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Influence of food safety knowledge, attitudes and practices of processors on microbiological quality of commercially produced traditional fermented cereal beverages, a case of *Obushera* in Kampala

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ABSTRACT

Traditionally, fermented foods were only consumed in regions of their origins but owing to increasing demand, some are finding their way into foreign markets. The challenge though, is the generally uncontrolled nature of the fermentations which raises safety concerns. This paper highlights the food safety challenges associated with traditional fermented foods with a special focus on commercially produced and packaged *Obushera*, a Ugandan traditional fermented cereal beverage. Microbial counts, titratable acidity (TA) and pH of *Obushera* samples (n = 59) were determined. Food safety knowledge, attitudes and practices (KAP) of processors (n = 47) were also evaluated. About 50% of samples did not conform to safety requirements. *Obushera* had 0.0–7.3 log cfu/mL total and thermo-tolerant coliforms, 0.0–6.2 log cfu/mL *E. coli* and 0.0–8.1 log cfu/mL *Staphylococcus* spp. Flour samples had 3.7–7.3 log cfu/g total coliforms, 3.2–7.1 log cfu/g thermo-tolerant coliforms, 1.0–4.9 log cfu/g *E. coli* and 2.4–7.3 log cfu/g *Staphylococcus* spp. *Salmonella* spp was not detected. *Obushera* (56 out of 59 samples) with pH ≤ 4.0 and TA = 0.1–3.1% had coliforms and *Staphylococcus* spp above the recommended minimum values. Scores showed that processors had fairly good knowledge (63.0 ± 2.3%) and attitudes (52.2 ± 3.0%) but poor practices (38.7 ± 2.4%). There was no correlation between the KAP and product quality. Therefore, processors should adopt better processing technologies that enhance food safety. There is also need for enforcement and regulation of food safety by concerned authorities. Trainings for processors should aim at positively changing their attitudes and causing them to adopt appropriate practices.

1. Introduction

The global fermented foods and drinks market is poised to register a compound annual growth rate (CAGR) of 7.2% during the forecast period of 2018–2023 (Mordor Intelligence, 2018). This is a competitive market driven by product innovation and the increasing awareness about healthy diets (Mordor Intelligence, 2018). For long, the market for beverages in some countries has been dominated by artificial soft drinks, many of which are foreign. Consumers often prefer the foreign foods because of their exotic presentation (Achi, 2005) and possibly trusted safety. Lately, though some traditional fermented foods have progressed from their localities onto the global market as trans-national staple foods (Soni & Dey, 2014). The problem however, is that most of these foods are produced under uncontrolled and unhygienic conditions which hamper adoption into new markets (Achi, 2005; Mukisa, 2012).

For a food product to effectively penetrate a foreign market, research and development are needed to improve the traditional fermentation (Borresen, Henderson, Kumar, Weir, & Ryan, 2012; Soni & Dey, 2014). Indeed, these have enabled foods like *Kimchi* (fermented vegetables from Korea) and *Natto* (fermented soybeans from Japan) to penetrate markets beyond Asia (Achi, 2005). Fermented foods are popular in native diets across the globe due to their peculiar sensory attributes, nutritional value and prolonged shelf life (Steinkraus, 1996). Among the various types of traditional fermented foods is *Obushera*, a sorghum and/or millet beverage from Uganda. Honey or cassava flour may also be added to the recipe (Mukisa et al., 2012; Muyanja, Kikafunda, Narvhus, Helgetun, & Langsrud, 2003). Traditionally, *Obushera* is consumed as a refreshment, thirst quencher or weaning

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food (Mukisa et al., 2012). Until recently, the beverage has been consumed by the lower market spectrum commonly served in dinghy village shops and city alleys. None-the-less, it is becoming popular among the up-market population (Kisangala, 2015). Sensing a potential market, especially among the growing middle class and Ugandans in the diaspora, a number of entrepreneurs are venturing into product commercialization (Kisangala, 2015). Consequently, many processors are engaging in haphazard production with some of them not obtaining official approval thus putting consumers at risk of foodborne illnesses.

The Burden of Disease study in Uganda stated that, 75% of life years lost to premature death are partly due to foodborne illnesses (FAO, 2004). The foodborne disease burden epidemiology reference group (FERG) 2007–2015 reported that the highest burden was in Africa (WHO, 2015). The burden was estimated at 1200 DALYs (disability-adjusted life year) per 100,000 population in the 'AFR E' sub region where Uganda falls (WHO, 2015). DALY is a health gap measure that combines the years of life lost due to premature death and years lived with disability from a disease or condition for varying degrees of severity. One DALY equates to one year of a healthy life lost (WHO, 2015). Nearly 70% of the foodborne disease burden in the 'AFR E' sub region is due to diarrheal pathogens (WHO, 2015).

The presence of pathogens in traditional fermented foods is documented (Lues et al., 2011; Lyumugabe, Kamaliza, Bajyana, & Thonart, 2010). The safety of these products is determined in part by processors' knowledge, attitudes and practices - KAP (Martins, Hogg, & Otero, 2012). Studies in Uganda have reported discrepancies in the link between the food safety KAP of processors and the microbiological quality of foodstuffs (Baluka, Miller, & Kannene, 2015; Heilmann, Roesel, Clausen, & Grace, 2016; Muyanja, Nayiga, Namugumya, & Nasinyama, 2011; Roesel et al., 2013). Research on *Obushera* has largely focused on understanding and optimizing its production process (Mukisa et al., 2012; Mukisa, Ntaate, & Byakika, 2017; Muyanja, Langsrud, & Narvhus, 2004). Furthermore, Byaruhanga and Ndifuna (2002) for the first time successfully applied modern food preservation techniques (pasteurization and/or refrigeration) on *Obushera* to increase shelf life and microbial safety. For long, the microbial safety of *Obushera* has received minimal attention in spite of the discovery of *Streptococcus gallolyticus* in the beverage (Mukisa et al., 2012). Therefore, the study evaluated the microbiological and physicochemical quality of commercially produced and packaged *Obushera* in relation to the food safety KAP of processors. This information is critical for guiding production of safe fermented cereal beverages.

2. Materials and methods

2.1. Study design and sample size

A descriptive cross-sectional study was carried out between August and September 2017. The estimated sample size was obtained using an automated online calculator (Raosoft Inc, 2004). It was used with predetermined margin of error of 5%, confidence level of 95% and an estimated population size of commercial *Obushera* processors = 50. A preliminary survey showed that there were about 30 branded and 20 unbranded *Obushera* products on the Kampala market. Thus the minimal calculated sample size was 45 processors. The required sample size was further increased to 50 taking into account a 10% non-responsive rate. However, a total of 47 producers of *Obushera* were interviewed in the five divisions of Kampala (Central division (n = 5), Kawempe division (n = 12), Makindye division (n = 7), Nakawa division (n = 14), and Rubaga division (n = 9). Respondents were selected based on their interest in participant. Initially the objective was to interview ten processors per division but this was not possible as some processors declined to participate. Kampala district was selected for this study because it is cosmopolitan, the capital city and the main industrial and business center of the country.

