Wolkite University

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College of Engineering & Technology

Food Process Engineering Department

Title: Effect of mashing temperature on physicochemical and sensory quality of beer made from finger millet

A Thesis Submitted to Department of Food Process Engineering in partial Fulfillment of the Requirements for the degree of Bachelor in Food Process Engineering

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DECLARATION

We, the undersigned students of Food Process Engineering want to declare that this final year thesis documents our original work and has not been presented in any university for a degree program fulfillment. All materials used as a source for this document has dully acknowledged.

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This thesis proposal has been submitted for examination by our approval as a thesis advisor.

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Executive Summery

This study was conducted the effect of mashing temperature on quality of physicochemical and sensory quality of beer made from finger millet, literature review of the study was contained material and method of the study the experimental design of the study was CRD it means temperature vary. Production and quality analysis of malt and beer such as GC, GE and MC and Physico-chemical analysis and Sensory analysis . And also finally Data Analysis of the study all data was analyzed by using Analysis of variance (ANNOV) Statically Analysis of softer ware (SAS) for window version 9.0. finger millet malt analysis GE = 96.42, GC =89.68and barely GE= 95.58, GC= 87.33 and moisture of malt for finger millet 15.56 and for barely =9.7067 between two sample significance difference .finally we see the gelatinization temperature of finger millet starch samples was determined and results ranged between 65^{0}C, 75 ^{0}C and 85 ^{0}C, however best mashing temperature for finger millet 75 ^{0} C. Other key parameters evaluated were wort perfect specific gravities and pH, Original gravity, colour, and content of wort starch were also determined result SG=1.01to 1.02 ,OG= 10.2to 14.66 and pH= 5.04 5.5 between the samples significant difference. Results showed that the specific gravities pH, and colour (EBC) obtained for the finger millet finished beer samples ranged PH 4.34, coluor 13.00EBC respectively. In addition to the above parameters, three additional parameters, original gravities (OG) specific gravity (SG) and alcohol by volume (abv) were measured for the finger millet starch orang beer with the following results (OG) 8.936, (SG) 1.004, alcohol by volume (abv) 5.36.

Keyword: *finger millet beer, Physico-chemical analysis, Sensory analysis, CRD, ANNOV and germination capacity and germination energy*

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
EBC	European Brewery Convection
LSD	Least Significant Difference
CRD	Complete Randomized Design
SAS	Statically Analysis of softer war
GE	Germination Energy
GC	Germination Capacity
SG	Specific Gravity
OG	Original Gravity
TSS	Total Soluble Solid

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CHAPTER ONE

1. INTRODUCTION

1.1. Background

Beer is an alcoholic beverage made from cereals like barley, corn, rice, oat, sorghum, finger millet etc. and tuber crops like cassava. Beer is made by fermentation and has an alcohol content of 2 to 6 percent. Arnold, J. (2005).Millets are in the family of cereals grown globally with differential importance across continents and within regions of the world. Finger millet is an important staple food in East and Central Africa and in India (Hulse *et al.,* 1980) and has an excellent food value as its seeds contain protein ranging from 7 to 14% and are particularly rich in methionine amino acid, iron, and calcium. Being a staple and consumed at household levels, processing must be considered at both traditional and industrial levels.

Millet is staple food crop in drought-prone areas of the world and often considered as component of food security. (Jowar, 2003). The solution is to find suitable raw materials that are guaranteed to be free of this protein fraction, as well as to elaborate and optimize a technology bythe application of which chance of gluten contamination can be eliminated, and a product with acceptable flavour and quality may be done. Recently beer is the most popular alcoholic beverage in the world and the share market is risen up in Ethiopia every year. Among this, the low price beer made with adjunct was accounted at least 80% due to the economic problems made consumer chose them. Therefore, the low price beer is the favorite product and the alternative sources of carbohydrate are attractive for brewery. There are many attempts to produce beer from alternative cereal malts and adjuncts in order to attribute special characters of beer; for example, a white beer from wheat, dunkelweissbierfrom dark wheat malt with dark barley malt, African kaffir beer from sorghum malt, tesguinoin central America from maize malt and zutho in India from rice malt, etc. (Teramoto, Yoshida, and Seinosuke, 2000). Along with the development of the beer industry, these are insufficient resources. Finger millet is a new potential substitute for barley or rice, which can resolve not only the ingredient problem, but also raise economic benefits.

