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Traditionally Fermented Alcoholic Beverages in Sub-Saharan Africa: Comprehensive Studies

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Abstract: *Fermentation processes are believed to have been developed over thousands of years in order to preserve food for times of scarcity, to impart desirable flavour to foods, and to reduce toxicity. A diversity of fermented products, including porridges, beverages (alcoholic and non-alcoholic), breads and pancakes, fermented meat, fish, vegetables, dairy products and condiments are produced from both edible and inedible raw materials in many countries. Today, fermentation is still widely practised as a household or rural-level technology in many developing countries, but comparatively very few operations are carried out at an industrial level. Fermentation is a low-input enterprise and provides the vast population of developing and under developed nations characterised by limiting purchasing power, access to safe, inexpensive and nutritious foods. The tradition of fermented beverages is long embedded in many cultures, and despite traditional production technologies remaining, there is potential for extension services to introduce some improved methods, particularly those for hygiene and safety. Microorganisms associated with these fermentative processes include Rhizopus oryzae, Saccharomyces cerevisiae, Aspergillus flavus, Penicillium funiculosum, Penicillium citrinum, Giberella fujikuroi and Botryodiplodia theobromae. Traditional methods for fermentation that yielded alcoholic beverages in developing countries and indeed Africa has long been in existence-since prehistoric times. Amongst these are burukutu and pito (majorly in Western Africa), Palm wine (Sub-Saharan Africa), 'Urwaga' in Kenya, 'Kasiksi' in DR Congo, 'Urwagwa' in Rwanda and Burundi, Tej in Ethiopia, 'Mes' in Eritrea. Although there are some health concerns attributed to the production of these traditionally fermented alcoholic drinks, standardization of procedures and proper hygienic practices can effectively control these health threats.*

Keywords: *Alcoholic beverages, Food processing, Pito, Sub-Saharan Africa, Traditional fermentation.*

1. INTRODUCTION

Fermentation plays an important role contributing to the livelihoods of rural and peri-urban dwellers alike, through enhanced food security, and income generation via a valuable small-scale enterprise option. There is such a diversity of fermentable substrate available year-round, that the activity can provide a regular income. Although harvesting of food crops may be seasonal, fermentation itself is largely independent of weather and by-products can be recycled into livestock fodder. Fermentation activities are highly combinable with a variety of other traditional and domestic activities, and can make a particularly important contribution to the livelihoods of women, the disabled and landless poor who, with appropriate training and access to inputs, can increase their independence and self-esteem through income generation [1].

In developing countries, there are a large variety of fermented foods and beverages with traditional and cultural value. This is not restricted to the developmental status of these countries. The diversity of such fermented products derives from the plurality of traditions found in the world, cultural preference, different geographical areas where they are produced and the staple and/or by-products used for fermentation. In many instances it is highly likely that the methods of production were unknown and came about by trial and error, and passed down via cultural and traditional values to successive generations. Some of the most popular fermented products derive from grain, fruit and vegetables and are alcoholic-based – most notably and popularly a variety of traditional beers and wines. There are also many fermented food products which are extremely important in meeting the nutritional requirements of a large proportion of the global population. Such

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products have a long history of production via “kitchen” fermentation, contributing to household nutrition and to important socio-cultural practices [2].

The importance of fermentation in modern-day life is underlined by the wide spectrum of foods marketed both in developing and industrialized countries, not only for the benefit of preservation and safety, but also for their highly appreciated sensory attributes. Fermented foods are treasured as major dietary constituents in numerous developing countries because of their quality under ambient conditions - thereby contributing to food security - and enhance nutritional quality, digestibility, improve food safety, traditionally acceptable and easily accessible [3, 4]. Fermentation is a low-input enterprise and provides the vast population of developing and under developed nations characterised by limiting purchasing power, access to safe, inexpensive and nutritious foods.

Preservation and safeguarding of foods and beverages remain the principal objectives of fermentation, with wholesomeness, acceptability and overall quality, having become increasingly valued features to consumers, especially in rural areas where old traditions and cultural particularities in food fermentations are generally well maintained [5].

2. TRADITIONALLY FERMENTED FOODS

Fermented foods constitute a significant component of food consumed by the populace of many developing countries. Emphasis given to African diets, most of them undergo some type of fermentation or the other. Many fermented foods are known, some serve as main course meals, others as beverages are highly prized food condiments [6].

The world dietary culture has three distinct traditional food habits based on staple cereal diets:

- Cooked-rice eaters of Eastern food culture,
- Wheat/barley-based breads/loaves of Western and Australian food culture,
- Sorghum/maize porridges of African and South American food culture [7].

The African dietary ethos includes both fermented and non-fermented sorghum, maize, millet and cassava products, wild legume seeds and tubers, but also meat, milk products, and alcoholic beverages [7]. Of importance to all rural societies are low-cost and, where possible, “low-tech” food processing procedures affordable also by the poor. In African civilizations, food fermentation still plays a major role in combating food spoilage and foodborne diseases that are prevalent in many of its resource disadvantaged regions.

The lactic acid fermentation is probably the oldest and best accepted among the African people [8], and is largely a home-based process used throughout the continent [9]. In Table 1, examples of fermentation types and raw materials used are shown, exemplifying diversity and expansive nature of the traditional fermentation. The legume fermentations, although alkaline and typically dominated by *Bacillus* spp., are also characterized by the presence of LAB, in particular enterococci, albeit as a minor group. Fermented foods in Africa can be classified in the following major groups based on the raw material used in their production [10]:

- Fermented non-alcoholic cereals,
- Starchy root crops,
- Fermented animal proteins,
- Fermented vegetable proteins, and
- Alcoholic beverages.

The first group is predominant and relatively safe, even for infants.

Table 1: Overview of raw materials and fermentation types of African alcoholic fermentations [8]

Single Step LAB fermentation	**Soaking followed by Lactic fermentation**	**Lactic/alcoholic fermentation**	**Dough with LAB dominant**
Mawe ^{1}	Kenkey	Palmwines ^{8}	Injera ^{1,2,3}
Mahewu ^{1}	Uji ^{1,2,3}	Traditional beers ^{3,2,1}	Kisra ^{3}
Kule naoto ^{6}	Ben saalaga ^{2}	Tej^{7}	Kocho^{5}
Ergo ^{6}		Sherbote ^{9}	Kishk $^{6+4}$

Raw materials: ^{1} = maize; ^{2} = millet; ^{3} = sorghum; ^{4} = wheat; ^{5} = ensete; ^{6} = milk; ^{7} = honey; ^{8} = palm juice; ^{9} = dates; ^{10} = bananas.