2.2. Interviews on food safety knowledge, attitudes and practices (KAP) of processors

Data on food safety KAP of processors was collected through face-to-face interviews using a structured questionnaire. The questionnaire was first peer-reviewed and pretested before use. It collected data on the demographic characteristics of processors, *Obushera* production, food safety knowledge, attitudes and self-reported practices (personal hygiene, equipment sanitization, raw materials and product handling and storage, water quality, garbage disposal, quality assurance and quality control).

2.3. Obushera and flour samples

Obushera samples (n = 59) were collected from the interviewed processors. Malted and unmalted flours; sorghum flour (n = 20), millet flour (n = 20) and cassava flour (n = 11) were collected from wholesale shops and major markets in Kampala where the processors interviewed reported to regularly obtain their raw materials.

2.4. Analyses

2.4.1. Microbiological analyses

Coliform counts were determined by pour plating selected serial dilutions of samples in sterile Violet Red Bile Lactose (VRBL) agar (Laboratorios, CONDA, Madrid, Spain) and incubating for 24 h at 37 °C and 44.5 °C for total coliforms and thermo-tolerant coliforms, respectively. *E. coli* counts were determined by pour plating selected serial dilutions of the sample in *E. coli*-coliforms chromogenic agar (Laboratorios CONDA, Madrid, Spain) at 37 °C for 24 h. *Staphylococcus* spp counts were determined by surface spreading selected serial dilutions of the sample on sterile pre-poured Baird Parker Agar (BPA) (Laboratorios, CONDA, Madrid, Spain) containing tellurite egg yolk supplement (Laboratorios, CONDA, Madrid, Spain) and incubating at 30 °C for 48 h. Presence of *Salmonella* spp was determined by pre-enrichment of the sample in Buffered Peptone Water (Laboratorios, CONDA, Madrid, Spain) and incubating at 37 °C for 24 h. This was followed by a second enrichment step in Rappaport Vassiliadis Soy broth (Laboratorios, CONDA, Madrid, Spain) and incubating at 41.5 °C for 24 h. Thereafter, streaking was done on Xylose Lysine Deoxycholate agar (Laboratorios, CONDA, Madrid, Spain) and Brilliant Green Agar (Laboratorios, CONDA, Madrid, Spain) followed by incubating the plates at 37 °C for 24 h. Presumptive *Salmonella* spp colonies were confirmed by streaking on Triple Sugar Iron (Laboratorios, CONDA, Madrid, Spain) and Simmon's Citrate agar (Laboratorios, CONDA, Madrid, Spain) slants and incubating at 37 °C for 24 h.

2.4.2. Physicochemical analyses

The pH of *Obushera* was determined using a digital pH meter (pH 98107, USA). Titratable acidity (TA) was determined by titrating 10 mL of the sample against a standardized solution of 0.1M NaOH with phenolphthalein as the indicator (AOAC method 942.15, 1990).

2.4.3. Data analyses

Data were analyzed using Statistical Package for Social Science (SPSS), version 19.0. Descriptive statistics were used to compile data on the demographics of processors, *Obushera* (raw materials, training and safety inspection), microbiological quality and physico-chemical properties of samples. For data on KAP, one point was awarded for each correct response while no point was given for a wrong response. Total points per participant per section were computed as a percentage. Final percentage scores per section were categorized as; 0–25% (very poor), 26–50% (fairly poor), 51–75 (fairly good) and 76–100% (very good). A Chi-Square test ($\alpha = 0.05$) was used to determine associations between the microbiological quality of *Obushera* and food safety KAP of processors. The effect of food safety KAP on the microbiological quality of

Table 1
Summary of microbial counts of flours and *Obushera*.

Sample	Total coliforms	Thermo-tolerant coliforms	*E. coli*	*Staphylococcus* spp.
	(log cfu/g)			
Sorghum flour (n = 20)	6.5 ± 0.8	5.8 ± 1.1	3.9 ± 0.9	4.1 ± 0.8
Millet flour (n = 20)	5.2 ± 0.9	4.3 ± 0.7	2.5 ± 0.8	4.3 ± 0.8
Cassava flour (n = 11)	6.1 ± 1.1	5.5 ± 1.0	1.9 ± 0.9	5.5 ± 1.1
Obushera (n = 59)	2.6 ± 2.7	2.3 ± 2.5	1.8 ± 2.2	2.8 ± 2.2

Values are means ± standard deviations.

Obushera was measured by conducting an independent *t*-test which compared the mean scores of persons who had good KAP with those that did not. The significance level was set at < 0.05.

3. Results and discussion

3.1. Microbiological quality of flours and Obushera

Mean total coliforms, thermo-tolerant coliforms, *E. coli* and *Staphylococcus* spp in flours ranged from 5.2 to 6.5, 4.3–5.8, 1.9–3.9, 4.1–5.5 log cfu/g, respectively (Table 1). There were no differences ($p > 0.05$) in the coliforms and *Staphylococcus* spp counts of malted and unmalted flours. *Obushera* had mean total coliforms, thermo-tolerant coliforms, *E. coli* and *Staphylococcus* spp counts of 2.6, 2.3, 1.8 and 2.8 log cfu/g, respectively (Table 1). *Salmonella* was not detected in any of the samples. The TA and pH of *Obushera* were 0.6% ± 0.4 and 3.7 ± 0.4, respectively.

The microbial counts of *Obushera* and flours and their conformance to safety standards are presented in Table 2. Majority of the samples did not conform to the food safety standards. Only 52.5%, 23.7% and 37.3% of the *Obushera* conformed to the *E. coli, Staphylococcus* spp and acidity specifications, respectively. None of the flours met the specifications for coliforms and *Staphylococcus* spp. Unfortunately, the fermented cereal beverages specification (UNBS, 2009) lacks specifications for total coliforms, thermo-tolerant coliforms, *Staphylococcus* spp and pH so standards for other ready-to-drink beverages were used. About 97% of *Obushera* had pH ≤ 4.0 as recommended by Steinkraus (1996). Despite that, 33 of the 57 samples (with pH ≤ 4.0) had coliforms (1.0–7.3 log cfu/mL) and (2.1–6.2 log cfu/mL) *Staphylococcus* spp. Only 37.3% of *Obushera* samples met the requirement for TA (≤0.4%).