1.2 Statement of the Problem

Barely has to be lowest production efficiency cultivation in Ethiopia region is not generally economically feasible thus, barley has to be imported from other countries and this involves expenditure of scarce foreign exchange (CSA. January 2009). Finger millet is a new potential substitute for barley which can be used as an alternate substrate and also raise economic benefits. The finger millet has high production efficiency it comes in to the brewing process to increase the production capacity of beer and to conduct types of beer diversion. Beyond this the malting process of barely is used long period of time than finger millet. It required high amount of energy consumptions and operational cost. But finger millet is reducing by half of energy and operational cost (O'Rourke, 2004). Mashing process is the main step in production of beer; however, the finger millet mashing profile has not been determined in brewing process (Palmer, 1989). Thus the aim of this study is to analyze and determine the appropriate mashing temperature for finger millet grist.

1.3 Objective of the Study

1.3.1. General Objective

- ❖ To determine the effect of mashing temperature on physicochemical and sensory quality of beer made from finger millet

1.3.2. Specific Objectives

- ❖ To determine the appropriate mashing temperature for finger millet beer.
- ❖ To determine the physicochemical quality of beer made from finger millet with different mashing temperature
- ❖ To analyze the sensory quality of beer made from finger millet with different mashing temperature

1.4 Significance of the Study

The study is helpful in substituting barely malting to finger millet on basis of cost of malting operation and to identify appropriate mashing temperature for finger millet grist. The beer made from finger millet has to reduce malt importing cost. As barely is substituted by finger millet it increases production of different beer type at the mean time income of farmers producing finger millet will be increased.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. General Description of Finger Millet

Finger millet is an important staple food in East and Central Africa and in India (Hulse *et al.,* 1980) and has an excellent food value as its seeds contain protein ranging from 7 to 14% and are particularly rich in methionine amino acid, iron, and calcium. Millet common name for several species of the grass family (see Grasses), and for their small-seeded grain, which is used to make porridge and flatbreads or as food for livestock, (Fapurusi, 1973). It is an important food staple in most of the former Soviet republics, western Africa, and Asia, where it probably originated more than 5000 years ago. Because it ripens in 60 to 80 days, grows in less-fertile soils, and resists drought, it is widely cultivated in poorer agricultural areas, (Ettasoe, 1972). The millets usually contain less protein than wheat or rye and more protein than rice

2.1.1. Nutritional contents of finger millets

Grown on marginal land provides a valuable resource in times of famine. Its grain tastes good and is nutritionally rich (compared to cassava, plantain, polished rice and maize meal) as it contains high levels of calcium, iron and manganese. It has a carbohydrate content of 81.5%, protein 7.3%, crude fiber 4.3% and mineral 2.7% that is comparable to other cereals and millets. Its crude fiber and mineral content is markedly higher than wheat (1.2% fiber, 1.5% minerals) and rice (0.2% fiber, 0.6% minerals); its protein is relatively better balanced; it contains more lysine, threonine and valine than other millets. The millet straw is also an important livestock feed, building material and fuel. Finger millet contains methionine, an essential amino acid lacking in the diets of hundreds of millions of the poor who rely mostly on starchy (Yenagi, Handigol, Ravi, Mal, & Padulosi, 2010).

2.2. Ingredients used for Beer Production

2.2.1. Malts

Malt is a cereal, usually barley, which has germinated for a certain period of time and then dried. Malting simply means steeping grains for several days, drying and milling it. Amylytic enzymes are produced during the germination process of the grain. This leads to the breakdown of the grain starches to sugars (Ekundayo, 1969). The sugars are conventionally fermented to lactic acid by the lactobacilli without the yeast. During alcoholic fermentation; yeast converts the sugars to alcohol which becomes the beer.

2.2.2. Starch source

The starch source in a beer provides the fermentable material and is a key determinant of the strength and flavour of the beer. The most common starch source used in beer is malted grain. Grain is malted by soaking it in water, allowing it to begin germination, and then drying the partially germinated grain in a kiln, (Ault, *et al*, 1971).

2.2.3. Adjuncts

Adjuncts are starchy materials which were originally introduced because the six-row barley varieties grown in the United States produced malt that had more diastatic power (i.e. amylases) than was required to hydrolyze the starch in the malt.. For example the term now includes sugars (e.g. sucrose) added to increase the alcoholic content of the beer (Okafor, 2007).