Milk from cattle, sheep and goats is typically fermented in Eastern and Southern Africa, and some regions in North and (more rarely) West Africa, where keeping of such livestock has a long tradition, while camel's milk is mainly fermented in Northern Africa and the Sudan region [11, 12]. Specific to Ethiopia is the enset (*Ensete ventricosum*) (also called false banana, Ethiopian banana, or Abyssinian banana) plant, which, can be converted into “kocho” by lactic fermentation [13], while tef (*Eragrostis tef*), also typical of Ethiopia, is used for preparing the traditional acid-leavened (sourdough) type of “pancake” called injera [8]. Maize (corn), sorghum and millet are most commonly fermented throughout Africa. In contrast to Asia and Europe, rice and wheat are only rarely used in African traditional food fermentations [9].

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3. FERMENTATION

Fermentation usually implies that the action of micro-organisms is desirable, and the process is used to produce alcoholic beverages such as wine and beer. Fermentation is also employed in preservation techniques to create lactic acid in sour foods such as sauerkraut, yogurt, or vinegar. As such, where controlled, fermentation is a relatively efficient food preservation process which gives beneficial results, and is therefore a highly appropriate technique for use in developing countries and remote areas where access to sophisticated equipment is limited [14].

The most common groups of microorganisms involved in fermentation as it concerns food includes:

- Bacteria: The most important bacteria in desirable food fermentations are the *Lactobacillaceae* which have the ability to produce lactic acid from carbohydrates. Other important bacteria, especially in the fermentation of fruits and vegetables, are the acetic acid producing *Acetobacter* species.
- Yeasts: Like bacteria and moulds, yeasts can have beneficial and non-beneficial effects in foods, and the most beneficial yeasts for desirable food fermentation are *Saccharomyces*, playing roles such as the leavening of bread and the production of alcohol and invert sugar.
- Moulds are also involved in the food processing industry, both as spoilers and preservers. Nearly all food fermentations are the result of more than one micro-organism, either working together or in a sequence, but growth is generally initiated by bacteria, followed by yeasts and then moulds.

3.1 Traditionally Fermented Drinks

The tradition of fermented beverages is long embedded in many cultures, and despite traditional production technologies remaining, there is potential for extension services to introduce some improved methods, particularly those for hygiene and safety. Drinks that have undergone fermentation stand a chance to be alcoholic but not all fermented drinks end up as alcoholic. There are fermented beverages that cut across geographical strata and a few of them are highlighted in Table 2 [15].

Tables 2. Fermented beverages from around the world

Source	**Name of fermented beverage**	**Name of distilled beverage**
Barley	Beer, ale	Scotch whisky
Rye	Rye beer	Rye whisky
Corn	Corn beer	Bourbon whiskey
Wheat	Wheat beer	Wheat whiskey, Korn (Germany)
Rice	Sake sonti	Shochu (Japan), Soja (Korea)
Juice of fruits, other than apples or pears	Wine (most commonly thought of from grapes)	Brandy, cognac (France), Branntwein (Germany), pisco (Peru/Chile)
Juice of apples	(“hard”) cider, apfelwein	Applejack (or apple brandy), Calvados
Juice of pears	Perry, or pear cider	Pear brandy
Juice of sugar cane, or molasses	Basi, betsa-betsa (regional)	Rum, cachaça, aguardiente, guaro
Juice of agave	Pulque	Tequila, mezcal
Potato and/or grain	Potato beer	Vodka: potato mostly used in Ukraine, otherwise grain
Milk	Kumis	Araka
Honey	Mead	Distilled mead (“mead brandy” or “honey brandy”)
Pomace	Pomace wine	Grappa (Italy), Trester (Germany), marc (France)
Juice of plums	Plum wine	Slivovitz, tzuica, palinca

3.2 Diversity of Products of Fermentation

A diversity of fermented products, including porridges, beverages (alcoholic and non-alcoholic), breads and pancakes, fermented meat, fish, vegetables, dairy products and condiments [16, 17] are produced from both edible and inedible raw materials in many countries. These are well documented in an FAO publication series on fermented foods. Fermented cereals and fermented roots and tubers are consumed as dietary staples throughout Africa, Asia, and Latin America, in various forms including breads, porridges, gruels, and pickles [18].

A wide range of grains, fruit and vegetables are also used to manufacture beverages, both thirst quenching products (mostly non-alcoholic), and those which are generally alcoholic and consumed on special occasions, including festivals. The former include tea, coffee, juices, nectars, syrups, and carbonated soft drinks. In some countries these are also used on special occasions, whereas in others alcoholic beverages, which may or may not be distilled, are preferred [19]. There is a vast array of fermentation products (Table 3).

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Table 3. Examples of foods and additive manufactured using industrial fermentation processes in developing countries [20].

Category	Examples	Countries
Alcoholic beverages	Some spirits, wines and beer	Nigeria, India, China
Dairy products	Milks, yogurt and cheeses	Sub-Saharan Africa, Eastern Europe
Flavours	Monosodium glutamate and nucleotides	Southern Africa, India, China
Organic Acids	Lactic acid, citric acid, acetic acid	Nigeria, China, India, Pakistan
Amino Acids	Lysine and glutamic acid	Ghana, Nigeria, India
Vitamins	A, C, B_{12} and riboflavin	Nigeria, Ghana, Southern Africa, India
Enzymes	Proteases, etc	China, India, Pakistan, Turkey

3.3 Non-alcoholic cereal fermentation

Cereals, mostly processed by natural fermentation, account for up to 80% of total calorie consumption in many African countries and they are also an important source of dietary protein. They are frequently complementary foods for young children and as dietary staples for adults. Lactic fermented cereal-based foods in Africa can be classified on the basis of either the raw cereal ingredients used for preparation, or the texture of the fermented product.

4.0 TRADITIONALLY FERMENTED ALCOHOLIC DRINKS

Traditional methods for fermentation that yielded alcoholic beverages in developing countries and indeed Africa has long been in existence- since prehistoric times. Amongst these, (primarily for emphasis) are burukutu and pito (taken majorly in Western Africa), Palm wine (taken in Sub-Saharan Africa), 'Urwaga' in Kenya, 'Kasiksi' in DR Congo, 'Lubisi' in Uganda and 'Urwagwa' in Rwanda and Burundi, Tej in Ethiopia, 'Mes' in Eritrea and 'iQhilika' and 'Khadi' of the Xhosa and Tswana people of Southern Africa respectively. Outside Africa, Sake form South Eastern Asia and milk Kefir from Eastern Europe.

