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Research Article

Comparison of Fermentability of Wort Produced from Millet and Sorghum to Malted Barley Wort

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Abstract

This research was done to unveil the fermentability of wort produced from Millet and Sorghum as compared to malted barley wort focuses on exploring viable alternatives to brewing industry. Since traditional barley remains the best grain for brewing, this work tends to create alternative grains that can be used as traditional barley is very costly and rare to find because it has to be imported. These grains are affordable and common within us. I was able to arrive to get my wort by following the due processes in brewing starting from malting which involves three stages, Steeping to germination and then to kilning, then to mashing where the wort was produced by the help of the external enzyme added and filtered off with whatman No 1 filter paper, and finally pitching and fermentation to produce our alcohol. During the fermentation, different analysis were being taken till the last day of fermentation which includes pH, original gravity, yeast concentration and yeast viability. Wort was produced by the addition of external enzyme that aided it's saccharification and pitching of yeast during fermentation that resulted in the production of alcohol.

Keywords: *Malt; Wort; Fermentability; Kiln; Enzyme; Steeping*

Introduction

The beer production is facing increasing pressure to diversify its raw materials and reduce its environmental impact. Millet and sorghum two abundant and sustainable grains, offer a promising alternative to traditional barley and wheat [1]. Recent studies have explored the potential of millet and Sorghum for brewing, highlighting their unique flavor profiles and nutritional benefits [2]. However, the fermentability of wort produced from millet and Sorghum remains largely unexplored.

According to a recent review, the fermentability of non-traditional grains like millet and sorghum is influenced by factors such as starch structure, enzyme activity, and yeast strain selection [3].

Millet and sorghum are staple cereals in many parts of the world, particularly in Africa and Asia. Millet is known for its resilience in arid environments and is a key food source. The use of these grains in brewing could provide numerous benefits, including cost reduction, utilization of local resources, and the production of gluten-free beer, which is increasingly in demand. Wort is the sugary liquid extracted from malted grains during the mashing process in brewing. Wort is the fermentation substrate for yeast, providing the necessary nutrients for growth and alcohol production. The fermentability of wort is a crucial aspect of brewing, as it directly impacts the final product's quality and character. Imagine a brewer carefully crafting a recipe, only to find that the wort refuses to ferment as expected. It's a frustrating and costly setback that can lead to inconsistent flavor profiles and even affect the beer's safety for consumption [3]. Fortunately, researchers have made significant strides in understanding the factors that influence wort fermentability. For instance, studies have shown that the type and amount of grains used, as well as the mashing and saccharification processes, can all impact the fermentability of the resulting wort (Menezes., *et al*. 2019). In the case of millet and Sorghum two grains gaining attention for their potential in brewing, the fermentability of their wort is still largely unexplored. Some studies suggest that these grains may require specialized enzymes or yeast strains to achieve optimal fermentation [1].

Millet, sorghum, and barley are all cereal grains but have different starch compositions and enzymatic properties, which can significantly influence their fermentability. Millet is a small, drought-resistant cereal that is rich in starch, but lacks the enzyme systems (like amylases) needed for efficient starch conversion during malting. Millet contains around 60-70% starch (Kadam., *et al*. 2017). However, its starch is highly gelatinizable, making it suitable for fermentation if pre-treated or supplemented with exogenous enzymes. Millet grains are valued for their high nutritional profile and are widely cultivated in arid regions. They contain a significant amount of carbohydrates, proteins, and micronutrients such as iron and zinc, which contribute to their utility in brewing. Millet is relatively high in dietary fiber (8-10%), affecting mash filtration and wort clarity. Rich in iron, calcium, and B vitamins, millet also has significant levels of antioxidants, which can contribute positively to the health properties of fermented products [4].

Sorghum is another drought-tolerant cereal with a high starch content (~70-75%). It is often used in gluten-free brewing (Bikram and Bhat, 2015). Its starch is more resistant to gelatinization compared to barley, so proper malting or enzymatic treatments are required to break down the starch into fermentable sugars (Mueller., *et al.* 2015). Sorghum is a drought-resistant grain widely used in African and Asian brewing. Its chemical composition makes it a viable alternative to barley in regions where barley cultivation is challenging. Sorghum contains about 70-75% carbohydrates, mostly starch [5]. This starch can be efficiently converted to fermentable sugars during the mashing process, although sorghum starch granules are less susceptible to enzymatic degradation than barley starch. Sorghum's protein content is typically between 8-11%. However, sorghum proteins, primarily kafirins, are less digestible than those in barley and may affect the efficiency of enzyme activity during malting.

Sorghum has a lipid content of around 3-4%, slightly higher than barley, contributing to potential flavor variations in the wort. Dietary fiber content in sorghum is about 6-8%, which can lead to challenges in wort filtration [6].

