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Manufacture of *Kachasu,* a Traditional Distilled Liquor in Lusaka, Zambia

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ABSTRACT

This study examined the manufacturing processes and safety concerns of *kachasu*, a traditional distilled liquor produced in Zambia and other African countries. Despite being illegal in Zambia, the production and sale of *kachasu* continues, raising public health concerns due to unsanitary manufacturing conditions and high alcohol content. The research involved key informant interviews with fourteen processors from high-density compounds in Lusaka, revealing the use of raw materials such as maize malt, sugar, water, and starter cultures from previous batches. Seven distinct production methods were identified, each involving spontaneous fermentation and distillation. The alcohol content of *kachasu* ranged between 20 per cent and 70 per cent, with three different grades collected during distillation. The unsanitary conditions of production, including the use of makeshift distillation equipment and contaminated packaging materials, pose significant health risks. This study highlights the need for regulatory oversight to improve the safety of *kachasu* and mitigate its potential public health impacts.

Keywords: *Kachasu production*, *Traditional distilled liquor*, *Spontaneous fermentation*, *Alcohol content*, *Public health risks*

Introduction

Kachasu is an African, traditionally fermented, highly intoxicating, distilled alcoholic spirit that is brewed in the Democratic Republic of Congo (DRC), Kenya, Malawi, Rwanda, Zambia, and Zimbabwe (1) In Malawi, Zambia, and Zimbabwe, it is known as *kachasu*, in Kenya as *urugwagwa* (2), Rwanda as *kanyanga* (3), Nigeria as *kaikai/ogogoro/apeteshi* or illicit gin (4) and DRC as *lotoko* (Gadaga et al,1999).

Kachasu is normally brewed from maize. However, other adjuncts like millet (5) sorghum, cassava and plantain (1)and fruits like *masau* (*ziziphus mauritiana*) and banana peel (6) can also be used. The manufacturing process relies on spontaneous fermentation in most areas and can also involve addition of brewer's yeast together with the carbohydrate sources to warm water and heating the mixture for a few minutes. The product is then allowed to ferment for several days, depending on the weather conditions. Distillation then follows using makeshift distilleries

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(6). The alcohol (ethanol) content of *kachasu* can vary significantly, depending on the strength of the brew. Lusaka Times (2021), has reported an alcohol content ranging from 20 to 70 per cent. They also claim that its alcohol content is sufficient for use as a biofuel.

In Zambia, no literature has been found which clearly identifies the raw materials used in the production of *kachasu*. In the African region, in Zimbabwe, *kachasu* is made from maize, millet, banana peels and masau (Ziziphus mauritiana) (Nyanga et al. 2012). In Nigeria, pito is made from maize or sorghum (Tamang *et al.* 2010). In the DRC, lotoko is brewed from either cassava, maize or plantains (Okienczuk,2023.). In Kenya common homebrew traditional beverages include *chang'aa* (wuruchi or wirgiik) a distilled spirit made from grains such as millet or bananas, busaa (molotek) which is a maize beer; *muratina* (kurubu), *mnazi* (coconut ale) and miti in dawa made of fermented sugar, yeast and herbs (Mkuu *et al.* 2019). The cereal/adjuncts are the main source of carbohydrates for fermentation to ethanol (Gadaga *et al.* 1999). The adjuncts provide starch for hydrolysis to simple sugars and fermentation is accomplished by amylolytic molds and yeasts that are found naturally on the raw materials (Tamang *et al.* 2010).

Kachasu production and sale is an illegal business in Zambia. *The Traditional beer Act Chapter* 168 *of the laws of Zambia of* 1974 makes the production and sale of *kachasu* illigal. The Act classifies *kachasu* as a traditional beer understandably, because its manufacture is based on traditional knowledge, and it has not been commercialised. However, from its manufacture and appearance, it qualifies to be called a distilled spirit.