2.2.4 Water

Water is the main importance in beer production and it’s free of impurities in order to contribute direct as an ingredient to beer. Water makes up 95% of beer. The mineral and ionic content and the pH of the water have profound effects on the type of beer produced. Some ions are undesirable in brewing water: Nitrates slow down fermentation, while iron destroys the colloidal stability of beer

2.2.5. Hops

Hops are dried cone-shaped female flower of hop-plant Humuluslupulus (synomyn: H. americanus, H.heomexicams,. cordifolius). It is a temperate crop and grows wild in the northern parts of Europe, Asia and North America (Ashurt,. 1971). The importance of hops in brewing lies in its resins which provide the precursors of bitter principles in beer and the essential (volatile) oils which provide the hop aroma (Grant, Herbet . 1995) Both the resin and the essential oils are lodged in lupulin gland borne on flowers.

2.2.6. Yeast

Yeast is the microorganism that is responsible for fermentation in beer. Yeast metabolizes the sugars extracted from grains, which produces alcohol and carbon dioxide, and thereby turns wort into beer. In addition to fermenting the beer, yeast influences the character and flavour (Okafor, 1987). The dominant types of yeast used to make beer are ale yeast (saccharomyces cerevisiae) and lager yeast (saccharomyces uvarum); their use distinguishes ale and lager.

2.2.7. Brewer's yeast

Yeast in general will produce alcohol from sugars under anaerobic conditions but not all yeast are necessary suitable for brewing. Brewing yeast is able, besides producing alcohol, to produce from wort sugars and proteins a balanced portion of esters, acids, higher alcohols, and ketones which contribute to the peculiar flavor of beer, (Boulton,. 1991).

2.2.8. Sugar

Sugar in the form of crystalline was used to yeast feed and activation .yeast increase yield of brew house. Before adding sugar in a wort kettle it was dissolved as a solution in a sugar tank by adding a desired level of sugar depending on the recipes and was added to wort kettle through gaff filter.

2.3. Brewing processes

The first step in brewing, called malting, involves steeping the grain in water for 42 hrs until it begins to germinate, or sprout. During germination, enzymes within the grain convert the hard, starchy interior of the grain to a type of sugar called maltose, (Kneen, 1944). At this point, the grain is called malt. After several days, when the majority of the starch has been converted to sugar, the malt is heated and dried. This process, called kilning, stops the malt from germinating any further. A portion of the malt may be further roasted to varying depths of color and flavor to create different styles of beer (Gold hammer,. et al; 2008). After kilning, the dried malt is processed in a mill, which cracks the husks (the outer coating of the grain). The cracked malt is transferred to a container called a mash tun, and hot water is added. The malt steeps in the liquid, usually for one to two hours. This process called mashing, breaks down the complex sugars in the grain and releases them in the water, producing sweet liquid called wort. The temperature and amount of time used to mash the malt affects the body and flavor of the finished beer (Ault,. *et al*; 1971) in the next step, called wort separation, the wort is transferred to a large brew kettle and boiled for up to two hours. Boiling effectively sterilizes the wort to kill any bacteria that may spoil the wort during fermentation. During this stage of the brewing process, hops are added to the wort to provide a spicy flavor and bitterness that balances the sweetness of the wort. The types of hops used and the length of time they are boiled are determined by the style of beer being made (Edward,. *et al*; 1977). To produce a beer with a stronger, bitterer flavor, hops are boiled for at least 30 minutes and often longer. This enables the bitter oils in the hops to fully infuse into the wort (Gold hammer Ted, 2008).Other ingredients may also be used to influence the flavor of the finished beer. For example, brewers of pale and light-bodied beers often add other cereal grains, such as corn and rice, to achieve the desired lightness in their product. Many large American breweries add corn and rice that has first been cooked to a gel-like consistency. This gives the beer a lighter color and body and a more mellow taste than beers produced from barley alone (Gutcho, 1976).After brewing, the wort is cooled and then strained to remove the hop leaves and other residue. The brewer transfers the wort to a container in which it can ferment. This vessel may be a deep, flat container with an open top or a tall cylindrical vat with a conical base (Hammond,.*et al*; 1993). Yeast is then added or pitched into the wort to begin fermentation. Saccharomyces cerevisiae floats on top of the liquid as it ferments the grain sugars and prefers warm temperatures ranging from 16° to 22° C (60° to 72° F). Saccharomyces uvarum sinks to the bottom of the liquid and ferments best at cool temperatures ranging from 3° to 10° C (38° to 50° F).

