Review Article
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Design and production of maize beer

Abstract

Beer is an alcoholic beverage made by brewing and fermentation from cereals, usually malted barley and flavored with hops and the like for a slightly bitter taste. It is widely consumed throughout the world and global production during the last decade. In Africa, the alcoholic beverages such as liqueurs, wine and especially barley beer are much consumed both during moments of joy (festivals, weddings, success in examinations or competitions, winning football matches, etc.) and moments of sadness (funerals, job losses, poverty etc.). The sale of beer is a significant source of revenue for the owners of the maquis, restaurants etc. It is therefore a creative activity of jobs. According to many works such as "health for all", barley beer would have many health benefits if it is consumed in moderate amounts. Some of these interesting health benefits would include the following: anti-cancer properties, reduced risk of cardiovascular diseases, increased bone density, diabetes, prevention of anemia, hypertension, anti-aging properties, gallstones, prevention of dementia and coronary disease, aids digestive system, kidney stones and osteoporosis, stress buster, diuretic. But unfortunately, barley beer is imported. To lessen the import costs, we want to produce a local beer that may have the similar characteristics like beer barley beer from another cereal, maize. Unlike barley, maize grows very well in all tropical countries of Africa. Qualitatively, the chemical and biochemical components are almost the same as well as in both barley and maize. There are several types of strains of microorganisms used for the production of beer, such as lactic bacteria and yeast. But we have used a yeast strain: Saccharomyces cerevisiae which we can find easily and cheaply. The manufacturing processes of our maize beer essentially involve treatment of grains, malting or germination, mashing or extraction with water, filtration and fermentation. Germination process is halted at desired malt quality, green brown malt is converted to stable, storable product, colour and flavor are developed, enzymes are stabilized and preserved, and unwanted flavours are removed.

The objectives of mashing are solubilization and dissolution of grain components, break down of grain cell wall structure extraction and hydrolysis of starch, sugars, proteins and non-starch polysaccharides, fermentable sugar profile is established. During the fermentation, alcohol level is established, flavor profile of beer is established and carbonation level is established. At the end of fermentation, yeast flocculates and can be easily separated. Cold maturation temperatures will influence beer clarity. Using a systematic procedure to solve material balance problems, mass balances in all six steps in this production process were solved. The results shows that this process is more effective for maximize product yields due to the approximately equal of receipt and expenditure with high yield for each operation.

Keywords: brewing, fermentation, cereals, barley, beverages, liqueurs

Volume 6 Issue 1 - 2018

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Received: August 30, 2016 | **Published:** January 25, 2018

Introduction

Comparison of barley and maize

Barley beer is a widely consumed alcoholic beverage throughout the world and global production figures have shown an increasing trend during the last decade. In Africa, the alcoholic beverages such as liqueurs, wine and especially barley beer are much consumed both during moments of joy (festivals, weddings, success in examinations or competitions, winning football matches etc.) and moments of sadness (funerals , job losses, poverty, etc.). The sale of beer is a significant source of revenue for the owners of the maquis, restaurants, etc. It is therefore a creative activity of jobs. But unfortunately, barley beer is imported. To lessen the import costs, we want to produce a local beer that may have the similar characteristics as beer barley beer from another cereal, maize. This can also allow us to diversify the raw material of beer in temperate countries in order to promote cooperation between Russia and African tropical countries for example. Unlike barley, maize grows very well in all tropical countries of Africa. The Table 1 below shows the comparative chemical composition of barley and maize.[1–13]

Qualitatively, the chemical and biochemical components are almost the same as well as in both barley and maize. Corn beer in the Andes has pre-Incan origins. There is archeological evidence that elite women were responsible for brewing in the Wari culture (600 to 1000 AD). In 1796 John Boston created a corn beer, the first fermented alcohol beverage made at Sydney, Australia. Traditionally, barley was the main grain used in brewing beer. However, many brewers use other grains along with barley. Most of the beer sold in the world is made with rice or corn making up a healthy portion of the grain bill. For just one Peruvian *sol* (around 30 cents), you can get drunk in Peru's Sacred Valley. Concealed amid the areas monstrous mountains, a series of domestic speakeasies serve an ancient Andean drink known as *chicha de jora*, a fermented corn beer dating back to the ancient Incan Empire. Still widely consumed in the Andean highlands, locals homebrew the concoction through a series of methodical steps involving the germination of *jora* (a type of yellow corn), a crop revered for its life-sustaining attributes.