There have been calls to legalise its production as it is being produced and sold in high-density populated compounds. Its consumption has been linked to mental illness as reported by the Chainama Hills Mental Hospital in Zambia (Lusaka times, 2021). A report in the African press revealed that patients, mostly youths, as young as sixteen years, are being treated for mental illness due to alcohol abuse. "In Nigeria, the consumption of *kaikai* was associated with eighty-nine deaths between April and June of 2015. Laboratory analysis that was carried out by the World Health Organisation (WHO) and National Agency for Food and Drug Administration and Control (NAFDAC) showed that the beverage contained 16.3 per cent methanol, while the blood methanol concentration of the victims was 1500-2000mg/l (Ohimain, 2016)." "Victims exhibited symptoms of methanol poisoning including loss of consciousness, dizziness, weakness, breathing difficulties, blurred vision and blindness, weight loss, headache, abdominal pains, nausea, diarrhoea and vomiting (4)." The purpose of this study was to determine the manufacturing process of *kachasu.*

In Kenya, homebrew has been linked to several fatalities and hospitalisation (Mkuu *et al.* 2019).

Ethanol, which is thought to be the major constituent of *kachasu*, has an array of uses including making food additives, as an antifreeze, as an antiseptic, major raw material for gasoline manufacture, a raw material for cosmetic products, and used a medicinal solvent (All uses of, 2021). Purifying the ethanol in *kachasu* would make it available for these uses, thereby reducing the amount that ends up being available for consumption. This would create an alternative source of revenue for the manufacturers.

Materials and Methods

Study Design

A cross-sectional study design was used to conduct this study. Key informant interviews were conducted using a guide.

Study Site

The study was conducted in Ng'ombe and Kalingalinga which are high density populated compounds in

Lusaka. These compounds were conveniently chosen because they are near the University of Zambia and *kachasu* had been reported to be produced and sold there. (Lusaka Times, 2021).

Informant Interviews to Identify *Kachasu* Processors

Interviews were conducted randomly during exploration of the suburbs to identify key *kachasu* producing compounds in Lusaka. An informant guide was used for the informant interviews as per appendix. The informants interviewed were part of the crowd that was found milling around places where *kachasu* was being sold. They were asked about their knowledge on the production of *kachasu* in each respective suburb where it is produced and their willingness to introduce the researcher to it's producers during the survey. The two informants that were chosen were respective residents (above 18years of age) of Kalingalinga and Ng'ombe who knew the producers of *kachasu* and were willing to facilitate discussions with the producers.

Interview of *Kachasu* Processors

A multi-stage sampling technique was used to sample the City, the compounds and the processors. Lusaka City was purposefully sampled because *kachasu* production had been reported in this city (Lusaka times, 2021). A non-probability sampling technique, purposeful sampling, was used to sample the high-density compounds and *kachasu* processors because a sampling frame was difficult to establish since the production is an illegal business. Further, it was difficult to determine the sample size of *kachasu* processors because the prevalence of *kachasu* processors was not known. The snowball sampling method was used to identify and sample of the *kachasu* processors. Two informants led the researcher to a few processors they knew, and through snowball sampling of the *kachasu* processors, a total of 11 processors in Kalingalinga and 5 in Ng'ombe were surveyed.

Data Collection Instruments

A survey questionnaire was used to collect data on the processing methods used by different processors (Appendix 2). It focused on the raw materials used, source of the raw materials, raw material storage, the recipes, processing time, processing temperatures, duration per unit operation, fermentation time, and parameters used to check for quality of the product. The processors' survey was translated into Nyanja by an Expert in Zambian local languages, Nyanja is a local language mostly spoken in Lusaka, (Appendix 3). It was anticipated that most participants might not be very conversant with the English language. The questionnaires were administered by the researcher.

Ethical Considerations

Ethical considerations about the studies were considered. The study involved interviewing the *kachasu* producers to determine the raw materials and procedure for manufacturing *kachasu*. Ethical approval was sought from the Tropical Diseases Research Center (TDRC) Ethics Review Committee under protocol number TDREC/103/02/23 and approval letter number TRC/C4/08/2023 as given in appendix 4. The participants were informed on the purpose of the study, benefits, risks, and the funding behind it. Participation in this study was on a voluntary basis. The processors were identified by the letters K and N for their compounds and a numerical number. K being Kalingalinga and N for Ng'ombe to maintain anonymity. Personal data was not collected. The questionnaire was translated to Nyanja (appendix 3) to make it easier for the processors to understand what was being asked. The interviews were conducted at the processors premises, to ensure participant's privacy and confidentiality. The questions asked were limited to the subject on hand, which was the manufacturing of *kachasu*. Permission to take photographs of the equipment and raw materials was sought and photographs were only taken where consent was given. No photographs of the processors or their customers or other family members were taken.