4.1 Pito

Pito is an artisanal alcoholic beer widely consumed in West African countries, especially in Nigeria, Ghana and some parts of Niger Republic and it provides a source of income for many in rural areas. The ingredients required for the production of pito are readily available in local cereal markets or could be cultivated in domestic farm lands. These ingredients are maize, sorghum, dried sweet potatoes and in Ghana, there is the addition of okra stem which facilitates the sedimentation of insoluble mash. The beverage is made from malted sorghum or millet grains or a combination of both and the production process involves malting, fermentation and then maturation [21].

The beer has a very short shelf life and is normally consumed within a day after production. The bacteria and fungi associated with the drink in Nigerian cities have been reported by several investigators. Similar to palm wine, there is a low prevalence of hygiene organisms which is due to the inhibitory action of other organisms that aid in the fermentative process and the yeast *Saccharomyces* is the dominant genera among the fungi species observed [22].

4.1.1 Traditional pito preparation: Sorghum grains are washed and soaked in water for 24 hours, drained, and kept for 2 days to germinate. After sprouting, the grains are sun-dried and ground into a flour. The flour is mixed with water and boiled for 3-4 hours to form a slurry. The boiled mash is allowed to settle; water is decanted while the sediment is recooked in water for another three hours. After cooking, the mixture is allowed to stand at room temperature for 24 hours, after which more water is added and the mixture reheated for 3 hours. The cooled cooked mash is filtered and allowed to stand overnight till the taste becomes slightly sour. The filtrate that was left overnight is then boiled to form a concentrate. A "starter" which is the leftover of the previous brew is added to the cooled concentrate and left for 24 hours. The product is pito, a dark-brown liquid with taste varying from sweet to bitter [21]. These steps for the production of pito are shown in Figure 1.

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Washing and soaking of Sorghum grains overnight
↓
Grains are drained and kept for 2 days to germinate
↓
Malted grains are sundried for 3-5 days
↓
Grinding of sundried grains
↓
Mixing with water into mash and boiled for 3-4 hours to form slurry
↓
Decanting of the supernatant slurry upon cooling
↓
Re-boiling of the sediment for 3 hours
↓
Decanting of the supernatant slurry upon cooling
↓
Addition of water to supernatant and left to stand for 24 hours
↓
Further filtration and left to stand till taste becomes slightly sour
↓
Addition of starter and left to stand for 24 hours
↓
Pito

Figure 1. Pito production

4.1.2 Microorganisms associated with pito production: There are certain microorganisms that have been reported to be associated with the cereal grains (sorghum or maize) used for the production of Pito. They are *Rhizopus oryzae, Saccharomyces cerevisiae*, *Aspergillus flavus*, *Penicillium funiculosum, Penicillium citrinum, Giberella fujikuroi* and *Botryodiplodia theobromae* [23]. Also, the starter used in the production of Pito has been observed to have microorganisms such as *Geotrichum candidum*, *Candida* sp. and *Lactobacillus* spp. which were frequently isolated while *Aspergillus versicolor, Peinicillium simplicissimum* and *Penicillium purpurogenum* occurred occasionally. Fungi have been observed to play a vital role in the hydrolysis of starch. *Rhizopus oryzae*, *Aspergillus flavus*, *Penicillium funiculosum*, *Penicillium citrinum* have been shown to be saccharifying agents and assist the malting process [22].

4.2 Burukutu

This is a local beer consumed mainly in the northern and middle belt region of Nigeria. It is the fermented drink called 'burukutu'. The drink is made similarly to pito, with the same materials but with slight variations in the production process. Both drinks are consumed within same communities and are distinguished based on colour of the finished product, aroma and the taste with Burukutu having a stronger vinegary flavour. Both drinks are shown in Figure 2 [24]. Burukutu consumption is much higher among low-income earners in Western Africa and is taken all year round.

Ingredients for production of Burukutu are sorghum grains or millet, maize which can be sourced traditionally from cereal and grains market. There has also been a surge in the cultivation of these crops [22].

Figure 2. (*From left to right*) Pito and Burukutu [25].

4.2.1 Traditional burukutu production: The production of Burukutu traditionally is similar to the production of Pito in the processing and raw materials involved. The steps can be categorized broadly into three namely; malting, fermentation of mash-garri mixture and the maturation process [26].

During the preparation, sorghum grains are steeped in water overnight. The grains are then poured into a basket and the water is allowed to drain off for about 2 hours. The grains are spread out on leaves or mats in a bed of about 3-4 inches in thickness and covered with another layer of leaves. During this malting period, the grains are watered on alternate days and occasionally turned over. Germination, which starts within 24 hours after steeping, is allowed to continue for a period of 4-5 days. The length of plumule is used in judging when germination has gone far enough. However, germination is usually complete after a period of 4 days. After germination the malt is spread in thin layers in the sun to dry for 1 or 2 days. The dried malt is ground into powder. In the next stage, gari (a starchy powder produced from the tuber of cassava plant, *Manihot utilissima*) is added to a mixture of the ground malt and water and stirred with a stick. The resulting mixture (gari-malt powder-water) is roughly in the ratio 1:2:6 by volume. The mixture is left to ferment for 2 days. At the end of fermentation, the mixture is boiled for about 4 h. The drink is then left to mature for another period of 2 days. The end product is a suspension of some particles in a creamy liquid [27]. The flow diagram for the production of Burukutu is shown in Figure 3.

Cereal (5kg) grains
↓
Soaked in water for 24 hours
↓
Draining
↓
Germination for 2 days at 28°C
↓
Sun-drying of germinated grains
↓
Grinding into flour
↓
Water is added
↓
Boiling for 3-4 hours
↓
Slurry
↓
Settling
↓
Decantation
↓
Fresh water is added and reheated for 3 hours
↓
Cooling and separation
↓
Sediment
↓
Fresh Burukutu
↓
Flavour development in calabash for 24 hours at room temperature
↓
Burukutu

Figure 3 Production of Burukutu [28]

4.2.2 Microorganisms associated with burukutu production: The sorghum malts used as the raw materials for the production of the beer have been reported by Bala *et al*. [26] to host a vast array of microorganisms that ranged from bacteria to fungi. These are *Saccharomyces cerevisiae, Canndida tropicalis, Candida krusei, Hansenula anomala, Rloeckera apiculate, Mucor rouxii, Aspergillus flavus, Aspergillus oryzae, Lactobacillus lactis, Lactobacillus delbriickii, Lactobacillus plantarum* and *Streptococcus lactis.*

The fermentation of the mixture of the mash and garri was also attributed to the function of a microflora of organisms. They are *Saccharomyces cerevisiae, Saccharomyces chevalieri, Candida tropicalis, Candida guilliermondii, Candida mycoderma, Hansenula anomala, Leuconostoc mesenteroides, Lactobacillus plantarum, Lactobacillus brevis, Lactobacillus delbruckii* and *Lactobacillus fermenti* [29]. This accounts for the drop in pH during the fermentation process from 6.4 to about 3.7 after 48 hours at room temperature.