The first fermentation lasts from a few days to two weeks. When the yeast has consumed most of the fermentable sugar, the wort becomes beer (Gold hammer, Ted 2008). The beer is transferred to an airtight container, called a conditioning tank, for a second fermentation or aging period, where the beer becomes naturally carbonated (Ault,. *et al*; 1971). Some brewers inject carbon dioxide gas into the beer when aging is complete to give it a bubbly, effervescent quality. Aging lasts for a few weeks to several months, depending on the type of beer being produced. After aging, the beer may appear somewhat cloudy from yeast cells and other particles that remain suspended in the liquid. The most common method of removing these impurities is filtration, a process in which the finished beer is pumped, under pressure, through a sterile filtering system that traps nearly all of the suspended particles from the liquid, resulting in a clear liquid (Ault,. *et al*; 1971). Even after filtration, however, some yeast may remain in the beer. To kill the remaining yeast, the beer is pasteurized, or heated to 82° C (180° F) after it has been sealed in cans or bottles. Draught beer, which is stored in metal kegs, usually is not pasteurized and must be kept refrigerated to prevent it from spoiling. Some brewers and beer drinkers believe that filtering and pasteurizing beer robs it of much of its original flavor and character.

2.3.1. Mashing process

Mashing is generally the conversion of insoluble into soluble forms. It is the most important process in Wort production.50% of beer production prepared from mashing (mash tun). The aim of mashing is to form extract with desired profile of sugars and desired level of proteins and other minor chemical constituents .Most of the extract is produced during mashing by the action of natural and artificial enzymes, which are activated at appropriate temperature, pH and concentration by their specific resting periods.

2.3.1.1. Parameters in mashing processes are: -Time, temperature and PH.

Time taken during mash shows late conversion of starch in to simple sugar, temperature is one of the most important factors in controlling enzyme reactions, PH the correct mashing pH is essential for correct enzyme action and extraction.

In mash tun three processes occur to Starch degradation (conversion of starch to simple sugar) those merge into one another as follows:-

- ✓ Gelatinization: - It is the swelling and bursting (no chemical degradation) of starch granules in hot aqueous solution. The starch molecules set free into this viscous solution are more easily attacked than un gelatinized starch by amylases.
- ✓ Liquefaction: - In liquefaction the long chains composed of glucose in starch are very rapidly broken open to from smaller chains by α-amylase. This causes a very rapid reduction of the viscosity of the gelatinized mash.
- ✓ Sccarification:-In Saccharification the β-amylase splits off two glucose residues from 7 – 12 glucose ends after α-amylase activity. It is the complete degradation of starch to maltose and dextrin’s by amylases. The iodine test is used to see if it is complete or not. When it is completed or converted in simple sugar it shows yellow color but when it is

blue colure it shows the starch presence in other word it doesn’t change in to simple sugar

2.3.2. Alcoholic fermentation

The anaerobic fermentation is the basis of the beer and wine industry. The anaerobic metabolism of glucose does not require the mitochondria. In yeast and other microorganisms, the reactions of glycolysis up to pyruvate formation are identical to those described for anaerobic glycolysis and the difference occurs only in its terminal steps. In contrast to animals, which utilize lactate dehydrogenase reaction for the re-oxidation of NADH to generate NAD+, the yeast cells (saccharomyces sp) utilize two enzymatic reactions for the purpose, as lactate dehydrogenase is not found in them; In the first step, the pyruvate resulting from glucose breakdown is decarboxylated by the action of pyruvate decarboxylase (=2 oxo acid carboxylase) to produce acetaldehyde and carbon dioxide (CO2). This is an irreversible reaction and does not involve the net oxidation of pyruvate (Jain, J.L. *et al.*, 2007).

CH_3—C—COO^- + H^+ → CH_3—C—H + CO_2

‖ ‖

O O

(Pyruvate) (Acetaldehyde)

In the second and final step, acetaldehyde is reduced to ethanol by NADH, derived fromglyceraldehydes-3-phosphate dehydrogenase reaction, i.e. step 6 of glycolysis, through the catalytic action of alcohol dehydrogenase (ADH). This is a reversible oxidation-reduction reaction.