Health benefits of barley beer

According to many research works related to health benefits of beer, such as "Bio-medicine" for example, barley beer would have many health benefits if it is consumed in moderate amounts. Some of these interesting health benefits would include the following:

Anti-cancer properties

Hops used in beer, through its flavonoid compound called Xanthohumol, would play a major role in the chemoprevention of cancer, including prostate cancer.

Reduced risk of cardiovascular diseases

Beer would contain vitamin B6, which would protect against heart diseases by preventing the build-up of a compound called homocysteine. Increased Bone Density: Moderate beer consumption would increase bone density, thereby preventing the risk of fractures and osteoporosis.

Diabetes

Moderate beer consumption would have a lower prevalence of type 2diabetes.

Prevention of anemia

Beer would be a good source of vitamin B12 and folic acid which would prevent anemia. Vitamin B12 is also essential for maintaining normal growth, good memory and concentration.

Hypertension

According to Biomedicine, regular beer drinkers would have lower blood pressure, compared to people that consume similar amounts of wine or other spirits.

Anti-aging properties

Beer would increase the potency and impact of vitamin E, which is a major antioxidant in the body. It would be an important part of the maintenance of healthy skin, while also slowing down the aging process.

Gallstones

Regular consumption of moderate amounts of beer would affect the cholesterol levels and decreases bile concentration, leading to a reduced risk of developing gallstones.

Prevention of dementia and coronary disease

Beer consumption also would boost the level of "good cholesterol" by 10-20%, thus reducing the risk of dementia and cardiovascular diseases.

Aids digestive system

Beer would possess a number of digestive properties, which would include the stimulation of gastrin, gastric acid, cholecystokinin and pancreatic enzymes.

Kidney sones and osteoporosis

Potassium, sodium and magnesium would be present in and would be important in reducing risk of kidney stones. The silicon would be also present in beer and would be readily absorbed by the body, further explaining the protective effect of beer against osteoporosis.

Stress buster

Beer would reduce stress, and facilitates sleep. So would do other alcohols.

Diuretic

Beer would act as a diuretic and significantly would increase urination. This facilitates the increased removal of toxins and waste materials from the body.

Maize beer production procedures

The main source maize beer is starch and its production includes the following steps:

Treatment of maize grains

The aim of this stage is to have safety grains. Therefore, detoxification of grain before malting may not be practical unless further growth of the mold is also prevented. Physical, biological, chemical and biological methods are used for inhibiting mold growth in grain.

Germination or malting

Grain is soaked in water. Water is absorbed by the grain. There are hydration of grain embryo and stimulation of grain for start of germination. Activities of embryo are awakened, and enzymes will be distributed evenly throughout the kernel. Grain is placed in shallow vessels. Water is removed. Aleurone layer is stimulated to produce enzymes. Enzymes act to degrade cell wall structures. Enzymes are stimulated from the aleurone layer and there is hydrolysis of proteins, carbohydrates, hemicellulose and lipids in maize grain. The temperature of the malt is raised from 15 to 85°C in a controlled manner (temperature, airflow, time). Germination process is halted at desired malt quality, green brown malt is converted to stable, storable product, colour and flavor are developed, enzymes are stabilized and preserved and unwanted flavours are removed.

Extraction with water or Mashing

Milled grain is mixed with water at various temperatures, rest times, agitation. Temperatures are optimized for the malt enzymes: 50°C for proteolysis, 62°C for gelatinization/liquefaction, 72°C for saccharification and 78°C for mashing-off and malt enzyme inactivation. There are solubilization and dissolution of grain components, break down of grain cell wall structure extraction and hydrolysis of starch, sugars, proteins and non-starch polysaccharides, fermentable sugar profile is established. Wort (aqueous solution) is separated from the spent grains (78°C). Grain bed is spared with hot water to extract as much extract as possible. Degree of clarity of wort is established; extract level of wort is established. Wort is boiled at 100°C; hops are added during the boil. We have evaporation of water, coagulation of proteins, isomerization of hop bitter components, inactivation of enzymes, wort sterilization, evaporation of undesirable volatiles, formation of flavour compounds and colour development.

Citation: Guillaume O, Mironov M, Shootov A. Design and production of maize beer. *MOJ Food Process Technol.* 2018;6(1):78–87.
DOI: 10.15406/mojfpt.2018.06.00148

First filtration

Insoluble material is separated from the wort solution. Coagulated proteins and insoluble hops material are removed.