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At the maturation stage, the microflora of microorganisms were *Saccharomyces pastorianus, Hansenula anomala, Candida mycoderma, Candida tropicalis, Kloeckera apiculate, Lactobacillus pastorianus, Acetobacter capsulatum, Acetobacter rancens, Acetobacter viscosum* and *Streptococcus mucilaginosus* [29].

Burukutu has shown a high prevalence of *Escherichia* and *Staphylococcus* possibly because of its physicochemical properties that allow bacteria to thrive. The prevalence of *Saccharomyces* is expected because of the sugar from the raw material available for fermentation. Again, *Aspergillus* prevalence may be a source of aflatoxins and it has been demonstrated to be present in the drink [30].

4.3 Palm Wine

Palm wine is a milky white alcoholic drink obtained from different species of palm trees around the world. It is believed to have oenological potentials [31] and maybe be suitable as a probiotic [32] or functional beverage. Palm 'wine' is an important alcoholic beverage in West Africa. It is consumed by an estimated 10 million individuals living in Southern Nigeria. In Figure 4, palm wine is shown served in carved wooded kettles which denotes key traditional elements attached to the consumption of Palm wine. Its popularity is due to the fact that it can be consumed in a variety of flavours varying from sweet unfermented sugary drinks with little alcohol to sour, well-fermented, vinegary alcoholic drinks [33].

4.3.1 Palm wine production: It is produced from sugary palm saps. The most frequently tapped palms are Raphia palms (*Raphia hookeri* or *R. vinifera*) and the oil palm (*Elaeis guineense*). The sap is collected by cutting the unexpanded flower spathe and tying a gourd to it. The juice trickles into the gourd and up to 3 litres of sap per day can be collected. The fresh palm juice is a sweet, clear, colourless juice containing 10-12% sugar and is neutral in reaction [6].

Figure 4. Palm wine [34]

4.3.2 Microbiology of palm wine production: Fermentation starts soon after the juice collects in the gourd. The organisms responsible are yeasts, mainly *S. cerevisiae* and *Schizosaccharomyces pombe*, and the bacteria *Lactobacillus plantarum* and *L. mesenteroides* [29]; other bacterial species vary. There are reports that the yeasts and bacteria originate from the gourd, palm tree, and tapping implements. However, the high sugar content of the juice would seem selectively to favour the growth of yeasts which might originate from the air. The fact that spontaneous fermentation also takes place in plastic containers lends further credence to this view. By 24 hours of fermentation the initial pH is reduced from 7.4-6.8 to 5.5 and the alcohol content ranges from 1.5 to 2.1 %. In a 72-hour wine, the ethanol content is from 4.5 to 5.2%, and pH is 4.0. The organic acids present are lactic, acetic and tartaric acids. Bassir [35] states that the ethanol content never rises above 7.1 %. Thus, palm wine is not really a wine in a strict oenological sense. Like most African alcoholic beverages, palm wine has a very short shelf life. Accumulation of an excessive amount of acetic acid makes it unacceptable to consumers. The bark of a tree (*Saccoglottis gabonensis*) commonly called ntala may be added as a preservative. Increases in thiamine, riboflavin and pyridoxine have been reported [22]. Vitamin B12 was also found to increase in fermented wine. The alkaloid and phenolic compounds which are extracted into the wine have antimicrobial effect [36] and can halt the onset of the acetic acid fermentation. Improved nutritional values have been reported in palm wine.

4.4 Honey Wine (Tej)

Honey wine (also known as 'mead' in Western countries) is a wine produced by fermenting honey with water. It can also be produced in several interesting varieties by the addition of different fruits and spices. Honey wine is arguably one

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of the oldest forms of wine and has a rich history in Africa, Europe, and Asia. However, since the population of bees in Europe declined significantly, European honey has become scarce and honey wine is no longer produced on a large scale in the West. Africa's abundant bee population and huge honey production potential gives it a big advantage in honey wine production. In Ethiopia and Kenya, the world's 10th largest honey producer, honey wine (traditionally known as 'Tej') is famous and widely enjoyed as the country's national drink. It is also widely consumed in Eritrea (called 'Mes') and remains a popular beverage of the Xhosa and Tswana people of Southern Africa who refer to it as 'iQhilika' and 'Khadi' respectively [37].

4.4.1 Production of Tej: Tej is a yellow, sweet alcoholic wine. One part of honey is mixed with four parts of water. This is poured into a fermentation pot which has been previously smoked over an olive wood, hop stem fire. The pot is covered and incubated in a warm place for 2-3 days after which wax and scum are removed. Boiled hops are added and the mixture is further fermented for another 8 days. The resultant coarse wine is filtered through cloth to get rid of the sediments; the final product is cloudy due to the actively fermenting yeasts and other organisms [17]. Tej is relatively expensive hence its consumption is restricted to special occasions and holidays. The flow diagram for tej wine production is seen in Figure 5.

Rinse fermentation pot
↓
Smoke the pot using olive wood and hop stems
↓
Mix 1 part of honey with 3 parts of water and place in pot
↓
Cover the pot and keep in warm place for 2 to 3 days to ferment
↓
Remove wax
↓
Boil washed, peeled hops in a portion of fermenting honey
↓
Return boiled hops to fermenting honey
↓
Cover the pot and ferment another 8 days
↓
Stir daily
↓
Filter 3 times through cloth
↓
Tej

Figure 5. Tej production [28].

4.4.2 Microorganisms associated with Tej production: Fermentation of tej relies on the microorganisms (lactic acid bacteria and yeast) present in the substrates, fermentation vats, and equipment. Their metabolic products contribute to acidity and also add distinctive flavour and aroma to the fermenting material [28]. Major yeast species in tej were *Saccharomyces cerevisiae, Kluyveromyces bulgaricus, Debaromyces phaffi*, and *Kluyveromyces veronae*. The lactic flora consisted of *Lactobacillus, Streptococcus, Leuconostoc*, and *Pediococcus* species [38].