CH_3—C—H + NADH + H^+ → CH_3 –CH_2OH + NAD+ O-

‖

O

(Alcohol) (Acetaldehyde)

The conversion of glucose into ethanol is known as alcohol fermentation. Thus, ethanol and CO_2 instead of lactate is the end product of this process.

The net equation for alcohol fermentation would be;

Glucose + 2Pi + 2ADP $\longrightarrow$ 2Ethanol + $2CO_2$ + 2ATP + $2H_2O$

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Experimental Sites

The experiment was conducted at Wolikite University College of Engineering and Technology in Food Process Engineering Laboratory.

3. 2 Experimental Materials

The raw materials finger millet, brewing yeast and malt barely were collected from local market while hop pellet was found in processed form in Food Process Engineering Laboratory.

3.3 Experimental Design

3.3.1. Experimental designs

Table1. Experimental Design

Types	**Mashing Temperature ^oC**		
	T_1 (65)	T_2 (75)	T_3 (85)
Finger Millet	FT_1	FT_2	FT_3
Local Barely (Control)		T=75	

Note:

Whereas: F: Finger Millet and T: Mashing Temperature (Ault,. *et al*; 1971).

Experimental Frame Work

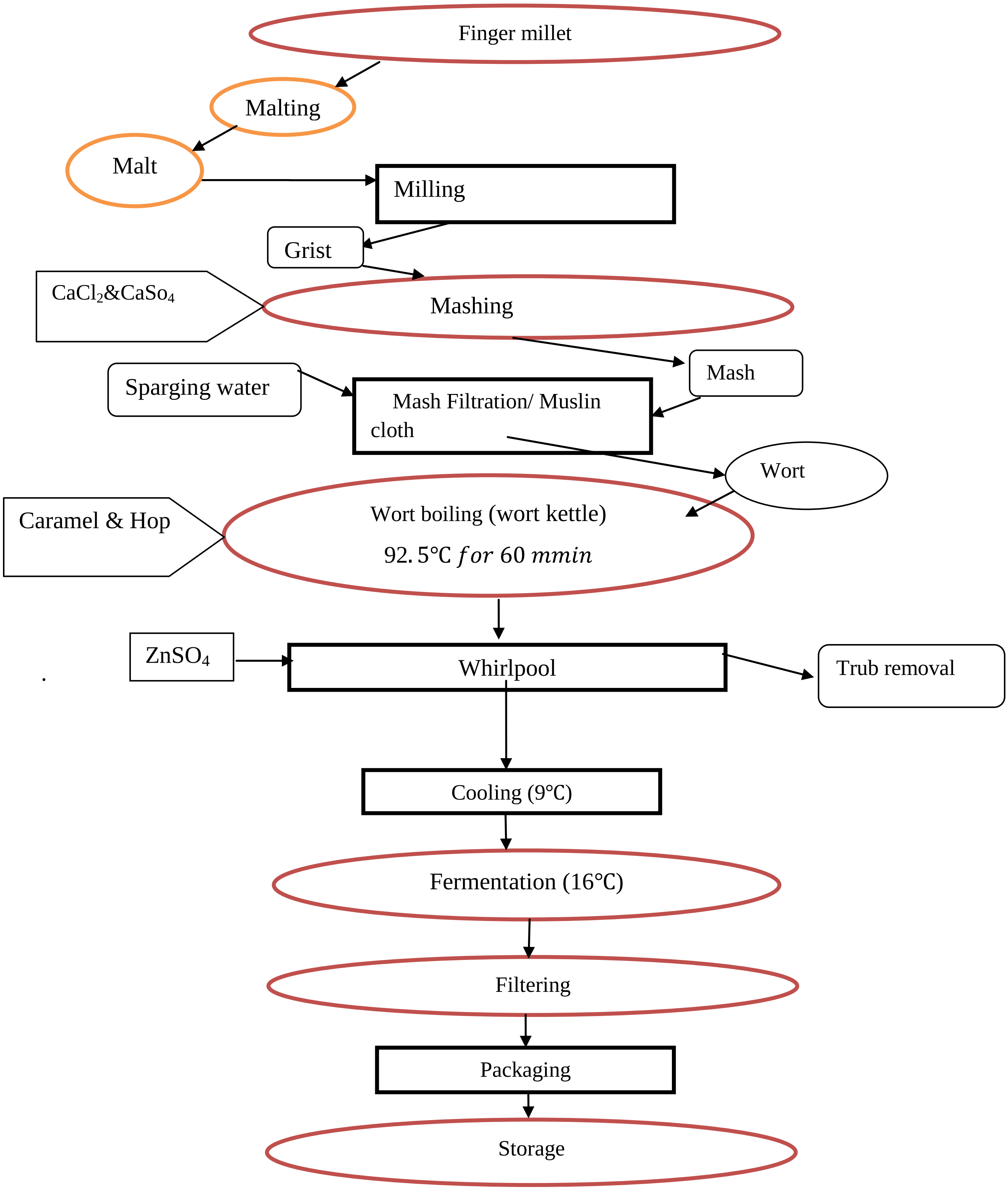

Figure 1 Process Flow Diagram of Beer Production from Finger Millet

3.4. Methods

3.4.1. Physic-chemical Analysis of Wort

3.4.1.1. Specific gravity

The specific gravities were determined using indirect method by mathematical calculation. 500 ml of sample from each treatment was filled in a 500ml of beaker and measured using digital balance. Then the specific gravity was determined from the density of the sample and density of water; by taking density of water at 25 ^{o}C to be 0.99825gm/cm^3 (Sprit indication Method).

$$DM=\frac{\text{Mass of material}}{\text{volume of material}}$$

$$SG=\frac{\text{density of material}}{\text{density of water}}$$

3.4.1.2. pH Determination

The pH was determined using pH meter which was calibrated using buffer solution of pH 4. Then the pH meter electrode was immersed into the beaker containing the sample. The electrode was rinsed with distilled water after each pH measurement (EBC, 1998).

3.4.1.3. Color