Barley is the primary grain used in brewing due to its optimal combination of starch and enzyme content. Barley malt naturally contains amylases, which help convert starches into fermentable sugars, including maltose, glucose, and dextrins [7]. Barley has around 55-70% starch. Barley is the standard grain for brewing due to its favorable malting and fermenting characteristics. According to Briggs., *et al*. [8], Barley typically contains 65-70% carbohydrates, primarily in the form of starch, which converts readily into fermentable sugars. Its starch granules are well-suited to enzymatic action, leading to high fermentability. Barley has a protein content of about 10-12%. Barley proteins, such as hordeins, provide nitrogen for yeast metabolism, contributing to fermentation efficiency and beer quality. Barley has a relatively low lipid content (2-3%), which is beneficial as excessive lipids can lead to off-flavors and stability issues in beer. Barley contains about 4-5% fiber, mainly in the husk, which aids in forming a natural filtration bed during mashing. Barley is rich in vitamins, particularly B vitamins, and essential minerals like phosphorus and magnesium, which support yeast health and fermentation [9].

Materials and Methods

The materials used in this research work include: Millet grains, Sorghum grains, Water, Yeast (*Saccharomyces uvarum*), Cheesecloth, Fermentation vessel, Incubator, Spectrophotometer, pH meter, Sugar analysis kit, External enzyme.

Methods

Sample collection

Millet and Sorghum grains were sourced from Orie Orba market Nsukka, in Udenu Local Government Area, Enugu State. The samples were collected and packaged with clean sacks and brought down to Legacy University Microbiology Laboratory for immediate use.

All equipment and glass wares were washed with clean water mixed with detergent and hypochlorite. The glass wares were afterward sterilized in the oven for 10 minutes.

Determination of one thousand (1000) corn weight

One thousand pieces of the millet, Sorghum and barley were counted each and weighed. The weight of 1000 grains of millet/sorghum/barley in grams (G) $= W \times 1000 \times DM$

Where, W = total weight of grain taken, DM= dry matter percentage of grain, N=total number of grains counted.

Malting and steeping

500g each of the millet and Sorghum were weighed out and washed well in tap water to remove dust. The grains were steeped in 1000ml of water, and 0.1ml of formaldehyde was added inside to reduce microbial load on the grains. And allowed for 2-3 days, while changing of the water was done each day.

Germination

Germination was done by spreading the grains in a plastic dish covered with soaked savert and allowed for two to five days with continuous sprinkling of 10 ml of distilled water every six hours to prevent drying and also turned intermittently to prevent of the grains.

Kilning

Kilning involves the drying of the grains in the oven at a relatively high temperature until rootlets become brittle or friable. The grains were kilned by drying in the oven at 76°C for 24 hours. The objective of Kilning is to stop embryo growth and enzyme activity while minimizing enzyme denaturation and the process develops color and flavour (melanoidin compounds). Kilning was carried out following the Recommended Method of Analysis of the Institute of Brewing (IOB) (2013).

Determination of germinative capacity

Hundred pieces of the millet and Sorghum grains were counted and added inside the conical flask and 5 ml of fresh hydrogen peroxide solution diluted with 195 ml of distilled water was put into the conical flask then homogenized and steeped for two days.

Determination of germinative energy

The objective of this test is to measure the percentage of grains that can be expected to germinate fully if the sample is malted normally at the time of the test. Two tests are made using 4 ml or 8 ml of distilled water; the 4 ml test will denote true germinative energy of the sample and the 8 ml test denotes water sensitivity. Two filter papers were placed at the bottom of the Petri dish. Hundred (100) pieces of millet and sorghum grains was added inside the Petri dish and 4 ml or 8 ml of distilled water was sprinkled to wet the papers evenly.

Mashing

Millet and Sorghum were mashed using the electric blender. Then 110g of the ground malt was weighed out and added inside the conical flask and dissolved with 1000 ml of distilled water, and heated up from 45 - 50°C using the water bath and allowed for 30 - 45 minutes followed by increase in temperature to 76°C and continuously stirred at 10 minutes interval and the saccharification temperature for the grains 75.5°C were taken. Saccharification temperature for barley is 68°C. The complete conversion of the mash was determined by iodine test. After mashing, it was allowed to cool and filtered using Whatman No 1 filter paper to get the wort, then afterwards the wort was boiled for 10 minutes and cooled in a refrigerator at 4°C before further wort analysis.

Wort analysis

Determination of original gravity, Hot water Extract and pH were carried out according to the Recommended Methods of Analysis of the Institute of Brewing (IOB, 2013).

pH measurement

The pH of the wort sample was determined using a standard digital laboratory pH meter.

Determination of original gravity (OG)

100 ml of wort sample was measured using a measuring cylinder and a standard saccharometer was dipped into the wort sample and readings were taken as well as the temperature values.

Determination of hot water extract (HWE)

25g of the ground malt of millet and Sorghum were weighed into 180 ml of distilled water and placed in a hot water bath for 15 minutes at 65°C, stirred at 30 minutes interval for 1 hour to eliminate all lumps. The mash was allowed to cool and filtered off and the specific gravity was obtained. The extract yield was obtained from the relation: Extract= Excess gravity × 10.310 kg.