This is the first study to focus on microorganisms of public health concern in *Obushera*, besides just total coliforms as has been the case in previous studies (Kateu, 1998; Mukisa et al., 2012; Muyanja et al., 2004; Muyanja, Narvhus, Treimo, & Langsrud, 2003). Our results indicate a potentially serious problem of coliform and Staphylococcal contamination in *Obushera* on the Kampala market. Similar studies in Nigeria reported the presence of *E. coli*, *Klebsiella, aerogenes*, *Staphylococcus aureus*, *Pseudomonas aeruginosa, Salmonella, Shigella, Citrobacter and Proteus* among others in *ogi,* a fermented cereal beverage (Izah, Kigigha, & Okowa, 2016; Oyelana & Coker, 2012). The primary source of contamination of *Obushera* is likely the flours since the raw materials are often dried on bare ground (Kaaya, 2005; Muyanja, Kikafunda, et al., 2003). Additionally, during malting some farmers steep the grains in streams, rivers or man-made ponds which most likely contribute to the contamination (Muyanja, Kikafunda, et al., 2003). In a similar study, Oyelana and Coker (2012) attributed the presence of potential pathogens in *ogi* to the use of contaminated water from streams and lakes. *Obushera* processors in Kampala have minimal control of the microbial quality of the flours since they obtain them from common wholesale points. The wholesalers buy the malted grain in bulk from rural areas and mill it in the city. The same milling machines are used for different batches which inevitably results in cross-contamination. Therefore, these could also explain the high contamination of the flours (Table 1). This concurs with Oyelana and Coker (2012) who highlighted millers as critical elements in flour contamination. The presence of coliforms and *Staphylococci* in the *Obushera* could also be due to post processing contamination. Packaging methods and materials have been implicated in product contamination after fermentation (Odugbemi, Oyerinde, Odujinrin, Akitoye, & Esumeh, 1993; Wacher,

Table 2
Conformance of *Obushera* and flour samples to standards.

Samples	Parameter	Specification or limit	% Conforming samples	Reference
Obushera (n = 59)	Total coliforms (cfu/mL)	Absent	40.7	UNBS (2010)
	Thermo-tolerant coliforms (cfu/mL)	Absent	45.8	UNBS (2010)
	E. coli (cfu/mL)	Not detected	52.5	UNBS (2009)
	Staphylococcus spp (log cfu/mL)	Absent	23.7	EAC (2006)
	Salmonella spp (per 25 mL)	Negative	100.0	UNBS (2009)
	Acidity, % (m/m), max.	0.4	37.3	UNBS (2009)
	pH	≤4.0	96.6	Steinkraus (1996)
Sorghum flour (n = 20)	Total coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	Thermo-tolerant coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	E. coli (cfu/g)	Absent	0.0	EAC (2011)
	Staphylococcus spp (log cfu/g)	10^2	0.0	EAC (2011)
	Salmonella spp (per 25 g)	Absent	100.0	EAC (2011)
Millet flour (n = 20)	Total coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	Thermo-tolerant coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	E. coli (cfu/g)	Not detectable	0.0	EAC (2016)
	Staphylococcus spp (log cfu/g)	Not detectable	0.0	EAC (2016)
	Salmonella spp (per 25 g)	Not detectable	100.0	EAC (2016)
Cassava flour (n = 11)	Total coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	Thermo-tolerant coliforms (cfu/g)	Absent	0.0	ARSO (2012)
	E. coli (cfu/g)	Not detected	0.0	UNBS (2007)
	Staphylococcus spp (log cfu/g)	10^2	0.0	EAC (2016)
	Salmonella spp (per 25 g)	Negative	100.0	UNBS (2007)

Canas, Cook, Barzana, & Owens, 1993). Although *Salmonella* was undetected (Table 1), other authors have reported its presence in similar beverages and flours (Umar et al., 2016; Victor et al., 2013; Yagoub, Suleiman, & Abdel-Gadir, 2009).

With regard to the physicochemical parameters (pH and acidity) of *Obushera*, some of the results particularly, TA deviated greatly from the specification (0.4% max.) in the standard - FDUS 872:2009 (UNBS, 2009). According to Steinkraus (1996), in order to ensure microbial safety, lactic acid fermented beverages should contain a minimum lactic acid content of 0.7%. This value is almost twice the minimum stated by the FDUS 872:2009 standard (UNBS, 2009). It was also observed that the same standard does not specify a limit for the maximum allowable pH. Therefore, based on earlier studies, pH = 4.0 was used as the maximum in *Obushera* meant for human consumption. At pH ≤ 4.0 many pathogens in fermented food products are inhibited (Kingamkono, Sjögren, & Svanberg, 1998; Nout, Rombouts, & Havelaar, 1989; Steinkraus, 1996). However, despite having pH ≤ 4.0 and TA ≥ 0.7%, 62.7% of *Obushera* samples contained coliforms (1.0–7.3 log cfu/mL) and *Staphylococcus* (2.1–6.2 log cfu/mL). In contrast, Muyanja et al. (2004) earlier demonstrated the effect of acid production in the suppression of coliforms during *Obushera* fermentation. Coliform counts increased from 6 to 8.4 log cfu/mL in the first 12 h of the fermentation but later decreased to < 2 log cfu/mL by 48 h (pH = 3.6, T.A = 0.6%). Mukisa (2012) also reported a decrease in coliform counts in *Obushera* from 2.0 to < 1 log cfu/mL after four days of fermentation (pH = 4.0–4.42 and TA = 0.13–1.33%). Other authors have also reported a similar trend in different traditional fermented products (Mbugua & Njenga, 1992; Simango & Rukure, 1992). Coliforms are known to be acid intolerant (Steinkraus, 1996) so their presence in acidified *Obushera* (pH ≤ 4.0 and T.A ≥ 0.7%) could imply that they are acid resistant strains and this presents an even more serious food safety challenge. The same assumption applies to the *Staphylococci*.

Based on our findings, the maximum TA value (0.4%) stated in the FDUS 872:2009 standard needs to be revised. Additionally, the pH, coliforms and *Staphylococci* limits need to be included in the standard.

3.2. Demographic characteristics of commercial Obushera processors

The demographic characteristics of commercial *Obushera* processors are summarized in Table 3. Majority of them were aged 46–65 years as has been reported for traditional producers of fermented products in other related studies (Akabanda, Hlortsi, & Owusu-Kwarteng, 2017; Olumakaiye & Bakare, 2013). Olumakaiye and Bakare (2013) observed that older workers (≥40 years) were more likely to observe better hygiene than the younger ones (≤35 years). We however, observed that there was no correlation between microbiological quality of *Obushera* and age of the processors. It was noteworthy that 42.5% of processors had secondary level while 30.0% had university education. None-the-less, education level did not influence the microbiological quality of the product. Similarly, Webb and Morancie (2015) observed that all food service workers at a university campus in Trinidad and Tobago had inadequate knowledge on food safety irrespective of their education level. We noted that most of the proprietors of the *Obushera* businesses doubled as the production personnel. Only 5% (n = 3) claimed to have qualified quality control personnel in their establishments. Ironically, the products from these three companies did not conform to the FDUS 872:2009 standard (UNBS, 2009). Çakıroğlu and Uçar (2008) reported that food handlers with more work experience (≥7 years) had better food hygiene scores than those with fewer years of experience. In our study about 45% of the processors had ≥7 years work experience but the microbial quality of their products was not different ($p > 0.05$) from that of processors with less work experience. Only one processor claimed to have received formal training in food quality assurance and food safety. Accordingly, the product from this processor confirmed to the FDUS 872:2009 standard. It is also important to note that even though training could contribute to strengthening food safety knowledge of processors, it does not necessarily translate into positive change in food handling attitudes and practices (Howes, McEwen, Griffiths, & Harris, 1996).