Results

The manufacture of *kachasu* starts with the selection and preparation of raw materials (section 3.1). Processors have different recipes as elaborated in section 3.2 and different process steps which are explained in section 3.3. They also utilise different types of equipment which is illustrated in section 3.2.

Raw materials

The raw materials used for the manufacture of *kachasu* were found to be maize malt, commercially produced white and brown table sugar, water, and a starter culture collected from the previous batch of *kachasu*. All the 14 processors used brown sugar except for processor K03 who uses white sugar. Some processors reported that other producers also added commercially produced brewer's yeast purchased from the supermarkets. However, out of all the 14 producers interviewed, none used yeast because they claimed that it affects the taste of the *kachasu*.

Some processors bought dry maize from the market and malted it while others bought ready-made wet malt. The maize was soaked in water in a plastic bucket until it germinated. Thereafter, the germinated maize was spread on the ground on plastic material, chitenge (cloth) fabric, and blankets or jute sacks and allowed to continue germinating (Figure 1A). Processor K09 retained heat and moisture by covering the germinating maize with an old blanket and routinely sprayed water onto the blanket until the maize germinated to the required growth stage.

The maize is allowed to germinate on the ground close to the household and is vulnerable to flies and animals like dogs as shown in Figure 1B. During the baseline visit to producer K09, it was learnt that sometimes it is even prone to contamination by children because children were observed to be playing with the malt as it was drying. The number of days taken for the malting to be complete was reported to be varied due to the quality of the maize. Some batches were reported to be of good quality and germinated faster whilst others took too long. Overall, it took between three to five days. Malt samples were collected, and these are shown in Figure 2.

Figure 1: A. Processor K09 germination of maize on a jute sack and old blanket, and B. Malt drying by processor K10.

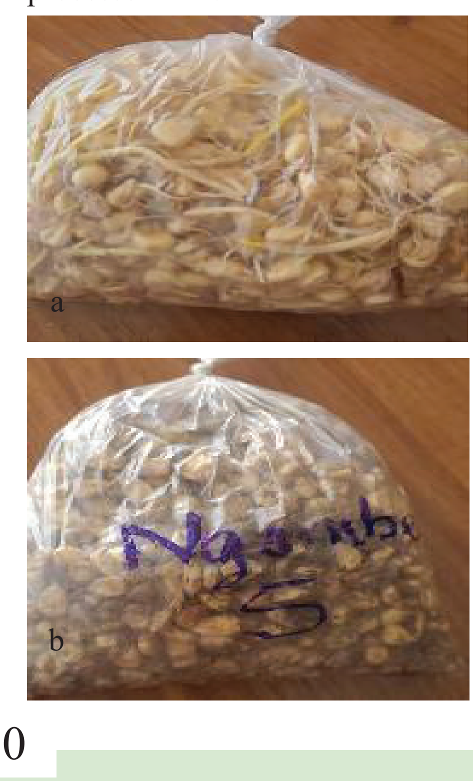

Figure 2: Maize malt samples from some processors: a. shows clean maize malt, b. and c. shows maize malt with molds.

Recipe

All the processors interviewed had their own unique combination of sugar, maize malt, and water. Out of 14 processors, only four (4) processors used the three core ingredients, while the rest added a starter culture called *matokoso* to each batch. *Matokoso* is either sour mash from the previous batch of *kachasu* or cooled porridge which remains after distillation. Each processor had their own ratio of ingredients. K09 had the highest sugar application rate while K07 had the lowest. Processors N01, N02 and N05 did not fully disclose their recipes as they deemed them to be their trade secrets. Overall, the amount of maize malt added was always less than the amount of sugar added except for K03, K07 and N04 where equal amounts were added and at N05 where more maize malt was added compared to sugar. K10 adds either five (5) liters of *Matokoso* or 10 liters depending on the strength of the sour mash from the *kachasu*.