Fermentation

Wort solution then cooled to yeast pitching temperature (21-25°C). Temperature is reduced to allow for yeast addition, Yeast is added to sterile cooled wort (cold temperatures encourage precipitation of proteins and beer clarification). Wort components of sugars and proteins are utilized by yeast to form alcohol, CO_2 and flavor components according to the following chemical reaction:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

As objective and results: alcohol level is established, flavor profile of beer is established and carbonation level is established. At the end of fermentation, yeast flocculates and can be easily separated. Cold maturation temperatures will influence beer clarity

Second filtration

After the completion of fermentation, the beer is filtered in order to remove the yeast and all the other solid derivatives. In this process, auxiliary materials of natural origin are used. After filtration, the clear product is driven to bottling.

Materials

The Table 2 shows the Reagents, materials and equipment in maize beer production. Figure 1 shows the data for the production of maize beer.

Data

Step 1: Treatment of maize grains: n=95%

Maize: 95%, Impurities: 5%

Step 2: Germination or malting: n=30-40%

The treated maize has 10% water. Water: 126.75%

$$\left(C_6H_{10}O_5\right)_n + H_2O \rightarrow nC_6H_{12}O_6$$

Step 3: Extraction with water or Mashing: n=50-60%

Step 4: First Filtration: n=95%

The percentage of sugar of the wort is about 8.8%.

Step 5: Fermentation: n=95%

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2co_2$$

Step 6: Second Filtration: n=98%

Mass of final product: 1000kg

Water: 89-95%, Dry matter: 5-11%, Ash: 0.27 to 0.47%, Alcohol: 4.3 to 5.8%, Protein: 0.39 to 0.71%

Total sugars: 0.04 to 0.10%

Density relative to water: between 1.00 and 1.02.

PH: 2.8 to 3.2

Calculation: How many Maize do I need to produce 1000 kg of beer 5% alcohol?

Step 2:

$$\left(C_6H_{10}O_5\right)_n + nH_2O \rightarrow nC_6H_{12}O_6$$
$$162n\ (g) \quad 18n\ (g) \quad 180n\ (g)$$

Step 5:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2co_2$$
$$180(g) \quad 2\times 46\,\text{g} \quad 2\times 44\,\text{g}$$

General yield=0.95x0.40x0.60x0.95x0.95x0.98=0.2017 or 20.17%; quantity of ethanol=1000x5%=50kg

$$\text{Weight of sugar (pure)} = \frac{\text{GEth} \times \text{Msug}}{2\times \text{Eth} \times \text{Gen.Y}} = \frac{50\times 162}{2\times 46\times 0.2017} = 436.5\text{kg}$$

$$\text{Technical Weight } = \frac{50\times 162}{2\times 46} = 88.04\text{kg}$$

$$Weight\ of\ maize:\ 100kg\ maize \rightarrow 72kg\ starch$$
$$X \qquad \rightarrow 436.5\ \text{kg}$$

$$X = \frac{100\times 436.5}{72} = 606.25kg\ \text{of maize}$$

Explanation of steps

Step 1: Treatment of grains

Quantity of grains: maize n=95%, impurities=5%

We need 606.25kg of maize (72% starch). As maize contains 0.5% of impurities, so we have 606.25kg x100/99.5=609.30kg as raw material

After treatment (our yield=95%), we'll get**:** 606.25kg x95/100=575.94kg as quantity of treated grains.

Receipts			Expenditure		
Raw Material	Content %(w)	Weight Kg	Products, Waste	Content %(w)	Weight Kg
Maize	99.5	609.3	Maize	94.5	575.94
			Dust	0.05	33.36
Total		609.3	Total		609.3

Step 2: Germination

The yield is 40%. We are 72% of sugar in 40% of maize (0.4x72/100=28.8% of maltose=575.94x28.8%=165.87 kg) and 11.2% of biomass (575.94x11.2%=64.51kg). So, the quantity of maltose and biomass is 165.87+64.51=230.38kg. The quantity of water has been increased in order to do the extraction with water. So, the yield is 230.38/575.94=40%.