3.3. Obushera: raw materials, training and safety inspection

Sorghum and millet were cited as the major cereals used for *Obushera* production but cassava is also used by a few processors (Table 4). Most of the sorghum and millet is sourced from Kabale district while the cassava flour is obtained from Soroti district. Other ingredients used include: preservatives (sodium benzoate and potassium sorbate), sugar and artificial sweeteners such as acesulfame potassium. According to the FDUS 872:2009 standard (UNBS, 2009), fermented cereal beverages may contain only permitted additives as specified in the Uganda Standard 45 (UNBS, 2011). The use of sugar and

Table 3
Demographic characteristics of *Obushera* processors (n = 47).

Characteristic		Respondents	
		Frequency	Percent
Gender	Female	17	36.2
	Male	30	63.8
Age (years)	15–24	7	14.9
	46–65	33	70.2
	25–45	7	14.9
Education level	No formal education	7	14.9
	Primary	7	14.9
	Secondary	17	36.2
	Vocational	4	8.5
	University	12	25.5
Position in company	Proprietor	43	71.7
	Production manager	14	23.3
	Quality control manager	3	5.0
Work experience (years)	< 1	4	8.5
	1–5	22	46.8
	6–10	9	19.1
	> 10	12	25.5
Source of training	Family member/family business	42	89.4
	Friend	4	8.5
	Formal training	1	2.1

Table 4
Obushera: raw materials, training and safety inspection.

Parameter		Respondents (n = 47)	
		Frequency	Percent
Raw material (flours)	Sorghum	37	78.7
	Millet	33	70.2
	Cassava	7	14.9
Additives	Honey	1	2.1
	Sugar	1	2.1
	Preservatives	2	4.3
	Artificial sweetener	1	2.1
Water source	National Water and Sewerage Corporation	42	89.4
	Spring/well	4	8.5
	Rain harvested	1	2.1
Water treatment	Boiling	43	91.5
	No treatment	4	8.5
Packaging material	Recycled	29	61.7
	Non-recycled	36	76.6
	Recycled and non-recycled	19	40.4
Training	Food processing	4	8.5
	Not trained	43	91.5
Business registration	Registered	15	31.9
	Not registered	32	68.1
Food safety inspection	Monitored	33	70.2
	Not monitored	14	29.8

Table 5
Food safety knowledge of *Obushera* processors.

Knowledge	Response % (n)	
	Correct	Wrong
Hand washing prior to processing contributes to *Obushera* safety	93.3 (42)	6.7 (3)
Hand washing after touching money is important for *Obushera* safety	57.8 (26)	42.2 (19)
Hand washing after using washrooms is important for *Obushera* safety	95.6 (43)	4.4 (2)
Hand washing after touching the body is important for *Obushera* safety	56.8 (25)	43.2 (19)
Hand washing after using the phone is important for *Obushera* safety	44.4 (20)	55.6 (25)
Hand washing hands after each break is important for *Obushera* safety	68.2 (30)	31.8 (14)
Hand washing after handling garbage is important for *Obushera* safety	95.6 (43)	4.4 (2)
Sanitizing utensils increases the risk of *Obushera* contamination	34.8 (16)	65.2 (30)
Washing utensils with detergent makes them sterile	30.4 (14)	69.6 (32)
Eating and drinking during processing increases the risk of *Obushera* contamination	34.0 (16)	66.0 (31)
Diarrhea, vomiting and stomach pain arise from drinking *Obushera* made unhygienically	91.3 (42)	8.7 (4)
Microorganisms are found on the skin, hair and hands of processors	74.5 (35)	25.5 (12)
Microorganisms are potential disease causers if they get into *Obushera*	85.1 (40)	14.9 (7)
The use of clean and well stored raw materials is vital for *Obushera* safety	100.0 (41)	0.0 (0)
Pasteurization is important for *Obushera* safety	17.0 (8)	83.0 (39)
Pathogens change the sensory properties of *Obushera*	29.8 (14)	70.2 (33)
Monitoring of water quality is important in ensuring *Obushera* safety	97.9 (46)	2.1 (1)

preservatives in traditional fermented foods is reported in other studies (Fapohunda & Adeware, 2012; Nwachukwu, Achi, & Ijeoma, 2010; Ogiehor, Ekundayo, & Okwu, 2005; Simatende, Gadaga, Nkambule, & Siwela, 2015).

About 90% of the processors claimed to use boiled water for making *Obushera*. However, further probing revealed that almost all processors do not boil water due to the high costs involved. Although majority (89.4%) use water supplied by the National Water and Sewerage Corporation (NWSC), this does not guarantee absolute water safety as it could get re-contaminated during distribution. Only 1 out of the 47 processors had their own piped water system and the others were supplied by resellers. Other processors relied on rain harvested water, unprotected springs and wells. The microbiological quality of such water cannot be trusted. So, the water possibly contributed to product contamination.

About 21% of processors sold the beverage in recycled containers (re-used bottles, jerrycans and cups), 48.9% used non-recycled (new polythene bags, bottles and jerrycans) while 29.8% relied on both recycled and non-recycled packaging materials. In a similar study, Mwale (2014) reported that the main packaging materials for *munkoyo and chibwantu* (Zambian cereal based fermented beverages) were re-used soft drink plastic bottles and re-used water bottles (64.7%, n = 17). Other *Obushera* processors (11.8%, n = 17) relied on new packaging materials. The use of recycled packages is worrisome especially if they are not properly cleaned and sanitized. Moreover, some processors reported that such containers were commonly picked from dumpsters. Some processors did not wash and sanitize new bottles before packaging because they believed that they were sterilized at the factory. Consumption of *Obushera* vended in such packages could result in diarrheal illnesses and spread of communicable diseases such as tuberculosis, typhoid, cholera, hepatitis B and influenza among others. Limited attention to the packaging used for traditional foods was also reported in West Africa (Oguntoyinbo, 2014). Unhygienic packaging materials expose food products not only to pathogens but also to physical and chemical contaminants (Olasupo, Okorie, & Oguntoyinbo, 2016).

