b ±2.08	2.30 ^a ±0.58	0.34 ^a ±0.59	4.17 ^b ±0.08
Unpeeled	3.30 ^b ±0.00	8.01 ^b ±0.11	49.04 ^c ±0.06	95.02 ^d ±0.13	14.04 ^b ±0.23	1.30 ^a ±0.23	0.09 ^a ±0.10	0.00 ^a ±0.00
Peeled parboiled	0.00 ^a ±0.00	0.00 ^a ±0.00	0.00 ^a ±0.00	0.00 ^a ±0.00	14.03 ^b ±0.15	0.71 ^a ±0.01	0.19 ^a ±0.27	0.04 ^a ±0.00
Unpeeled parboiled	0.00 ^a ±0.00	0.00 ^a ±0.00	0.00 ^a ±0.00	0.00 ^a ±0.00	2.60 ^a ±0.26	0.42 ^a ±0.00	0.02 ^a ±0.03	0.01 ^a ±0.01
Peeled boiled	1.10 ^b ±0.01	0.00 ^a ±0.00	0.00 ^a ±0.00	0.00 ^a ±0.00	1.10 ^a ±0.01	43.4 ^b ±0.63	4.34 ^b ±0.60	0.39 ^a ±0.00
Unpeeled boiled	2.00 ^b ±0.00	1.00 ^a ±0.00	0.00 ^a ±0.00	3.01 ^b ±0.00	7.41 ^b ±0.00	2.02 ^a ±0.00	0.06 ^a ±0.00	0.03 ^a ±0.00
Aerial Potato in back slope Fermentation (sfu/g x 10⁴)								
Peeled	0.00 ^a ±0.00	43.000 ^b ±1.53	17.00 ^b ±0.52	400.70 ^c ±0.12	467.00 ^c ±1.53	1333.00 ^b ±0.15	900.00 ^b ±2.00	380.00 ^c ±0.20
Unpeeled	80.10 ^b ±0.16	6.000 ^a ±0.04	12.00 ^a ±0.01	34.00 ^b ±0.02	44.40 ^b ±0.03	11.40 ^a ±0.10	8.00 ^a ±0.05	3.00 ^a ±0.02
Peeled parboiled	14.00 ^a ±0.00	1.000 ^a ±0.00	2.00 ^a ±0.01	2.00 ^a ±0.01	5.00 ^a ±0.03	4.00 ^a ±0.00	7.00 ^a ±0.01	4.00 ^a ±0.00
Unpeeled parboiled	1.10 ^a ±0.01	2.00 ^a ±0.00	1.00 ^a ±0.00	8.00 ^a ±0.01	3.00 ^a ±0.01	6.00 ^a ±0.00	7.00 ^a ±0.00	6.00 ^a ±0.01
Peeled boiled	16.00 ^a ±0.00	0.00 ^a ±0.00	44.00 ^b ±0.03	8.00 ^a ±0.05	2.00 ^a ±0.01	2.00 ^a ±0.00	1.00 ^a ±0.00	2.00 ^a ±0.00
Unpeeled boiled	4.00 ^a ±0.00	3.00 ^a ±0.00	0.00 ^a ±0.00	4.00 ^a ±0.00	9.00 ^a ±0.00	2.00 ^a ±0.00	1.00 ^a ±0.00	32.00 ^b ±0.00
Aerial Potato Fermented with starter culture (sfu/g x 10⁵)								
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 ^c	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	
<i>Acinetobacter radioresistens</i>	+	-	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	4(3.39)
<i>Bacillus farraginis</i>	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	+	+	4(3.39)
<i>Bacillus subtilis</i>	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	15(12.71)
<i>Citrobacter freundii</i>	+	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	3(2.54)
<i>Citrobacter sedlakii</i>	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	-	4(3.39)
<i>Dickeya chrysantheni</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	2(1.69)
<i>Escherichia coli</i>	+	+	-	+	-	-	+	-	-	+	+	-	-	-	-	-	-	-	6(5.08)
<i>Lactobacillus delbrueckii</i>	+	+	+	+	+	+	-	-	+	-	-	+	-	-	+	-	-	+	10(8.47)
<i>Lactobacillus fermentum</i>	+	+	+	-	+	+	-	+	+	-	-	+	-	-	+	-	+	+	10(8.47)
<i>Lactococcus lactis</i>	+	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	15(12.71)
<i>Lactobacillus plantarum</i>	+	+	+	-	+	+	+	+	+	-	-	+	+	+	+	-	-	+	13(11.02)
<i>Moraxella caprae</i>	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	3(2.54)
<i>Morganella morganii</i>	-	+	+	-	-	+	+	-	+	-	+	+	+	-	-	-	-	-	8(6.78)
<i>Pseudomonas aeruginosa</i>	+	-	-	+	+	+	+	-	-	+	+	+	-	-	-	+	+	-	10(8.47)
<i>Staphylococcus aureus</i>	+	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	5(4.24)
<i>Shigella flexneri</i>	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-	3(2.54)
<i>Yersinia massiliensis</i>	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-	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	
<i>Alternaria alternata</i>	-	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	3(6.00)
<i>Aspergillus fumigatus</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(2.00)
<i>Aspergillus niger</i>	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	3(6.00)
<i>Aspergillus parasiticus</i>	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(4.00)
<i>Aspergillus terreus</i>	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	1(2.00)
<i>Cladophialophora carrionii</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	2(4.00)
<i>Candida tropicalis</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	18(36.00)
<i>Fusarium oxysporum</i>	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	3(6.00)
<i>Geotrichum candidum</i>	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	2(4.00)
<i>Geomyces pannorum</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	1(2.00)
<i>Penicillium brevicompactum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1(2.00)
<i>Penicillium corylophilum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	1(2.00)
<i>Saccharomyces cerevisiae</i>	+	-	+	-	-	+	+	+	+	+	-	+	+	+	+	-	-	+	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 = backslipping 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 (73.62% in 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*, which are mostly involved in the fermentation processes help reduce their effects.** Also, 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 (Trimanto and Lia, 2015).** 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.

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