Receipts			**Expenditure**		
Raw Material	**Content % (w)**	**Weight Kg**	**Products, Waste**	**Content % (w)**	**Weight Kg**
Maize	40	575.94	Maltose	11.52	165.87
Water	60	863.91	Biomass	4.48	64.51
			Water	84	1209.47
Total		1439.85	Total		1439.85

Step 3: Extraction with water

The yield is 60%.The quantity of mash including sugar is 165.87x60%=99.52kg. The quantity of biomass increases and is 230.38-99.52=130.86kg.

Receipts			**Expenditure**		
Raw material	**Content % (w)**	**Weight Kg**	**Products, waste**	**Content % (w)**	**Weight Kg**
Maltose	11.52	165.87	Mash including sugar	6.91	99.52
Biomass	4.48	64.51	Biomass	9.09	130.86
Water	84	1202.9	Water	84	1202.9
Total		1439.85	Total		1439.85

Step 4: First filtration

The yield is 95%.

The quantity of sugar is 99.52x95%=94.54kg. The percentage of sugar is about 8.8%.So the quantity of wort is 94.54x100/8.8=1074.32 kg.

The quantity of precipitate is 1439.85-1074.32=365.53kg

Receipts			**Expenditure**		
Raw material	**Content % (w)**	**Weight Kg**	**Products, waste**	**Content % (w)**	**Weight Kg**
Mash including sugar	6.91	99.52	Wort(+Sugar)	74.61	1074.32 + 94.54
Biomass	9.09	130.86			
Water	84	1202.9	Precipitate	25.39	365.53
Total		1439.85	Total		1439.85

Step 5: Fermentation

The yield is 95%.

The quantity of sugar is 1074.32x95%=1020.60kg. The content of alcohol is about 5%. So the quantity of alcohol is 1020.60 x 5%=51.03kg. The quantity of lost is 1074.32-1020.60=365.53 kg.

Receipts			**Expenditure**		
Raw Material	**Content % (w)**	**Weight Kg**	**Products, Waste**	**Content % (w)**	**Weight Kg**
Wort including sugar	100, 8.8	1074.32, 94.54	Maize beer non-filtrated including alcohol	95	1020.6, 51.03
			Lost	5	53.72
Total		1074.32	Total		1074.32

Step 6: Second filtration

The yield is 98%.

The quantity of maize is 1020.60x98%=1000kg. The content of alcohol is about 5%. So the quantity of alcohol is 1000x5%=50kg.The quantity of precipitate is 1020.60-1000=20.60kg

Mass of final product: 1000kg

Water: 89-95%:890-950g

Dry matter: 5-11%, 50-110g,

Ash: 0.27 to 0.47%,:2.7 to 4.g,

Alcohol: 4.3 to 5.8%,: 43 to 58g,

Protein: 0.39 to 0.71%:3.9 to 7.1g

Total sugars: 0.04 to 0.10%: 0.4 to 1g

Density relative to water: between 1.00 and 1.02.

PH: 2.8 to 3.2

Receipts			**Expenditure**		
Raw Material	**Content % (w)**	**Weight Kg**	**Products, Waste**	**Content % (w)**	**Weight Kg**
Maize beer including Alcohol..	99.9	1020.6	Maize beer including Alcohol..	98, 5%	1000, 50
Flavoring substances	0.1	51.031	Precipitate	2	21.60
Total		1021.60	Total		1021.60

Practical case for production of 10-15kg beer

Treatment of maize grains: 6kg of maize have been treated and used as raw material.

Germination or malting

Soaking: 6kg of treated maize and 9kg (9liters) of drinking water have been mixed in a basin 24h/30°C.

Germination: 5kg of water have been removed in a bucket from the soaking. The germination took place on plastic sheet at 30°C/72h. The maize was recovered with non toxic vegetable leaves (cleaned before in a bleached solution) in order to retain moisture. The cereals were humidified twice per day. Fermentable sugars resulting from starch hydrolysis can be tested by Trommer's reaction with the formation of Cu_2O precipitation of red-brown colour**.**

Procedure: 1g of dried germinated maize can be poured into a test-tube, 6drops of 10% NaOH solution were added and drop by drop, 5drops of 2% $CuSO_4$ solution until non-vanishing $Cu(OH)_2$ blue coloration. After heating the content of the test-tube, changing of color can be observed. After heating the blue coloration, if the formation of Cu_2O precipitation of red-brown color is observed, we are presence of fermentable sugars.

Extraction with water or mashing

Drying: The product could be dried at 100°C/4h to 5h through an oven or in the sun. But, it was dried 3days in the sun through large white sheets of paper. Fortunately we were in summer.