This study showed that 91.5% of processors lacked formal training in general food processing. The rest (8.5%) stated that they had been trained in dairy processing and home management. Interestingly, majority (85%) did not think they needed formal training in *Obushera* processing because they believed they had received enough from their forefathers/ancestors. Other processors mentioned that they were interested in the formal training but there were no opportunities. It was interesting to note that 68.1% of processors did not have official permission to operate food processing enterprises. Some argued that: '*our enterprises/businesses were still very small*', '*approval was not mandatory*', '*approval would attract taxation*' and '*approval had no value*'. This possibly explains why there are many poor quality *Obushera* products on the market. In addition, it was established that all processors in the study did not undergo official routine food safety/health inspection. This was also observed by Djéni, Kouamé, Traoré, Nevry, and Marcellin (2014) who reported inadequate inspection of *attieke* (fermented cassava product) processors by municipalities and the local health sector in Côte d'Ivoire. We discovered that the '*health inspectors*' that some *Obushera* processors claimed to receive were actually tax inspectors. The reluctance of processors to strictly follow hygienic procedures could be because the prescribed punishment for breach of food sanitation laws is not severe enough to deter them from committing the offenses (Lawan, Iliyasu, Abubakar, Gajida, & Abdussalam, 2015). The disparity in the food safety practices of processors is an indication of the gap in the enforcement of public health laws in Kampala and possibly in other parts of the country.

3.4. Food safety knowledge, attitudes and practices (KAP) of Obushera processors

Tables 5–7 summarize the food safety KAP of processors. The tables show the percentage of correct and wrong responses to the food safety KAP questions. In spite of the fairly good knowledge and attitude scores most processors were ignorant about specific crucial safety issues. Consequently, they did not carry out certain practices which are fundamental in product safety. For instance, most did not know they needed to sanitize their materials and stated that sanitizers were only meant for clinical rather than food use. Others argued that the undesirable smell of the sanitizer (usually hypochlorite) would be transferred to the product. It was also observed that about 60% of processors did not believe they were a potential threat to *Obushera* safety, 64% did not agree with the idea of regular hand washing, 76.1% did not believe that their dress code was a food safety concern and 54.3% did not think that sick workers were potential sources of food contamination. These findings were similar to those reported by Djéni et al. (2014) who worked with *attieke* producers.

Production site analysis showed that almost all processors lacked basic facilities to support GMPs and this is in agreement with findings by Oguntoyinbo (2012). Close to 63% of *Obushera* processors did not check their workers for contagious diseases. In contrast, in a related study Kabacik (2008) reported that 98.7% of food handlers in Turkey took a health check before employment in food establishments although

Table 6
Food safety attitudes of *Obushera* processors.

Attitude	Response % (n)	
	Correct	Wrong
Food processing staff are not a serious threat to food safety	38.3 (18)	61.7 (29)
Foodborne illness is a result of poor hygiene	93.6 (44)	6.4 (3)
Raw materials and *Obushera* should be kept in separate places	70.2 (33)	29.8 (14)
All food processing equipment should be sanitized during production	58.7 (27)	41.3 (19)
Hand washing is only necessary before and after processing	36.2 (17)	63.8 (30)
A sick worker can engage in *Obushera* processing if she/he is energetic	45.7 (21)	54.3 (25)
A processor's dress code affects the safety of *Obushera*	23.9 (11)	76.1 (35)

Table 7
Food safety self-reported practices of *Obushera* processors.

Practices	Response % (n)	
	Correct	Wrong
Follow a Hazard Analytical Critical Control Point (HACCP) plan	0.0 (47)	100.0 (0)
Check the length and cleanliness of the nails of the processors	79.5 (35)	20.5 (9)
Ensure workers wear proper head gear during processing	47.8 (22)	52.2 (24)
Ensure workers wear closed shoes during processing	17.0 (8)	83.0 (39)
Processors remove jewellery and other accessories before processing	39.5 (17)	60.5 (26)
Ensure workers wear separate clothes specific for processing	22.7 (10)	77.3 (34)
Processors are examined for contagious diseases	37.2 (16)	62.8 (27)
Workers use a footbath before entering the processing area	2.2 (1)	97.8 (45)
Workers wash and sanitize their hands before and during work	26.7 (12)	73.3 (33)
Sanitization of utensils before processing	39.1 (18)	60.9 (28)
Sanitization of utensils after processing	34.1 (15)	65.9 (29)
Sanitization of the packaging material before use	17.1 (7)	82.9 (34)
Vermin proof storage facility	19.6 (9)	80.4 (37)
Use of treated water for *Obushera* processing	93.5 (43)	6.5 (3)
Use objective methods (pH, TA, bubbling ceases) to determine if *Obushera* is ready	2.4 (1)	97.6 (41)
Pasteurization of *Obushera* after fermentation	9.3 (4)	90.7 (39)
Adequate cleaning of used bottles and cups (use soap, clean water and sanitizer)	9.1 (2)	90.9 (20)
Use running water/regularly change water for washing used bottles and cups	0.0 (0)	100.0 (27)
Washing of the utensils after *Obushera* processing	95.7 (45)	4.3 (2)
Sanitize utensils after processing	41.3 (19)	58.7 (27)
Utensils stored in a clean area separate from raw materials	29.5 (13)	70.5 (31)
Obushera preparation utensils used for other purposes	83.7 (36)	16.3 (7)
Refrigeration of *Obushera* during storage before sale	65.2 (30)	34.8 (16)
Refrigeration of *Obushera* during transportation	3.7 (1)	96.3 (26)
Refrigeration of *Obushera* during marketing	84.8 (39)	15.2 (7)
Garbage disposal in a garbage receptacle	84.8 (39)	15.2 (7)
Covered garbage receptacle	11.6 (5)	88.4 (38)

the number of workers that continued with the checks eventually declined after employment. Such a decline maybe attributed to financial limitations (Yardımcı, Hakli, Çakiroğlu, & Özçelik, 2015). Therefore, ignorance and financial constraints may explain why *Obushera* processors do not carry out health checkups. This study showed that close to 73% of *Obushera* processors practiced irregular hand washing. This agrees with Okojie, Wagbatsoma, and Ighoroge (2005) who also reported very low hand washing frequency among food handlers in Nigeria. Moreover, poor hand washing practices among food handlers is associated with coagulase positive Staphylococcal contamination in food products (Stepanović et al., 2005). Therefore, the poor hand washing practices of processors could also explain the product contamination (Table 1).

The other critical concerns in this study were that the processors relied on spontaneous fermentation, had poor storage and garbage facilities. The problem with spontaneous fermentation is that undesirable microorganisms such as coliforms could thrive in the product. Worst still 90.7% of processors did not pasteurize *Obushera* after fermentation because of the high costs involved and/or ignorance. Moreover, pasteurization not only guarantees safety but also significantly prolongs the shelf life of *Obushera* (Byaruhanga & Ndifuna, 2002). About 80% of processors kept their raw materials, processing utensils/containers and *Obushera* in the same stores. Many of these stores were infested by cockroaches and rats. It was also observed that 88% of processors had uncovered garbage receptacles yet these act as breeding sites for rodents and insects which eventually cause food contamination (Umoh & Odoba, 1999).