Table 1: Recipes of *kachasu* by processor (NB: NS means not stated.)

Processor	Ingredient			
	Sugar (kg)	Maize malt (L)	Water (L)	Matokoso (L)
K01	30	20	80	20
K03	20	20	110	0
K04	40	20	120	80
K05	60	20	140	20
K06	10	5	60	20
K07	20	20	160	20
K09	50	20	80	40
K10	20	10	80	5/10
K11	25	10	120	0
N01	20	10	30	NS
N02	NS	NS	NS	0
N03	20	10	80	20
N04	10	10	60	0
N05	10	20	NS	NS

Manufacturing Processes

Fourteen manufacturers were interviewed with nine coming from Kalingalinga (K) and five from Ng'ombe (N) compounds and seven production methods were found (Figure 3). The process of making *kachasu* starts with the malting of maize. Maize kennels are procured from the market and soaked in water for them to absorb moisture. The number of days taken depend on the weather conditions and the quality of maize. After steeping, the maize is allowed to germinate. Additional water may be added. Once the maize has germinated it is referred to as malt. The maize malt is pounded and mixed with water and sugar. This mixture is allowed to ferment spontaneously. Four processors (K01, K05, K07, K11) dry the maize malt prior to pounding.

While mixing, some processors (N05, N01, K04, K06 and K10) also add sour mash to the sugar, maize malt and water mixture. Sour mash is a mixture of maize malt, sugar and water that has fermented and is ready for distillation. This practice of adding sour mash to a new batch is known as backslopping. One processor (N03) takes the cooled porridge from distillation and adds it to the sugar, maize malt, and water mixture. The resultant mixture is then allowed to ferment. Fermentation can take three to seven days depending on the weather conditions. During the hot season or summer, the fermentation period is short (3-4 days) and longer (5-7days) during the winter. Fermentation is done indoors. Soon after mixing, the mixture is very sweet. Every day, the mixture is stirred using a traditional wooden cooking stick and tasted for sweetness.

As fermentation of the sugar to alcohol progresses, the sweetness of the mixture reduces due to the depletion of sugar and formation of ethanol, lactic acid, and carbon dioxide ((7). When the mixture is no longer sweet and has attained a distinct sourness, it is ready for distillation. Other processors listen to the sound of bubbles that are produced. Soon after mixing, the mixture is quiet due to acclimatisation of the microorganisms from the malt and the sour mash to the new environment in a batch. Once acclimatisation is achieved, the microorganisms will start multiplying in number. Thereafter, on the second day the production of bubbles will become vigorous. By the third day, they will be more vigorous and begin to die down towards the end of the third day. On the fourth day, the mash will be quiet indicating the end of fermentation. When the mash is quiet, then it is ready for distillation. This is the period that it takes for fermentation in the hot season. In winter, the process is longer.

Distillation is carried out during the early hours of the day before the law enforcement officers start their patrols. The first distillate to be collected is referred to as "number 1", the second is "number 2" and the last one is termed "number 3". Each of these constitute three distinct grades of *kachasu* which are estimated to be approximately 33 per cent each of the total volume collected. Upon sample collection, the number 1 grade was the most expensive. However, the processors normally sell the mixed grade only which is cheaper than number 1 and number 2. Only processor K11 collected number 1 and number 2 simultaneously because of the double barrel designed distillation unit. Each batch is divided into two and fed to a distillation unit as two distillation units are in place. Leftover *nshima/pap/sadza* (stiff porridge) is used to seal the connection between the drum and the condenser pipes. Distillation takes approximately 4 hours. A typical distillation unit is shown in Figure 4.4.

After distillation, the *kachasu* is packaged into 500ml bottles. The bottles are pre-used or recycled mineral water, energy drinks and juice bottles. They are washed prior to filling. At processors N01 and K04, the washing process was observed and it was noted that the water used was very dirty. At processor N01, the washing station was also infested with flies. The source of the bottles was not disclosed. However, while conducting identification of the processors, some people were seen moving around collecting used water and juice bottles from ground litter and from trash bins.