Grinding or pounding: The dried maize has been pounded through a mill. The weight was 6kg of malted maize.

Extraction: 6kg of malted maize and 1kg of rice husks have been added to hot water. 30liters of hot water have been used. First, 15liters of hot water have been used for the first mashing: 72°C/90minutes. Second, 10liters of the same water have been added for the second mashing: 78°C/60minutes. During the extraction, we were often stirring the mixture. During the filtration, we had added the other 5liters, liter by liter. We had obtained about 20liters of wort with 10°Brix. If the wort is very starchy after Iodine test, we have to add 1kg of barley malt.

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Boiling: The boiling has been done at 100°C/90 minutes. About 25kg hops have been added after 45minutes of boiling. We had 15°Brix.

First filtration

The wort added with hops had been filtered, and we had obtained about 14liters of product.

Fermentation

Cooling: The filtered hopped wort has been cooled between 20 and 25°C through heat exchanger.

Fermentation: The fermentation has been done with 11grams of yeast about 24°C. Before, the tank of fermentation has been rinsed with a paracetic acid solution 1%. We had 15°Brix (density: 1.06). After one week, we had 11°Brix (density: 1.045).

Second filtration

After two weeks, we had 8°Brix (density: 1.035).

We have filtered this fermentation pouring the supernatant through a siphon in a tank beforehand cleaned with a paracetic acid solution (50ml in about two liters of water).

After Four weeks, we had 8°Brix (density:1.035). The beverage was filtered in a tank previously washed with H_2O_2 solution 1%for 24hours and rinsed with the solution of paracetic acid solution.

The tank was tightly closed, then the CO_2 to saturation, was injected at 1.7bars.

-The tank was then kept at 4°C for one week.

Quality control

Physical and chemical analysis: Apart from the quality criteria for ashes, and total sugars, our beer meets the physico-chemical criteria of quality (Table 3). Traditional beer usually uses several ingredients and different types of grains and hops. So the quality of ash rise could be improved with time and practice. The quantity of protein is very near to the criteria and good in mashing wort, 0.48%. In any case, too much protein makes the beer cloudy. As for the amount of total sugars, it is high because maize malt does not have all the enzymes alpha and beta amylases in full. There are only beta amylases. However, even if it does not meet the standards, it is not bad sanitary to have a relatively high rate of carbohydrates. Careful analysis could be made to identify exactly all the sugars present.

Sensory analysis: The sensory analysis was carried out on a population of 15 people. The results (A6) and the summary table yielded are the followings (Annexes):

i. Transparency: 2/3, good;
ii. Color: 3/3 excellent;
iii. Flavor: 4/4 excellent;
iv. Taste: 4/5, good
v. Foam and carbon saturation with carbon dioxide:8/10 good.

The sensory analysis was carried out on a population of 15people about transparency, color, flavor, taste and foam. They all appreciated

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our corn beer, except for the criterion of the foam which was not very strong at the opening. The results are mentioned in the above Table 4.

With the mark of 21/25, our maize beer was good. All the 15people appreciated our corn beer. However, they found that the foam which was not very strong at the opening. The results are mentioned in the table above. Two of them even ordered a dozen bottles of 2liters of our beer. Unfortunately, the quantity was insufficient during the festival. The quality control about the sensory analysis, meets the criteria. However, much remains to be done to perfect our product. That is why we want to compare the chemical characteristics with those of traditional beer, to check whether it is close to international standards and whether it can have the same therapeutic qualities as traditional beer.

Microbiological analysis

The microbiological analysis was not carried out for the following reasons. All arrangements (food hygiene, boiling, adding CO_2 in final product, etc.) have been made to avoid contamination of the product by the application of the HACCP system. So, all dangers of physical, chemical and biological origin have been minimized to the maximum. At all stages of production from raw materials until the final product, we have endeavored to apply and respect the rules of personal hygiene, clothing, environment, premises, equipment, etc.

On the other hand, if the microbiological analysis should be done, we should research the following germs: *Lactobacillus, Pediococcus, Acetobacter, Zymomonas mobilis*, etc.[14–24] Which are not dangerous but contaminate the beer and can affect its taste and smell. But fortunately all necessary measures have been taken. Moreover, the pH, which is 4.7, is not conducive to the development of certain pathogenic microorganisms such as Enterobacteria.