3.4.1. Relationship between the food safety KAP of processors and microbial quality of Obushera

Fig. 1 shows the processors' average food safety KAP scores. The processors had fairly good knowledge (63.0% ± 2.3) and attitudes (52.2% ± 3.0) but the self-reported practices were fairly poor (38.7% ± 2.4). The fairly good knowledge and attitudes did not necessarily translate into good practices. When education level, access to formal training in processing (Table 3) and knowledge scores (Table 5) were compared with product microbial levels a Chi-Square test showed no association ($p > 0.05$) between the parameters. Additionally, an independent sample *t*-test showed no differences ($p > 0.05$) in the microbial levels of *Obushera* from processors with very good knowledge scores (≥75%) and those with very poor knowledge scores (≤25%). Similarly, the food safety attitudes and practices were not associated ($p > 0.05$) with the product microbial quality. Such discrepancies in KAP and product quality have been reported elsewhere (Azanza, Gatchalian, & Ortega, 2000; Baş, Ersun, & Kıvanç, 2006; Zain & Naing, 2002). Knowledge of food safety practices does not always cause positive changes in food handling behavior (Akabanda et al., 2017; Ansari-Lari, Soodbakhsh, & Lakzadeh, 2010). For instance, many food

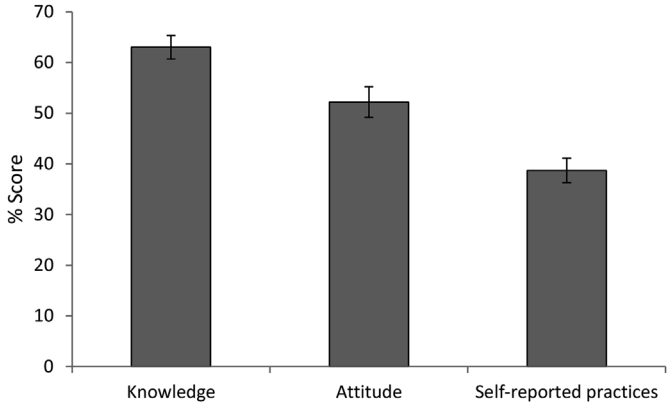

Fig. 1. Average scores of food safety knowledge, attitude and self-reported practices of *Obushera* processors.

handlers in the United Kingdom acknowledged that they did not always follow the food safety practices they knew (Clayton, Griffith, Price, & Peters, 2002). Samapundo, Climat, Xhaferi, and Devlieghere (2015) also reported that although 76% of food handlers in Port-au-Prince, Haiti knew the importance of hand washing in food safety, without supervision, they ignored the practice. So, supervision even after knowledge acquisition is vital for ensuring food safety (Osaili et al., 2013; Yardımcı et al., 2015).

Djéni et al. (2014) and Azanza et al. (2000) attribute these discrepancies to finances being a higher priority than food safety. Many processors and their families rely on the food products for their income so it is restrictive for them to invest in certain hygienic products (e.g sanitizers) or practices (e.g pasteurization and health checkups) before their own economic needs. It also appears that in Uganda, there is no heavy price for producing unsafe food. Therefore, there is need to strengthen surveillance and punish non-conforming processors.

4. Conclusion

This study revealed that a lot of the *Obushera* on the market in Kampala possibly does not meet microbial safety standards and could therefore, be a serious public health concern. The presence of *Staphylococcus* spp, *E. coli* and other coliforms in up to 50% of the samples is indicative of the potential of *Obushera* and similar traditional fermented cereal products to act as vehicles for foodborne pathogens. Although processors were generally knowledgeable and had fairly good attitudes with regards to food safety, these did not sufficiently translate into good practices. The fact that processors obtain highly contaminated raw materials from similar wholesalers and do not pasteurize their products is possibly the key underlying reason for the poor microbial quality of *Obushera*. Regulatory authorities need to strengthen enforcement and surveillance to ensure compliance by processors.

Conflicts of interest

The authors have no conflict of interest to declare.

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References

Achi, O. (2005). The potential for upgrading traditional fermented foods through biotechnology. *African Journal of Biotechnology, 4*(5), 375–380.

Akabanda, F., Hlortsi, E. H., & Owusu-Kwarteng, J. (2017). Food safety knowledge, attitudes and practices of institutional food-handlers in Ghana. *BMC Public Health, 17*(1), 40. https://doi.org/10.1186/s12889-016-3986-9.

Ansari-Lari, M., Soodbakhsh, S., & Lakzadeh, L. (2010). Knowledge, attitudes and practices of workers on food hygienic practices in meat processing plants in Fars, Iran. *Food Control, 21*(3), 260–263.

ARSO, African Organisation for Standardisation (2012). *Wheat flour-Specification (ARS 470:2012).* Nairobi, Kenya: African Organisation for Standardisation.

Azanza, P. F., Gatchalian, C. F., & Ortega, M. P. (2000). Food safety knowledge and practices of streetfood vendors in a Philippines university campus. *International Journal of Food Sciences & Nutrition, 51*(4), 235–246.

Baluka, S. A., Miller, R., & Kannene, J. B. (2015). Hygiene practices and food contamination in managed food service facilities in Uganda. *African Journal of Food Science, 9*(1), 31–42.

Baş, M., Ersun, A.Ş., & Kıvanç, G. (2006). The evaluation of food hygiene knowledge, attitudes, and practices of food handlers' in food businesses in Turkey. *Food Control, 17*(4), 317–322.

Borresen, E. C., Henderson, A., J, Kumar, A., Weir, T. L., & Ryan, E. P. (2012). Fermented foods: Patented approaches and formulations for nutritional supplementation and health promotion. *Recent Patents on Food, Nutrition & Agriculture, 4*(2), 134–140.

Byaruhanga, Y., & Ndifuna, M. (2002). Effect of selected preservation methods on the shelf life and sensory quality of'Obushera. *Muarik-Bulletin, 5*, 92–100.

Çakıroğlu, F. P., & Uçar, A. (2008). Employees' perception of hygiene in the catering industry in Ankara (Turkey). *Food Control, 19*(1), 9–15.

Clayton, D. A., Griffith, C. J., Price, P., & Peters, A. C. (2002). Food handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research, 12*(1), 25–39.

Djéni, T. N., Kouamé, A. K., Traoré, Y., Nevry, R. K., & Marcellin, K. D. (2014). Assessment of knowledge, attitudes and practices of food handlers in Attieke production units in relation to food hygiene and safety in Côte d'Ivoire in 2012. *Food and Nutrition Sciences, 5*(10), 896–904.

EAC, East African Community (2006). *Yoghurt - specification (EAS 33: 2016).* Arusha, Tanzania: East African Community.

EAC, East African Community (2011). *Sorghum flour - specification (DEAS 95: 2011).* Arusha, Tanzania: East African Community.