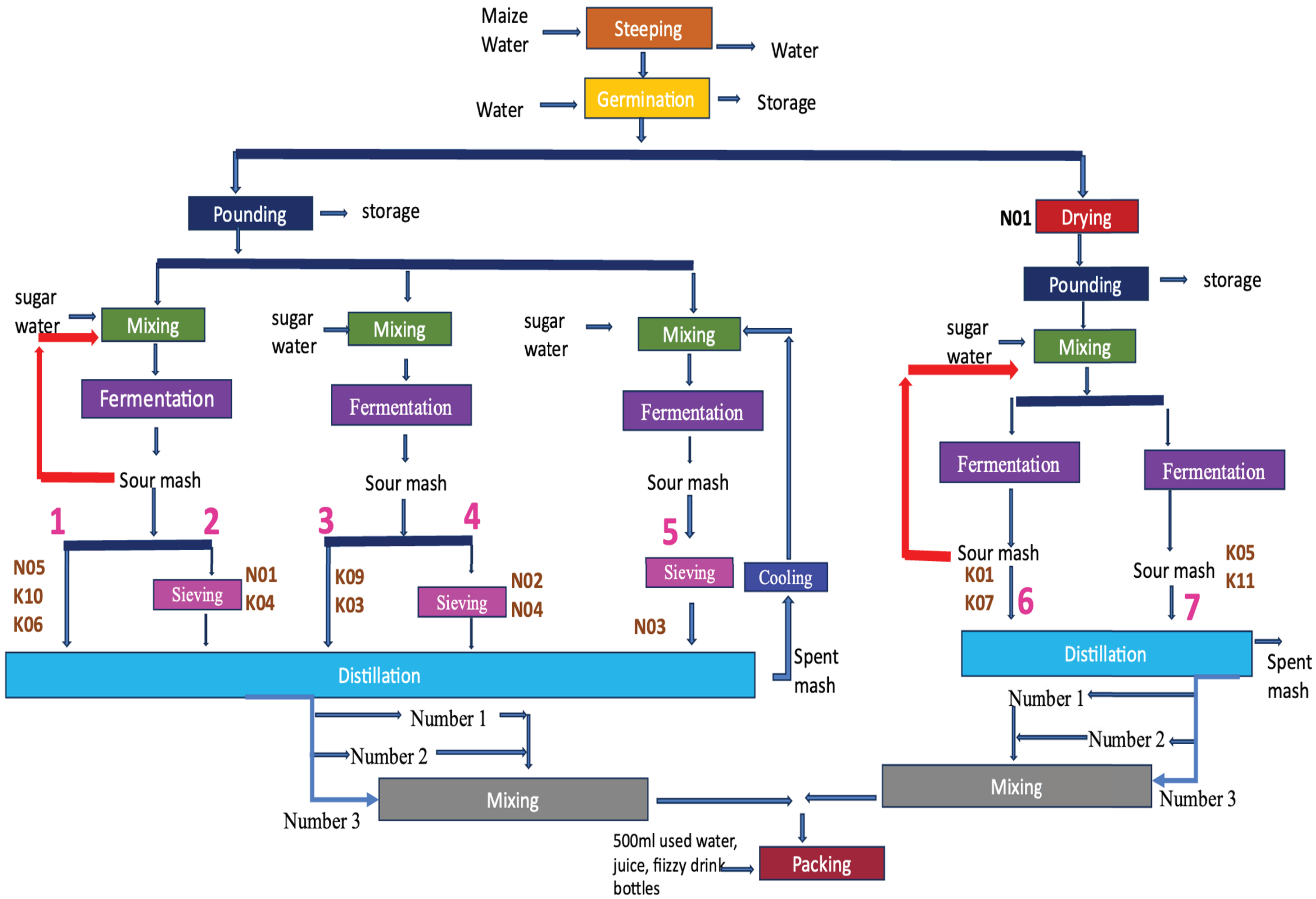

Figure 3: The 7 *Kachasu* manufacturing processes that were identified denoted by the numbers 1,2,3,4,5,6 and 7. Each processor is shown by a letter and the processor number (e.g. N01, K11) prior to distillation. Three grades of *kachasu* (number 1, number 2 and number 3) are collected during distillation

Manufacturing Processes Identified.