4.5 Kaffir Beer

Kaffir beer is the traditional beverage drink of the Bantu people of Southern Africa. Kaffir beer is an opaque, effervescent beer with yeasty odour and fruity flavour. It is pink due to sorghum tannins. It contains an average alcohol content of 3.2% and lactic acid content of 0.3%. The beer must not contain acetic acid [39]. If a beer contains little alcohol but is well soured, it is still very acceptable. Kaffir beer is made from malted kaffircorn (sorghum) and unmalted maize and kaffir corn. Millets may be used in place of these.

4.5.1 Production of kaffir beer: The method of producing kaffir beer is shown in figure 5. The details of the process were described by Novellie [40]. Cleaned and washed kaffir corn grains are steeped for 8-24 hours, then drained and spread out in layers to germinate (at about 30°C) for 5-7 days. The grains are watered for the first 3 days and they are turned and cool air used to reduce heat. Germination continues until the plumule is (2-5 cm) (1-2in) in length. They are then sun-dried or dried in an oven at 50-60°C and ground. The finished malt contains β-amylase (30-40%), α-amylase (60-70%) and diastatic power of 11.6-17.2 (Lintner). The main steps in kaffir beer brewing are mashing, souring, boiling, conversion, straining and alcoholic fermentation. Warm water (50°C) is used for mashing. Malted sorghum is added to unmalted grains in the ratio of 1:4. Water and inoculum from the previous batch are added. Souring (lactic acid fermentation) takes place at 48-

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50°C for 8-16 hours. *Lactobacillus* is chiefly responsible. The finished sour mash has a pH of about 3-3.3. The mash is diluted with 2 volumes of water and boiled for 2 hours. It is then cooled to 40-60°C and additional malt added. Conversion proceeds for 2 hours and then the mash is cooled to 30°C. After straining to remove coarse malt husks, alcoholic fermentation begins using top-fermenting yeast (*Saccharomyces cerevisiae*) as inoculum. Kaffir beer is ready in 4-8 hours at which time it is still actively fermenting. It has a shelf-life of up to 40 hours. Acetic acid production by *Acetobacter* is the principal cause of spoilage [6]. These steps involved in the production of Kaffir beer are outlined in Figure 6.

Sorghum (kaffir corn, red varieties)
↓
Cleaned and washed
↓
Steeped for 8-24 hours
↓
Germinated for 5-7 days at 25-30°C in depth of 3 - 4ft and watered for first 3 days
↓
Grains turned and cool air used to reduce heat
↓
Malt (60-65% moisture: roots and shoots 1-2inches in length)
↓
Dried at 50-60°C
↓
Ground
↓
Finished Sorghum malt
↓
Warm water + unmalted cereal 10% innoculum from previous batch
↓
Fermentation, 48-50°C, 8-16 hours
↓
Finished sour mash, Ph 3-3.33
↓
Pumped to cooker and diluted with 2 vol of water
↓
Intermittent addition of corn grits
↓
Cooked for 2 hours at atmospheric pressure
↓
Cooked to 40-60°C
↓
Sorghum malt added
↓
Held for 2 hours
↓
Cooled to 30°C and top fermenting yeast (Saccharomyces cerevisiae added as pure yeast)
↓
Strained to remove coarse particles fo malt husks
↓
Fermentors 30°C, 8-24 hours
↓
Finished Kaffir beer

Figure 6. Kaffir beer production [6]

5.0 BENEFITS OF ALCOHOLIC FERMENTATION

The primary benefit of fermentation is the conversion of sugars and other carbohydrates to usable end products. According to Steinkraus [17], the traditional fermentation of foods serves several functions, which includes: enhancement of diet through development of flavour, aroma, and texture in food substrates, preservation and shelf-life extension through lactic acid, alcohol, acetic acid and alkaline fermentation, enhancement of food quality with protein, essential amino acids, essential fatty acids and vitamins, improving digestibility and nutrient availability, detoxification of anti-nutrient through food fermentation processes, and a decrease in cooking time and fuel requirement.

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- Some foods are converted by fermentation into products with pleasant odours and colours which remove the monotony common among most vegetable diets. In this way some high quality meat flavours are derived from vegetable origin. This leads to increase in acceptability, palatability, better appearance, better flavour and increased nutritional quality.
- Fermentation is a cheap means of preserving the local staples for long periods. Perishable substrates, for example, maize, sorghum, cassava, fish, beans, etc are converted into products with good keeping qualities such as gam, sour fish, fermented bean condiments etc. Fermented food products such as dawadawa that contain spices and salt have an enhanced keeping quality and longer shelf life.
- Fermentation is a low cost method of producing nutritious protein-rich or high-vitamin beverages. It leads to increase in the protein content of high starch substrates. Digestibility of fermented products is increased by the breakdown of the proteins into amino acids. This is of particular importance in the case of pulses. Because of the limited amount of protein found around developing countries, there is an increasing need for the poorer countries to be self-sufficient by producing more protein foods via fermentation and other techniques. Some water-soluble B-vitamin levels are increased by fermentation as observed in Palm wine and Ugba. Some bacteria in fermented palm wine can also add vitamin B_{12} [41].
- Fermentation eliminates toxic substances like cyanide, protease inhibitors, hemagglutinins, ricin, tannins, phytates, flatus causing oligosacchandes etc This is important in the case of cassava, soyabeans, castor beans and African locust beans which are very toxic in the raw state but become non-toxic and edible after fermentation. Understandably these toxic compounds which also affect digestibility are destroyed due to the soaking and cooking steps as well as the discarding of the soak or cook water [25].
- Cooking time of most fermented foods is reduced when compared to that of raw unfermented substrates. This may be attributed to processes such as dehulling, soaking, milling, salts addition, etc which are steps involved in the local fermentation techniques [25].
- The bulk of food material is reduced by fermentation. This facilitates transport of the food product especially in developing countries where transportation is poor. Bulk reduction occurs due to the processes (such as peeling, dehulling, grating, soaking, squeezing, drying) involved in the fermentation techniques as observed in cassava fermentation into garri.
- The fermentation technique can salvage products such as fish bones, waste foods (yams, cassava) that cannot be readily used for food. Such foods become edible and presentable after fermentation.
- Most local fermented beverages are inexpensive and are therefore within the purchasing power of many individuals in the community. Production of fermented food by small scale food processors will therefore contribute to the economy of Nigeria and to the improvement in the nutrition of consumers [25].