EAC, East African Community (2016). *Millet flour- specification (EAS 89: 2016).* Arusha, Tanzania: East African Community.

FAO, Food and Agriculture Organization (2004). *Building a food safety system in Uganda.* Retrieved from http://www.fao.org/docrep/meeting/008/ae191e.htm/, Accessed date: 18 April 2018.

Fapohunda, S., & Adeware, A. (2012). Microbial load and keeping quality of kunu under various preservative regimes. *Journal of Nutrition & Food Sciences, 2*(4), 1–4.

Heilmann, M., Roesel, K., Clausen, P., & Grace, D. (2016). *Knowledge, attitudes and practices among customers at pork butcheries in Kampala, Uganda.* Retrieved from https://www.researchgate.net/publication/308417082_Knowledge_attitudes_and_practices_among_customers_at_pork_butcheries_in_Kampala_Uganda/, Accessed date: 7 April 2018.

Howes, M., McEwen, S., Griffiths, M., & Harris, L. (1996). Food handler certification by home study: Measuring changes in knowledge and behavior. *Dairy, Food, and Environmental Sanitation, 16*, 737–744.

Izah, S. C., Kigigha, L. T., & Okowa, I. P. (2016). Microbial quality assessment of fermented maize Ogi (a cereal product) and options for overcoming constraints in production. *Biotechnological Research, 2*(2), 81–93.

Kaaya, A. (2005). *Management of aflatoxins in cereals, legumes and tubers. Training manual for AT Uganda training of trainers.* Retrieved from http://r4d.dfid.gov.uk/Output/180670/Default.aspx/, Accessed date: 25 May 2018.

Kabacik, M. (2008). *Determining the food safety knowledge level of the kitchen staff working for 4 and 5 star hotel kitchens*M.Sc thesis. Ankara, Turkey: Gazi University.

Kisangala, O. (2015). *Bushera gets a kick up market. Independent.* Retrieved from https://www.independent.co.ug/bushera-gets-kick-market/, Accessed date: 16 April 2018.

Kateu, K. K. (1998). *A study of traditional production of Ugandan fermented cereal beverage*Obushera. MSc. thesis. Sydney, Australia: Western Sydney University.

Kingamkono, R., Sjögren, E., & Svanberg, U. (1998). Inhibition of enterotoxin production by, and growth of enteropathogens in a lactic acid-fermenting cereal gruel. *World Journal of Microbiology and Biotechnology, 14*(5), 661–667.

Lawan, U. M., Iliyasu, Z., Abubakar, S., Gajida, A. U., & Abdussalam, A. (2015). Personal and food hygiene practices of subsistence food vendors operating in Kano metropolis, northwestern Nigeria. *International Journal of Medical Science and Public Health, 4*(2), 214.

Lues, J., Ikalafeng, B., Maharasoa, M., Shale, K., Malebo, N., & Pool, E. (2011). Staphylococci and other selected microbiota associated with indigenous traditional beer. *African Journal of Microbiology Research, 5*(13), 1691–1696.

Lyumugabe, F., Kamaliza, G., Bajyana, E., & Thonart, P. (2010). Microbiological and physico-chemical characteristic of Rwandese traditional beer "Ikigage". *African Journal of Biotechnology, 9*(27), 4241–4246.

Martins, R. B., Hogg, T., & Otero, J. G. (2012). Food handlers' knowledge on food hygiene: The case of a catering company in Portugal. *Food Control, 23*(1), 184–190.

Mbugua, S. K., & Njenga, J. (1992). The antimicrobial activity of fermented uji. *Ecology of Food and Nutrition, 28*(3), 191–198. https://doi.org/10.1080/03670244.1992.9991270.

Mordor Intelligence (2018). *Global fermented foods and drinks market – growth, trends and forecast (2018 - 2023).* Retrieved from https://www.mordorintelligence.com/industry-reports/fermented-foods-drinks-market/, Accessed date: 5 May 2018.

Mukisa, I. M. (2012). *Sensory characteristics, microbial diversity and starter culture development for Obushera, a traditional cereal fermented beverage from Uganda*PhD thesis. Aas, Norway: Norwegian University of Life Sciences.

Mukisa, I. M., Ntaate, D., & Byakika, S. (2017). Application of starter cultures in the production of Enturire–a traditional sorghum-based alcoholic beverage. *Food Sciences and Nutrition, 5*(3), 609–616.

Mukisa, I. M., Porcellato, D., Byaruhanga, Y. B., Muyanja, C., Rudi, K., Langsrud, T., et al. (2012). The dominant microbial community associated with fermentation of Obushera (sorghum and millet beverages) determined by culture-dependent and culture-independent methods. *International Journal of Food Microbiology, 160*(1), 1–10.

Muyanja, C., Kikafunda, J. K., Narvhus, J. A., Helgetun, K., & Langsrud, T. (2003a). Production methods and composition of bushera: A Ugandan traditional fermented cereal beverage. *African Journal of Food, Agriculture, Nutrition and Development, 3*(1), 10–19.

Muyanja, C., Langsrud, T., & Narvhus, J. A. (2004). The use of starter cultures in the fermentation of bushera: A Ugandan traditional fermented sorghum beverage. *Uganda Journal of Agricultural Sciences, 9*(1), 606–616.

Muyanja, C., Narvhus, J. A., Treimo, J., & Langsrud, T. (2003b). Isolation, characterisation and identification of lactic acid bacteria from bushera: A Ugandan traditional