There were seven distinct manufacturing processes that were identified (Figure 4.3). All processing methods start with the malting of maize. Malting is the controlled germination and kilning of a grain. It is a three-step process consisting of steeping, germination, and finally kilning (Chaudhary *et al.*, 2014). Some processors omit the kilning (drying) step and use the malt wet (methods 1 to 5 in figure 3). All processors pound the malt to reduce its particle size followed by mixing the dry and wet ingredients.

Fermentation is the same across all producers and the duration is determined by the environmental conditions. The differentiation of processing methods comes after fermentation where some processors sieve the mash prior to distillation. Others (N05, K10, K06, K03, K09, K01, K07, K05 and K11) just take the fermented mash and distill without sieving. Figure 4A shows the spent grain removed prior to distillation.

Methods 2, 4 and 5 have the sieving step as part of the process. The processors highlighted that removal of spent grain is done to avoid burning of the porridge during distillation. Distillation, mixing, and packing is the same across all producers. Methods 1, 2, 5 and 6 have backslopping as part of the manufacturing process. In methods 1, 2 and 6, sour mash that is ready for distillation is used for backslopping while method 5 uses the porridge that is left over from distillation. This porridge is cooled first before mixing with all the other ingredients.

Figure 4: A. Spent grain sieved prior to distillation and B. porridge being cooled after distillation.

Manufacturing Equipment

The processors use similar equipment for manufacturing *kachasu*. A traditional pestle and mortar were used to pound the malt as shown in Figure 5A and 5B respectively. Secondhand buckets (Figure 5C) are used for measuring the maize malt, water, and starter culture. The mash is fermented in blue, 200l plastic drums as per Figure 5D. Distillation is carried out using a 200l metal drum that is fitted with metal pipes (Figure 5E). The metal drum is covered using a black polythene sheet as shown in Figure 5E. The sheet is secured using rubber bands from old bicycle tubes. In some cases, one or two pipes are used as shown in Figure 6G and 6H. The pipes are fitted in a dish (Figure 5F) and water is poured into the dish to condense the distillate. Mud or leftover pap/nshima/sadza is used to seal the connections. The condenser is shown in Figure 5F. The dish is set on some stones/chair/bucket/another drum. Collection of the distillate is carried out in any of 5l used motor oil bottles (Figure 6I), 5l high density polyethylene (HDPE) natural bottles (Figure 6G), and HDPE buckets (Figure 6J). Some processors have funnels for directing the distillate as in Figure 6I, yet some use pre-used water sachets or plastic bags as in Figure 6H. Others just collect directly from the condenser (Figure 6J). Stirring is done using the traditional wooden cooking stick as shown in Figure 5D. The distillation apparatus is fired by firewood (Figure 5E) and charcoal.

The hygiene of the processing equipment was below average for all the processors. The blue drums used for fermentation were dirty. Processor N01 washed the 500ml bottles prior to filling. However, the water that was being used for washing the bottles was dirty and there were flies around the surroundings as shown in Figure 6K.

Figure 5: A. Mortar used for pounding malt and the sieve. B. Pestle for pounding. C. Bucket used for measuring maize malt. D. Plastic drum used as a fermentation vessel. E. Distillation drum covered by a black polyethene sheet and secured with a rubber rope, F. The condenser dish for cooling the distilled vapour.

Figure 6: Double barrel condenser with HDPE natural collection bottles. H. Single barrel condenser with plastic paper directing the condensate into used motor oil bottles. I. Double barrel distillation with plastic funnels aided by water sachets and used motor oil collection bottles. J. Double barrel distillation with collection into an open bucket. K. Bottle washing station with dirty water.

Discussion

The study identified the raw materials used to manufacture *kachasu* as table sugar, maize malt, water, and a starter culture from the previous batch. Sugar is the main carbohydrate source. This is procured from the local supermarkets and wholesalers. The quality of the table sugar is dependent on the major producers who include Zambia Sugar and Mansa Sugar. The sugar is kept in its original packaging hence its integrity is not compromised. The sugar (sucrose) together with water, are fermented to ethanol and carbon dioxide in the absence of oxygen by the enzymes found in yeasts (Pepin *et al.* 2015). The water also acts as a medium for the sugar to dissolve and for extraction of sugars, bacteria, and yeasts from the maize malt. They are essential for fermentation.