6.0 IMPORTANCE OF MICROORGANISMS IN ALCOHOLIC FERMENTATION

i. Improvement of Organoleptic Properties

Microbial fermentation makes the fermented beverage palatable as there will be an improvement on the organoleptic properties, texture, aroma, and flavor [42]. Fermentation of Tej relies on the microorganisms (LAB and yeast), and their metabolic products contribute to acidity and also add distinctive flavor and aroma to the fermenting material. LAB isolated from various fermented foods produces organic acids and a high diversity of antimicrobial agents, which are responsible for the upkeep of quality and the palatability of fermented foods. Yeasts of genus *Saccharomyces* were reported to be responsible for the conversion of sugars to ethanol in Tej. According to the finding by Debela *et al*. [43], after 10 days of fermentation, Tella, produced by the fermentation of barley, sorghum, maize, teff and dagusa, becomes more acidic to consume due to the growth of *Acetobacter* spp., which converts ethanol to acetic acid under anaerobic conditions. The organoleptic properties of the fermented beverage make them more important, since it has wider acceptance [41]

ii. Use as Probiotics

Probiotics are usually defined as microbial food supplements with beneficial effects on consumers. Probiotics have a great potential for improving nutrition, soothing intestinal disorders, improving the immune system, optimizing gut ecology, and promoting overall health because of their ability to compete with pathogens for adhesion sites, to antagonize pathogens, or to modulate the host's immune response, pharmaceutical preparations, and functional foods for the betterment of public health [44]. In many communities around the world, there are traditional beliefs that some fermented foods or beverages have medicinal value. Most probiotic products contain LAB and molds that have been found to produce antibiotics and bacteriocins. The LAB belongs to the genera *Lactobacillus, Bifidobacterium, Enterococcus, Lactococcus, Streptococcus*, and *Leuconostoc*, and *Lactobacillus plantarum* strain CIP 103151, *Lactobacillus paracasei* strain NBRC 15889, and *Lactobacillus plantarum* strain JCM 1149, inherently present in some traditionally fermented alcoholic beverages such as Palm wine and Pito, have antimicrobial properties against various foodborne pathogens invading the gastrointestinal tract. Thus, a better understanding of the intestinal microbial populations will contribute to the development of new strategies for the prevention and/or treatment of several diseases [41].

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iii. Provision of Nutritional Quality

Fermentation processes increase the digestibility and availability of nutrients. The enzymes such as amylase, proteases, lipases, and phytates modify the primary food products through hydrolysis of polysaccharides, phytates, proteins, and lipids. For instance, those beverages that use malt are known to contain much more free amino nitrogen than does the original grain, i.e, the partial degradation of reserve proteins in cereals makes the free amino nitrogen available [42]. The number of proteins and the content of the water-soluble vitamins increase, while the antinutrient factors (ANFs) in the foods decline during fermentation. Palm wine is high in vitamin B_{12}, which is very important for people with low meat intake and for who subsist primarily on a vegetarian diet [1]

Lactic acid fermentation of cereals has been used as a strategy to decrease the content of antinutrients, such as phytate and tannins. This leads to increased bioavailability of micronutrients such as zinc, calcium, phosphorous iron, and amino acids [41].

iv. Bio-preservative Properties

The control/growth of an undesired organism by another has received much attention in recent years [45]. Many bacteria associated with fermented foods produce antimicrobial bioactive molecules, such as hydrogen peroxide, organic acids, and bacteriocins that make them effective bio-preservatives. In fermented foods, bio-preservation refers to the use/benefit of antagonistic microorganisms or their metabolic products to inhibit undesired microorganisms in fermented food products, thereby upgrading food safety and extending the shelf life of foods [45].

The lowering of the pH value is due to the production of acids which acts as a bio-preservative mechanism. Acid content plays an important role in alcoholic beverages for the preservation of beverages. The acid produced inhibits the growth of pathogenic microbes which can cause disease, thereby, prolonging the shelf life of fermented beverages. For example, LAB has antifungal activities. By doing this, the shelf life of fermented food can be prolonged. Acetic acid and propionic acid produced by LAB strains interact with cell membranes and cause intracellular acidification and protein denaturation. With these properties, associated microorganisms inhibit the growth of both pathogenic and non-pathogenic microorganisms in fermented beverages [41].

7.0 USES OF TRADITIONALLY FERMENTED BEVERAGES

There is a vast array of uses for traditionally fermented beverages especially within the African community set-up. These can be broadly categorised into four which are:

i. Medicinal purposes

Some of the inhibitory compounds against other bacteria include hydrogen peroxide and bacteriocins. A myriad of beneficial activities such as immunomodulatory, antiallergenic, antimicrobial, antihypertensive and anti-tumorigenic effects have been reported [46]. One of the supporting use of LAB fermentation to prevent diarrheal diseases is because they modify the composition of intestinal microorganisms and by this, act as deterrents for pathogenic enteric bacteria [47]. Thus, Lactic Acid Bacteria are applied as a barrier against non-acid tolerant bacteria, which are ecologically eliminated from the medium due to their sensitivity to acidic environment. Also, fermentation has been demonstrated to be more effective in the removal of Gram negative than the Gram-positive bacteria, which are more resistant to fermentation processing. As such, fermented food can control diarrhoeal diseases in children. Moreover, Lactic Acid Bacteria are also known to produce protein antimicrobial agents such as bacteriocins, peptides that elicit antimicrobial activity against food spoilage organisms and food borne pathogens, but do not affect the producing organisms [47].

ii. Financial purposes

Local production of alcoholic fermented beverages provides a source of income and means of poverty alleviation contributing to food security of Nigeria [47]. The preparation of this traditionally fermented beverages like Burukutu, pito and Kaffir beers has become technology in many homes in the rural communities and more recently in the urban areas where commercial production due to support from the government through the poverty alleviation scheme, has helped to alleviate poverty among the people [48].

iii. Ceremonial and recreational purposes

Traditional fermented alcoholic beverages especially sorghum beers and palm wine play important socio-cultural and economic roles in Africa. Previously, they were prepared in family settings alone and used in ceremonies, traditional sorghum beers have now become a common drink among the general population. Pito and Dolo (a similar traditionally fermented alcoholic beverage indigenous to Burkina Faso) are undoubtedly the most popular ancestral alcoholic drink in West Africa and are widely produced and consumed in both rural and urban communities. In Burkina Faso, about 75% of the sorghum produced is used for the production of dolo which is consumed by nearly 60% of the population [49]. Traditionally fermented beverages are almost always used for traditional ceremonies and socio-cultural events such as weddings, baptisms, funerals, enthronements, initiations and festivals [47].

Many traditionally fermented alcoholic beverages consumed by different ethnic groups have therapeutic values, some of the most widely known are fermented milks (kefir milk) which contain high concentrations of probiotic bacteria that can

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lower the cholesterol level [50], improvement of nutrients absorption and digestion, restores the balance of bacteria in the gut to hinder constipation, abdominal cramps, asthma, allergies, lactose and gluten intolerance [47].