fermented beverage. *International Journal of Food Microbiology, 80*(3), 201–210.
Muyanja, C., Nayiga, L., Namugumya, B., & Nasinyama, G. (2011). Practices, knowledge and risk factors of street food vendors in Uganda. *Food Control, 22*(10), 1551–1558.
Mwale, M. M. (2014). *Microbiological quality and safety of the Zambian fermented cereal beverage: Chibwantu*PhD thesis. Bloemfontein, South Africa: University of the Free State.
Nout, M. J. R., Rombouts, F. M., & Havelaar, A. (1989). Effect of accelerated natural lactic fermentation of infant good ingredients on some pathogenic microorganisms. *International Journal of Food Microbiology, 8*(4), 351–361.
Nwachukwu, E., Achi, O., & Ijeoma, I. (2010). Lactic acid bacteria in fermentation of cereals for the production of indigenous Nigerian foods. *African Journal of Food Science and Technology, 1*(2), 021–026.
Odugbemi, T., Oyerinde, J., Odujinrin, O., Akitoye, C., & Esumeh, F. (1993). Bacteriological study of cooked ogi (fermented cereal weaning food) and its potential safety in a rural Nigerian community. *Transactions of the Royal Society of Tropical Medicine and Hygiene, 87*(2), 234–235.
Ogiehor, I., Ekundayo, A., & Okwu, G. (2005). Shelf stability of agidi produced from maize (*Zea mays*) and the effects of sodium benzoate treatment in combination with low temperature storage. *African Journal of Biotechnology, 4*(7), 738–743.
Oguntoyinbo, F. A. (2012). Development of Hazard Analysis Critical Control Points (HACCP) and enhancement of microbial safety quality during production of fermented legume based condiments in Nigeria. *Nigerian Food Journal, 30*(1), 59–66. https://doi.org/10.1016/s0189-7241(15)30014-x.
Oguntoyinbo, F. A. (2014). Safety challenges associated with traditional foods of West Africa. *Food Reviews International, 30*(4), 338–358.
Okojie, O., Wagbatsoma, V., & Ighoroge, A. (2005). An assessment of food hygiene among food handlers in a Nigerian university campus. *The Nigerian Postgraduate Medical Journal, 12*(2), 93–96.
Olasupo, N. A., Okorie, C. P., & Oguntoyinbo, F. A. (2016). The biotechnology of ugba, a Nigerian traditional fermented food condiment. *Frontiers in Microbiology, 7*, 1153. https://doi.org/10.3389/fmicb.2016.01153.
Olumakaiye, M. F., & Bakare, K. O. (2013). Training of food providers for improved environmental conditions of food service outlets in urban area Nigeria. *Food and Nutrition Sciences, 04*(07), 99–105. https://doi.org/10.4236/fns.2013.47A012.
Osaili, T. M., Jamous, D. O. A., Obeidat, B. A., Bawadi, H. A., Tayyem, R. F., & Subih, H. S. (2013). Food safety knowledge among food workers in restaurants in Jordan. *Food Control, 31*(1), 145–150.
Oyelana, O., & Coker, A. (2012). Microbial contamination at different stages of production of ogi in mowe: A rural community, southwest, Nigeria. *Bacteriology Journal, 2*(1), 1–11.
Raosoft Inc (2004). *Sample size calculator*. Retrieved from http://www.raosoft.com/samplesize.html/, Accessed date: 15 June 2017.
Roesel, K., Grace, D., Dione, M. M., Ouma, E. A., Pezo, D., Kungu, J., et al. (2013). Assessment of knowledge, attitudes and practices on pork safety among smallholder pig farmers in Uganda. *Poster prepared for the first african regional conference of the international association on ecology and health (Africa 2013 ecohealth), grand-bassam, Côte d'Ivoire, 1-5 october 2013*Nairobi, Kenya: ILRI. Retrieved from https://www.slideshare.net/ILRI/assessment-of-knowledge-attitudes-and-practices-on-pork-safety-among-smallholder-pig-farmers-in-uganda/, Accessed date: 15 June 2018.
Samapundo, S., Climat, R., Xhaferi, R., & Devlieghere, F. (2015). Food safety knowledge, attitudes and practices of street food vendors and consumers in Port-au-Prince, Haiti. *Food Control, 50*, 457–466.
Simango, C., & Rukure, G. (1992). Survival of bacterial enteric pathogens in traditional fermented foods. *Journal of Applied Bacteriology, 73*(1), 37–40.
Simatende, P., Gadaga, T. H., Nkambule, S. J., & Siwela, M. (2015). Methods of preparation of Swazi traditional fermented foods. *Journal of Ethnic Foods, 2*(3), 119–125.
Soni, S., & Dey, G. (2014). Perspectives on global fermented foods. *British Food Journal, 116*(11), 1767–1787.
Steinkraus, K. H. (1996). *Handbook of indigenous fermented foods. rev. and expanded. Food Science and Technology (USA)* (pp. 73). .
Stepanović, S., Dakić, I., Morrison, D., Hauschild, T., Ježek, P., Petráš, P., et al. (2005). Identification and characterization of clinical isolates of members of the Staphylococcus sciuri group. *Journal of Clinical Microbiology, 43*(2), 956–958.
Umar, M., Mohammed, I., Abdulkarim, I., Yusuf, G., Yaya, A., & Leo, G. (2016). Comparative studies on the prevalence of salmonella species in two homemade fermented beverages (Zobo and Kunun-Zaki) Sold at Samaru, Zaria, Kaduna, Nigeria. *International Journal of Scientific and Research Publications, 6*(3), 428–435.
Umoh, V., & Odoba, M. (1999). Safety and quality evaluation of street foods sold in Zaria, Nigeria. *Food Control, 10*(1), 9–14.
UNBS, Uganda National Bureau of Standards (2007). *Cassava flour-specification (US 347: 2007)*. Kampala, Uganda: Uganda National Bureau of Standards.
UNBS, Uganda National Bureau of Standards (2009). *Fermented (non-alcoholic) cereal beverages- Specification (FDUS 872:2009)*. Kampala, Uganda: Uganda National Bureau of Standards.
UNBS, Uganda National Bureau of Standards (2010). *Fruit juice drinks- Specification (DUS 62:2010)*. Kampala, Uganda: Uganda National Bureau of Standards.
UNBS, Uganda National Bureau of Standards (2011). *General standard for food additives (US 45:2011)*. Kampala, Uganda: Uganda National Bureau of Standards.
Victor, N., Bekele, M. S., Ntseliseng, M., Makotoko, M., Peter, C., & Asita, A. O. (2013). Microbial and physicochemical characterization of maize and wheat flour from a milling company, Lesotho. *Internet Journal of Food Safety, 15*, 11–19.
Wacher, C., Canas, A., Cook, P., Barzana, E., & Owens, J. (1993). Sources of microorganisms in pozol, a traditional Mexican fermented maize dough. *World Journal of Microbiology and Biotechnology, 9*(2), 269–274.
Webb, M., & Morancie, A. (2015). Food safety knowledge of foodservice workers at a university campus by education level, experience, and food safety training. *Food Control, 50*, 259–264. https://doi.org/10.1016/j.foodcont.2014.09.002.
WHO, World Health Organization (2015). *WHO estimates of the global burden of foodborne diseases: Foodborne disease burden epidemiology reference group 2007-2015*. Retrieved from http://www.who.int/foodsafety/publications/foodborne_disease/fergreport/en/, Accessed date: 20 March 2018.
Yagoub, A. E., Suleiman, A. M. E., & Abdel-Gadir, W. (2009). Effect of fermentation on the nutritional and microbiological of quality of dough of different sorghum varieties. *Journal of Science and Technology, 10*(3), 109–119.
Yardımcı, H., Hakli, G., Çakiroğlu, F. P., & Özçelik, A.Ö. (2015). Hygiene knowledge of food staff in catering industry. *SAGE Open, 5*(2), https://doi.org/10.1177/2158244015580376 215824401558037.
Zain, M. M., & Naing, N. N. (2002). Sociodemographic characteristics of food handlers and their knowledge, attitude and practice towards food sanitation: A preliminary report. *Southeast Asian Journal of Tropical Medicine and Public Health, 33*(2), 410–417.