Yeast viability determination

0.1 ml of yeast cells were mixed with 0.1 ml of methylene blue solution. Viable yeast cells will reduce methylene blue enzymatically to a colorless stage. Dead cells with no enzymatic activity stains blue and the percentage of cells which are unstained is a measure of the viability of the yeast. This was determined by pipetting 0.1 ml of yeast sample and 0.1 ml of methylene blue solution into test tube and homogenized. And allowed for 5 to 10 minutes, then place a drop of the well mixed suspension onto a microscopic slide, covered with cover slip and examined under a microscope using a magnification of ×40. And then count the number of unstained cells.

Yeast concentration determination

This was determined using hemocytometer or Newberg counting chamber. The hemocytometer and cover slip were cleaned with 70% ethanol. Cover slip was placed on the hemocytometer and pipetted drop of the suspension onto the cover slip and allowed for 30 seconds for the cells to settle and viewed under the microscope using a magnification of×100 for count. The total number of cells found was counted in the four large corner squares. Counts of Live cells (without methylene blue) and dead cells (with methylene blue).

Yeast harvesting

The yeast cells were harvested immediately after fermentation using a separatory flask, allowing the yeast to flocculate and settle towards the bottom of the flask.

Results

The results obtained from this research work were presented below.

Sample	Weight
Barley Sorghum Millet	33.6g 27.6g 32.6g

Table 1: *One thousand corn weight of the barley, sorghum and millet.*

Sample	Germinative Capacity (%)
Sorghum Millet	31 60

Table 2: *Germinative capacity of sorghum and millet.*

Sample	Germinative Energy (%)
Sorghum Millet	50 75

Table 3: *Germinative energy of sorghum and millet.*

Sample	Water sensitivity
Sorghum Millet	52 77

Table 4: *Water sensitivity of sorghum and millet.*

Sample	Moisture content
Sorghum Millet	78 80

Table 5: *Moisture content of sorghum and millet.*

Sample	Rout lets weight.
Sorghum Millet	12.6g 19.4g

Table 6: *Malting loss of sorghum and millet.*

Sample	Extract value (%/kg)
Barley malt Sorghum malt Millet malt	350.9 293.8 272.0

Table 7: *Hot water extract of wort from sorghum, barley and millet.*

Sample	Apparent Fermentability
Barley Sorghum Millet	21.29 40.95 35.21

Table 8: *Apparent fermentability of wort from barley malt, sorghum malt and millet malt.*

Sample	pH	Day 2	Day 3	Day 4	Day 5	Day 6
Barley	4.4	4.3	4.0	3.9	3.9	3.5
Sorghum	4.3	4.0	3.7	3.4	3.4	3.0
Millet	4.4	4.2	4.0	3.6	3.6	3.0

Table 9: *pH values of sorghum, barley and millet malt.*

Sample	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Sorghum	393×10^4	363×10^4	358×10^4	330×10^4	325×10^4	295×10^4
Barley Millet	423×10^4	375×10^4	358×10^4	358×10^4	340×10^4	308×10^4
	403×10^4	370×10^4	343×10^4	340×10^4	338×10^4	318×10^4

Table 10: *Yeast concentration of sorghum, barley and millet.*

Sample	Before fermentation (%)	After fermentation (%)
Sorghum	71	65
Millet	71	64
Barley	71	63

Table 11: *Yeast viability of sorghum, barley and millet.*

Discussion

The results from table 1 showed that barley has the highest one thousand grain weight followed by millet and then sorghum. And the results from table 2 showed that millet has the highest germinative capacity, table 3 showed that millet also has the highest germinative energy. Likewise table 4 still showed that millet has highest water sensitivity.

Table 6 showed that the rootlets of millet is high than that of sorghum. Table 7 showed that the hot water extract of wort from barley malt is high, followed by sorghum and millet is the lowest. Table 9 showed that the pH were decreasing down to the last day of fermentation.

Table 5 showed that millet has more moisture content than sorghum, showing that millet absorbs more water and germinate faster than sorghum.

Table 9 indicates that the yeast concentration and viability was decreasing through out the fermentation days. Saccharification temperature of millet and sorghum was at 75.8°C.

We were able to produce my wort by the addition of external enzyme which aids in it's saccharification and finally got alcohol by adding yeast (*Saccharomyces uvarum*) during the fermentation.

The results of this research demonstrate that millet and Sorghum can be viable alternatives to malted barley for brewing, with fermentability comparable to or even exceeding that of malted barley wort.

Barley has low gelatinization temperature, allowing starches to dissolve easily during mashing, making sugars more accessible to yeast during fermentation. Sorghum's starch has a higher gelatinization temperature than barley requiring adjustment in brewing processes to optimize fermentability. Millet has lower enzyme activity compared to barley but performs better than sorghum in terms of starch breakdown. With added enzymes, millet can achieve moderate fermentability levels and offers unique flavor attributes. Also millet tends to germinate faster than sorghum [10-12].

Conclusion

This research came to the conclusion that wort being produced from millet and sorghum with the help of external enzyme amylase and protease can be used as an alternative in brewing industry since the known traditional barley malt is very costly and rare to find whereas our millet and Sorghum grains is very affordable and rampant within us. And by so doing we can produce beer with different flavor.

Recommendation

We recommend it to the brewery industry to use these grains as an alternative to the traditional barley because they are cheap and common within us.

We recommend that the grains should be used with external enzyme to enable saccharification.

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