There are also yeasts which are defenders of our beer against other possible microorganisms of contamination. Finally, there is bitterness (10.8IBUs) which prevents dangerous microorganisms from developing there. However, microbiological analysis could have been carried out as a precautionary measure and verified the effectiveness of the prevention measures. We wanted to spare our department from expenses. Food hygiene is also economy.

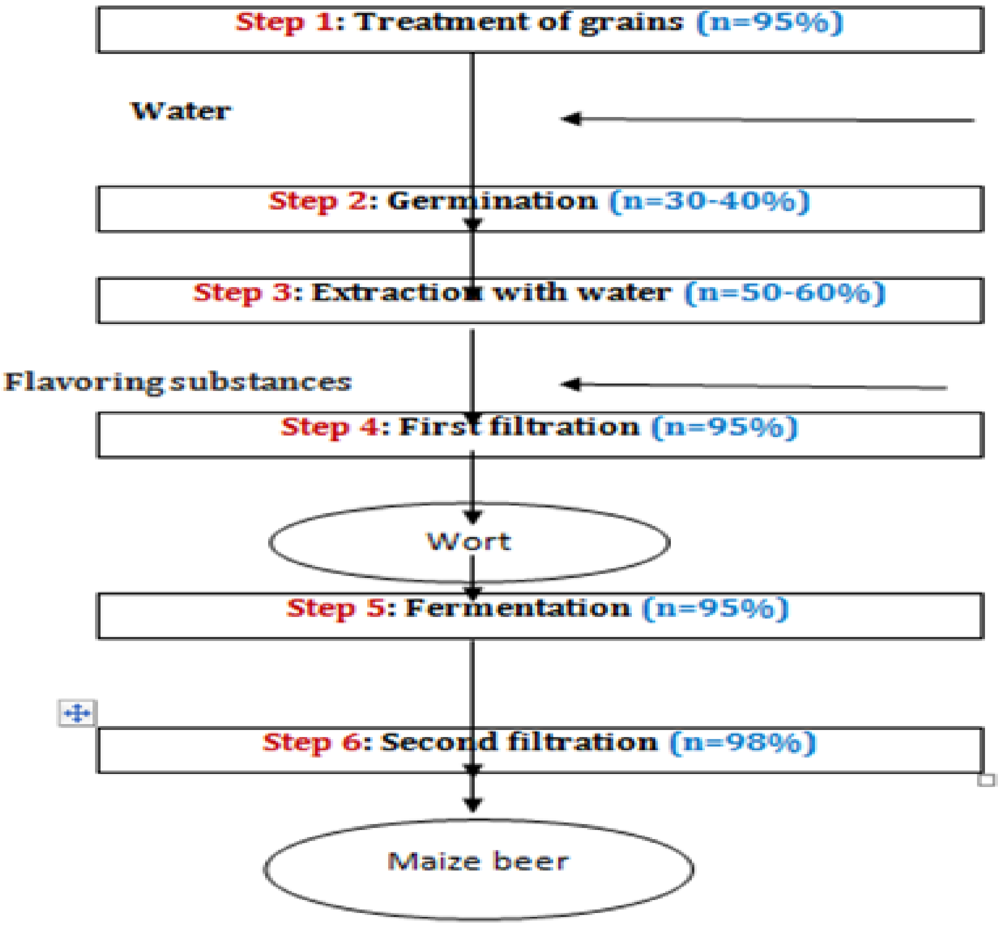

Figure 1 Principles of the production of maize beer.

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Table 1 Comparative chemical composition of barley and maize

Raw barley	Maizegrain
Nutritional value per 100g	
Energy 1,473 kJ (352 kcal)	Energy 1,528 kJ (365 kcal)
Carbohydrates	
77.7g	74g (starch=72-73%)
Sugars 0.8g	Sugars 0.64g
Dietary fiber 15.6g	Dietary fiber 7.3g
Fats 1.2g	Fats 4.74g
Proteins 9.9g	Proteins 9.4g
Vitamins	
Beta carotene 13µg	Beta carotene 97µg
Lutein zeaxanthin 160µg	Lutein zeaxanthin 1355µg
Thiamine (B1) 0.191mg	Thiamine (B1) 0.39mg
Riboflavin (B2) 0.114mg	Riboflavin (B2) 0.20mg
Niacin (B3) 4.604mg	Niacin (B3) 3.63mg
Pantothenic acid (B5) 0.282mg	Pantothenic acid (B5) 0.42mg
Vitamin B6 0.26mg	Vitamin B6 0.62mg
Folate (B9) 23µg	Folate (B9) 19µg
Choline 37.8mg	Vitamin E 0.49µg
Vitamin K 2.2µg	Vitamin K 0.3µg
Minerals	
Calcium 29mg	Calcium 7mg
Iron 2.5mg	Iron 2.71mg
Magnesium 79mg	Magnesium 127mg
Manganese 1.322mg	Manganese 0.49mg
Phosphorus 221mg	Phosphorus 210mg
Potassium 280mg	Potassium 287mg
Sodium 9mg	Sodium 35mg
Zinc 2.13mg	Zinc 2.21mg