Traditional homemade alcoholic drinks are also prepared to be shared and offered to friends and special guests, especially during visits and outings together. Such beverages are never exchanged for money, as they are intended as symbols of friendship, hospitality, family bonding and gratitude. They could even be offered for free by restaurant owners to regular customers after meals. Traditionally fermented alcoholic beverages act as a sort of "social lubricant," giving special importance to meals, celebrations and other social occasions [51].

8.0 HEALTH CONCERNS OF SOME TRADITIONALLY FERMENTED ALCOHOLIC BEVERAGES

Some traditionally fermented alcoholic beverages include palm wine, sake, burukutu, milk kefir and pito. These drinks are consumed daily in households of many developing countries and they may fall under several names based on cultural practices and geographical location [52].

8.1 Palm Wine

The drink is tapped via incisions made into the palm trees. These are left overnight in loosely or partially covered containers. This makes palm wine prone to biological, chemical and physical hazards. Increased microbiological studies of the product in the last five years has led to more information on the diversity of *Saccharomyces cerevisiae* strains prevalent in the product [53] and discovery of new microorganisms from the drink. It has been reported that the drink can be contaminated at multiple steps in the production process and should be regulated for quality control to avoid health risks [54]. In addition, plant material treated with herbicides and pesticides can be present in the palm wine processing environment, and it is not uncommon to see producers that use leaves to cover containers containing the drink. Leaves, stem and bark can also get into the palm wine either when the incision is made to begin the tapping process or when the sap is flowing into a container. In some palm wine processing environments, insects could be a source of food safety hazards when they fly into bowls or containers containing the drink [55].

Nwaiwu and Itumoh [55] reported chemical contaminants in palm wine. These were Styrene, benzene, trimethyldioxolane, dichloromethane, methylene fluoride, dichloroethanol, dimethylhydrazine and tetraacetyl-D-xylonic. Their sources ranged from the plastic containers used for tapping of the wine (styrene) to the environment as a result of pesticides. Bezene formation was as a result of the interaction between ascorbic acid inherent in palm wine and benzoic acid. Other chemical hazards in palm wine [56] can come from pesticides and veterinary medicines used in farming, acrylamides used in processing, natural aflatoxin that occur during storage and pollutants such as dioxins in the environment.

Physical and biological contaminants can get into the drink through the water used for dilution. A frequent complaint by palm wine consumers is adulteration of the product with water to boost product volume followed by addition of artificial sweeteners [57]. Due to no portable water at some palm wine processing centers in Africa, water may be sourced from nearby open wells and streams or transported with plastic containers, and, if the container has been used to store other materials, there is the possibility of introduction of extraneous materials into the drink. The extraneous items may include plant leaves, twigs and dead insects. Ukhun *et al*. [56] compared the heavy metal profile of fresh palm wine and those of seven brands of bottled palm wine using atomic absorption spectroscopy in Benin City, Nigeria and found that the bottled samples contained toxic levels of either lead or cadmium. Both metals were detected in fresh palm wine and it was suggested that most of the metals detected were as a result of dilution with contaminated water. The suspicion that the water used for bottling was from questionable sources was strong, given that around the time the study was carried out, there were reports that the ground water in Benin City was reported to be contaminated with unacceptable levels of lead, cadmium, chromium and zinc [31].

8.2 Milk Kefir

This is a fermented milk drink similar to thin yogurt that is made from kefir grains. The drink has origins in North Caucasus from where it came to Russia from where it spread to Europe and the United States. It is made by inoculating the milks of cows, goats or sheep with kefir grains [58].

Hazards that have been observed in this fermented alcoholic milk drink are physical, biological and chemical. Some biological hazards are often microbiological in nature. These are the growth of *Escherichia coli, Salmonella spp.*, *Staphylococcus aureus*, other coliforms, unwanted yeasts and *Aspergillus niger* and pathogens. Chemical risk factors such as antibiotics often administered to the animals that pass through the milk are often detected. Others include toxins such as aflatoxin, inhibitors and some toxic elements. Physical risk factors include foreign impurities, equipment metallic particles [59]. Heavy metals and radionuclide content have been detected in milk kefir (Table 4). These pose as chemical risk factors to the desired product.

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Table 4: Heavy metal and radionuclide content in milk kefir [59]

Heavy metal	Maximum allowable concentration	Content
Cadmium, mg/kg	0.03	0.008
Lead, mg/kg	0.1	0.03
Arsenic, mg/kg	0.05	Below the detection limit
Mercury, mg/kg	0.005	Below the detection limit
Caesium-137, Bq/l	100	2.5
Strontium-90, Bq/l	25	4.0

Milk kefir had inherent risk factors (microbiological, chemical and physical) that required careful control to ensure product safety and quality. Table 5 outlined those potential risk factors and adequate preventive action [59].

Table 5: Potential Risk factors in milk kefir

s/ no	Process name	Factor	Characteristic under control	Preventive action
1	Milk processing	Microbiological	Coliforms, pathogens including *Salmonella*	Inspection of transport document
		Chemical	Inhibitors, toxic elements, aflatoxin, antibiotics	Incoming quality control
2	Milk storage	Microbiological	Temperature, duration, acidity	Storage mode control
3	Storage of packaging materials	Microbiological	Temperature, *coliform* group bacteria	Storage mode control
4	Pasteurization of milk during the preparation of ferment	Microbiological	Temperature, duration, coliform group bacteria, pasteurization effectiveness	Pasteurization mode control
5	Fermentation of laboratory sample of ferment	Microbiological	Clotting density, foreign microflora	Creation of aseptic conditions
6	Holding of laboratory sample of ferment	Microbiological	Coliform group bacteria, mold	Preparation of ferment on skimmed milk, control of aging modes
7	Pasteurization of milk during the preparation of ferment for industrial purpose	Microbiological	Temperature, pressure, duration, coliform group bacteria, pasteurization test	Pasteurization mode control
8	Fermentation of ferment for industrial purpose	Microbiological	Clotting density, coliform group bacteria	Creation of aseptic conditions
9	Ripening of ferment for industrial purpose	Microbiological	Temperature, clot acidity, duration, coliform group bacteria	Ripening mode control
10	Ageing of ferment for industrial purpose	Microbiological	Clot acidity, coliform group bacteria, lactic streptococci, sticks and yeast	Ageing mode control
11	Pasteurization of milk during the preparation of an sour milk drink	Microbiological	Temperature, pressure, duration, coliform group bacteria	Pasteurization mode control
12	Fermentation of pasteurized milk	Microbiological	Coliform group bacteria	Creation of aseptic conditions
13	Ripening	Microbiological	Temperature, clot acidity	Ripening mode control
14	Cooling	Microbiological	Water temperature, duration	Temperature control
15	Adding of biological agent	Microbiological	Coliform group bacteria	Creation of aseptic conditions
		Physical	Foreign impurities	Scheduled preventive repair