The study looked at the processing methods used to manufacture *kachasu* and found seven distinct methods (Figure 3). *Kachasu* processing starts with the production of maize malt. Maize is procured from the local market. The malting process relies on traditional knowledge, weather conditions and the quality of the maize. The ratio of water to maize for steeping is based on a quantity that is just enough to cover the maize grains in a plastic bucket. Steeping is done to initiate germination through absorption of moisture by the grain. Steeping is terminated when the grains are impregnated by water and a visual test is done. Some processors (K10) use old blankets as germination boxes as shown in Figure 1. The blanket keeps the maize grains moist, and water is regularly sprinkled on top to replenish the moisture. To allow for even germination, there is need for turning of the grains (Ndife *et al.* 2019). However, there was no evidence of turning of the grain at K10. The growth of the acrospire is measured visually. An acrospire is the first shoot developing from the plumule of a germinating grain seed (Felšöciová *et al.* 2020).The acrospire is allowed to grow excessively (Figure 1A) implying that very few sugars will be left as they would have been consumed by the shoot for it to grow. The storage conditions of the malt were not conducive for its integrity. The malt in Figure 2B had molds on it indicating that it was stored wet in a warm area with poor circulation of air. Molds result in the production of off flavors like mercaptans (Ndife *et al.* 2019).

The manufacture of *kachasu* can be modified by use of barley malt instead of maize malt since barley malt has a higher diastatic power. Diastatic power is the level of enzymes that are responsible for the conversion of starch to simple sugars in brewing. Also, barley has a shorter germination period compared to maize. This would have an impact on the flavour profile since barley malt has a different flavour from maize malt (Ohimain, 2016). This would result in a shorter malting period that would increase the production capacity of the *kachasu* processors.

Some processors (N01, N02, N03, N04, N05, K03. K04, K 06, K10) dry their malt before use as illustrated in Figure 4.1B. The figure shows that the drying area is not protected from animals and pests as a puppy is sleeping peacefully next to the malt after playing in the malt. Good Manufacturing Practices (GMPs) dictate that all food contact surfaces must be always in a sanitary condition (Gould *et al.* 1994). The puppies may contaminate the maize malt with pathogens like *Staphylococcus intermedius, Salmonella, Leptospira interrogans* and *Campylobacter*. Ingestion of s*almonella* results in several infectious diseases such as gastroenteritis, enteric fever, bacteremia, and osteomyelitis. Gastroenteritis diseases are the most common clinical presentations of *Salmonella* in human and dogs though, most infected animals or humans are asymptomatic and may shed the pathogen through faeces for a period of six weeks and transmit the pathogen to other animals or individuals (Ghasemzadeh *et al.* 2015). *Campylobacter* causes fever, diarrhea and vomiting in humans. *L. interrogans* causes leptospirosis which may present as fever, non-productive cough, vomiting, nausea, diarrhoea, and muscular pain (Ghasemzadeh *et al.* 2015).

Control of these microorganisms may be at the distillation stage of the manufacturing process because the mash has to be boiled to enable the alcohol to evaporate. The efficacy of the control needs to be established through further studies because the temperature is not measured during distillation. As a result, the effectiveness of the heating remains unknown. In addition to that, since tasting of the mash is done from day 1 of mixing, there is a possibility of transmission of the pathogens from the puppy to the processor through the maize malt from urine and faecal matter of the animal.

Some processors (K01, K05, K07, K11) omit the kilning step and use the germinated grains while the rest kiln it by drying it in the sun to reduce its moisture content. Drying also halts the biological processes that will be taking place within the grain. Kilning by addition of heat would have resulted in a bit of caramelisation that will impact on the flavour of the distilled *kachasu* (Ohimain, 2016). The maize malt is pounded to reduce its particle size. This enables effective extraction of sugars and enzymes from the maize malt because the surface area for contact with water is increased. Maize malt is a source of Lactic Acid Bacteria (LAB) and the number of microorganisms found depends on whether wet or dry malt is used (Udota, 2007).