Table 2 Reagents, materials and equipment in maize beer production

Objects	Reagents	Materials	Equipment
Maize (Drygrains)	**Bleach solution**	**Basin**	**Weighs**
Drinking water	Solution of NaOH 10%	Material to winnow	Test tubes
Rice husks	Solution of $CuSO_4$ 2%	Bowl of a liter	Thermometers
Barley (optional)	Paracetic acid solution	Gloves	Refractometer
Hops Dr. Rudy	Iodine solution	Filter or piece of clean cloth	Oven
Abbaye Belgium Ale Yeast	H2O2 solution 1%	Cassava leaves or other non toxic vegetable leaves	Mill or mortar and pestle
		Plastic sheet	Crutcher
		Bucket	Cooler
		Large white sheets of paper	CO_2 injection equipment

Table3 Physical and chemical analysis of maize beer

Tests	Criteria	Results
Water	89-95%	89.90%
Dry matter	5-11%,	5.40%
Ash	0.27 to 0.47%	0.07%
Alcohol	4.3 to 5.8%	4.70%
Protein	0.39 to 0.71%	0.34%
Total sugars	0.04 to 0.10%	4.50%
Density relative to water	1.00 and 1.02	1.02
pH	2.8 to 6.2	4.7

Table 4 Overall maize beer quality assessment in scores

Assessment	Total score	Our score
Excellent	22…25	
Good	19…21	21
Satisfactory	13…18	
Poor	<12	

Conclusion

Throughout sub-Saharan Africa, maize is the grain of choice to produce traditional cloudy and opaque (maize) beers. The key ingredient of these beers is maize malt, which provides hydrolytic enzymes (especially amylases to ferment sugars into ethanol and carbon dioxide), starch (the source of fermentable sugars), yeast nutrients and beer flavour and colour substances.

The design and production of maize beer can be beneficial for everyone in tropical African countries, for the following reasons:

i. The main raw material is on site and cheaper, otherwise farmers will be encouraged to produce more in the fight against poverty.

ii. Maize beer can be produced by craftsmen.

iii. It may have to increase economic activities and employment creation, etc. It is possible to do the comparison of the all physical and chemical characteristics between barley beer and maize beer in order to check the components which are responsible for health benefits in maize beer like barley beer.

The problem of lack of β-amylase in maize can be solved by importing barley malt from temperate countries in reduced amount (10% in the manufacture of beer maize) or associating maize with other cereals. Our work can be improved in order to preserve the shelf life, organoleptic and chemical qualities of our maize beer and also to avoid chemical, physical and microbial contamination. A whole special attention must be made to all unit operations such as germination, drying, mashing, boiling, fermentation, etc. so that our production process could exceeds African borders. By the way, we have to conduct a study about further research of maize beer and barley beer comparison and what would be the mixing percentage of both for healthy person and what preservatives are required.

Acknowledgements

i. All our teachers for their very important, rich, efficient and concrete lectures, specially :

ii. Professor Maxim Mironov (our Supervisor) and Professor Elena Kovaleva for their efforts in order to succeed our Food biotechnology program;

iii. Mr. Alexey Shootov : General Director of Beersfan;

iv. Mr. Vladimir Pochivalov: Director;

v. Mr. Vladislav Ivoilov: Manager;

vi. Mr. Dmitriy Kopotilov: Brewer;

vii. Mr. Alexander Baracuda: Brewer;

viii. Miss Yulia Simanova: our translator from Russian into English and vice versa.

Conflict of interest

The author declares no conflict of interest.

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Citation: Guillaume O, Mironov M, Shootov A. Design and production of maize beer. *MOJ Food Process Technol.* 2018;6(1):78–87.
DOI: 10.15406/mojfpt.2018.06.00148