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			Equipment metallic particles	
16	Aging	Microbiological	Duration, temperature	Ageing mode control
17	Filing	Microbiological	*Escherichia coli* group bacteria	Creation of aseptic conditions
		Physical	Foreign impurities Equipment metallic particles	Scheduled preventive repair
18	Packaging	Microbiological	Poor quality packaging	Equipment checkout
19	Storing	Microbiological	Duration, temperature	Storage mode control

8.3 Burukutu and Pito

Pito is a cream coloured liquor while Burukutu is a brown coloured suspension both of which are brewed from sorghum, millet, maize or a mixture of these cereals. Both drinks are brewed concurrently by fermentation of malted or germinated cereals. Sorghum grains (5 kg) are soaked in water (10 L) for 24 hours, drained, and kept for 2 days to germinate. After sprouting, the grains are sun-dried and ground into a flour. The flour is mixed with water and boiled for 3-4 hours to form a slurry. The boiled mash is allowed to settle; water is decanted while the sediment is recooked in water for another three hours. After cooking, the mixture is allowed to stand at room temperature for 24 hours, after which more water is added and the mixture reheated for 3 hours. The mixture is then allowed to cool, forming a clear layer and a sediment. The top clear layer is known as "pito" while the sediment which is a thick brown suspension is known as "burukutu." Each fraction is decanted into a clean calabash pot where it is allowed to stand and ferment for 1day at room temperature for proper flavour development after which the drink can then be consumed [25].

Sorghum and maize can be used as cereal adjuncts in the brewing of beer. These cereals especially sorghum can substitute up to 80% of barley used in brewing lager beers in Nigeria.

Bala *et al*., [26] reported the microorganisms haboured in burukutu included *Escherichia coli, Staphylococcus aureus, Bacillus subtillis, Aspergillus niger, Aspergllus flavus* with others such as species of *Enterobacter, Klebsiella, Saccharomyces*, *Streptococcus* and *Fusarium.* A few of these microorganisms stand as microbiological hazards to pito and burukutu and this would have to be eliminated or reduced to acceptable limits to prevent food borne diseases. Faparusi *et al*. [29] observed a sharp and detectable change in the pH of burukutu as fermentation occurred. Over a 48-hour period, the pH declined from 6.4 to about 3.7. With proper boiling and adequate fermentation period, this serves as a control for microbes that are unable to survive he strong acidity and are pathogenic. This serves as both a preventive and corrective action in the production process of both burukutu and pito.

Controls for microbiological hazards such as *E. coli* and *S. aureus* which are coliforms and inhabitants of the skin respectively are adequate boiling and proper fermentation which further reduces the pH [26]. These microorganisms indicate the use of poor quality of water for the dilution of the drinks and in the production process and transfer of normal flora of the skin, *S. aureus* to the beverages. *B. subtillis,* which is autochthonous in the soil, also serves as a microbiological hazard and was reported to be in high numbers and this might be as a result of the grains used for the raw materials [26].

Physical hazards such as stones, chaff, leaves of other plants, debris of polyethylene were also reported by Danbaba *et al*. [60] while chemical hazards such as the presence of metals, and pesticides were also reported [61].

8.4 Honey Wine (Tej)

Though frequently praised for its health benefits, drinking mead could have negative health consequences that may be worth considering before you start filling your glass.

- **Alcohol Content**

The alcohol content of honey wine ranges from about 5% to 20% depending on the country that it is been produced. For comparison, regular grape wine has a typical alcohol content of about 12– 14%. Excessive alcohol consumption can lead to serious health risks including liver disease, systemic inflammation and impaired digestive and immune system function. The American Dietary Guidelines recommend limiting your alcohol intake to one serving per day for women and two for men [62]. One serving equals about five fluid ounces (148 ml) of honey wine with 12% alcohol by volume (ABV). Given the relatively high alcohol content of mead, it could be easy to go overboard, especially if you're drinking it under the assumption that it's good for your health.

Mead should be treated like any other alcoholic beverage. It's good to exercise moderation and limit your intake if you plan to drink it [63].

- **Allergic Reactions**

Honey wine is typically gluten-free, depending on what is added during the fermentation process. Thus, for fear of gluten allergy, there should be a double check on the honey wine to ensure no gluten-containing ingredients were included in the brew [63].

Also, honey wine may potentially cause serious allergic reactions in some people, especially those with honey and alcohol allergies or intolerances. Though rare, there have been reports of honey leading to anaphylactic reactions. A good indicator of honey wine allergy is allergy to honey itself or bee pollen [64].

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- **Calorie Content**

Honey wine is a high-calorie beverage; thus, overconsumption could negatively impact your health. Drinking too much of any alcoholic beverage, including tej, can increase your blood triglycerides, blood pressure and your risk of obesity and diabetes [63].

While there isn't much information available on the precise nutritional content of tej, pure alcohol alone provides 7 calories per gram. One serving of any alcoholic beverage contains about 14 grams of alcohol, equalling at least 100 calories. This doesn't take into account any of the calories from, for example, the sugar content of the tej [62].

CONCLUSION

The importance of fermented drinks, fermented foods and food products cannot be over emphasized as it holds the key to survival at various economic strata and enhanced nutrition for healthy living. Not just because of the enhancement of taste but as a cheaper means of food preservation and production of probiotics imbibed in such foods. Although there are some health concerns attributed to the production of these traditionally fermented alcoholic drinks, standardization of procedures can effectively nip these health threats. Indeed, these traditionally fermented alcoholic products stand a competitive chance to be manufactured en-mass and exported to the rest of the world.

RECOMMENDATIONS

1. There are quite a lot of things that are left unknown about the microbiology of many indigenously traditionally fermented alcoholic beverages and this is an aspect of further research.
2. The microbiological potential of the traditionally fermented beverages also has to enhanced to see the possibility of improved probiotic production.
3. Proper sanitary practices should also be adhered to while producing these beverages.
4. The indiscriminate use of pesticides also be a great health threat to theses traditionally fermented drinks and these in turn could be health hazards thus adequate enlightenment of rural and urban farmers is highly recommended.

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