Eight processors utilise the backslopping technique, which is also utilised in the production of sauerkraut, sour dough bread (5), and *kefir* (10). The sour mash utilised to produce *kachasu* may have a higher concentration of microorganisms compared to the cooked porridge which has been subjected to heat treatment during distillation. Some of these microorganisms include yeasts and LAB that are essential for the fermentation process (Kim *et al*. 2018).

Fermentation time for the mash is influenced by the optimal fermentation conditions for yeast and LAB. The optimal fermentation temperature of traditional brewing yeast is 28–33°C, while optimal fermentation temperature for LAB is 30-40°C (Melikoglu *et al.* 2016). Since fermentation is carried out indoors, it must be very hot outside for the temperature to be ideal. Brewing yeast multiplication is very slow under low temperatures (Melikoglu *et al.* 2016) hence the longer fermentation time in the cold season. During fermentation, the processors periodically taste the mash for sweetness. Tasting for sweetness is a practice that is quick and requires the skill of the brewer to make the correct decision. In the production of *kanyanga* in Rwanda, fermentation is carried out for 4 to 7 days while the container is sealed. The test for the mash's readiness for distillation wasn't defined (Lyumugabe *et al.* 2019). Tasting is not an option since the fermentation vessels are sealed and a small hole opened when it is time to distill.

The *kachasu* manufacturing process in the two compounds under this study had a similar procedure with *kachasu* from maize in Zimbabwe (Gadaga *et al.* 1999) as well as that of *kanyanga* from Burundi and *kanyanga* from Rwanda (Lyumugabe *et al.* 2019). The processes are all characterised by malting of a cereal grain, fermentation and distillation. The equipment used is also the rudimentary type and the processes rely on spontaneous fermentation, which lacks effective controls. It is also carried out under poor hygienic and unsterile environments (Ohimain, 2016; Nyanga *et al.*, 2008b).

Use of secondhand PET bottles for the packaging of *kachasu* is a violation of the *Potable Spirits Act of Zambia*. The Act stipulates that a distilled liquor should be packaged in a glass bottle or new food grade materials that do not affect the product quality and safety ('SI-18-of-2020_-Portable-Spirits'). Cleaning of the bottles is done under unhygienic conditions and the effectiveness of the cleaning needs to be studied to understand its impact on the safety of *kachasu*. The highest alcohol content from the baseline study, of 71.12 per cent, is sufficient to disinfect pathogens. However, this is not the concentration at which *kachasu* is sold. In addition, this does not eliminate chemical impurities that could have penetrated or reacted with the plastic after beverage consumption. These chemicals would then be released into the *kachasu.* There were flies around the homestead and the water used for washing the bottles, was visually dirty. Hence there is a possibility of contamination of the *kachasu* by cleaning detergent and dirty water. Guidelines for cleaning of packaging material dictate that bottles should be rinsed with potable water and sterilised prior to packaging of food (Gould *et al,*.1994).

The condition of the equipment used to manufacture *kachasu* was unsanitary across all the processors who took part in this study, from the malting blankets (Figure 1) to the fermentation drums (Figure 5D). Some of the blue plastic drums used for fermentation had turned khaki in color. There was no evidence of cleaning of these drums from one batch to the next. This violates the *Potable Spirits Act of Zambia* which demands that any distilled liquor should be produced under hygienic conditions (SI-18-of-2020_-Portable-Spirits).

The type of metal that the condensation pipes were made from could not be identified. However, the metal drums were used oil drums sold at the market. The used motor oil bottles that are used to collect the distillate can possibly contaminate the *kachasu* as shown by the migration study carried out on HDPE bottles with 50 per cent ethanol (Zimmermann, 2023). The setup of the equipment does not follow any GMP guidelines. The equipment is set up in the same premises where the cooking of food for the family is also normally done. The plastic used to cover the drum during distillation is black polythene sheeting that is made from recycled material. This also poses the risk of contamination of the liquor by chemicals which were packaged in the material before recycling (Zimmermann, 2023).

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