Color measurement was done based on European Brewery Convention method (1998) using the spectrophotometer. The digital spectrophotometer was set at 430nm wavelength. Blank test was first done with distilled water and used to adjust the absorbance to 0.000. After rinsing the 10mm cuvette with the bright malt wort, the absorbance of the samples was determined.

3.4.2. Physico-Chemical Analysis of Finished Product

The pH, color, gravity (OG), tiritable acidity were measured using the European Brewing Convention method (EBC, 1998) while the specific gravity (SG) and alcohol were determined using sprit indication method

3.4.2.1. Tiritable Acidity

Five ml of the sample was pipetted into a conical flask from each treatment and titrated against 0.1N NaOH solution using phenopeitalin as an indicator. The end point is read at pH 7.1 and the predominant acid, citric acid, is calculated as follows: -

$$\text{Acidity} = \frac{\textbf{Titre volume} * \textbf{MNaoH} * \textbf{0.064}}{\textbf{volume of sample}}$$

3.4.2.2.Alcohol content

500 ml of final beer from each treatment was boiled until its volume is down to about half of the original volume. Then cold distilled water was added to make boiled down sample to its initial volume. After cooling the sample to 20^{O}C the alcohol content was determined.

$$\text{Spirit Indication } = SG1 - SG2 \, * 1000$$

Where

SG_1 Initial specific

SG_2 Final specific gravity

3.4.2.3.Original Gravity

Original gravity of beer was analyzed by measuring the TSS of filtered beer.

$$\textbf{TSS} = 263.3 \left(1 - \frac{1}{SG} \right)$$ where , TSS = total soluble solid

$$\textbf{OG} = 259 - \frac{259}{SG}$$ OG = original gravity

SG= specific gravity

3.4.3. Sensory Analysis

The sensory analysis was conducted using 10 panelists. The panelists were asked to evaluate the sensory attributes (color, flavor, bitterness, and overall acceptability) of samples on a 9-point hedonic scale from 1(Extremely dislike) to 9 (Extremely like).

3.5. Data Analysis

All data was analyzed by using Analysis of variance (ANOVA) Statically Analysis of softer ware (SAS) for window version 9.0. Fisher's Least Significance Difference (LSD) was used to identify significant differences among mean main effects at ($P<0.05$) level of significance.

CHPTER FOUR

4. RESULT AND DISCUSTION

4.1. Physico Chemical Analysis of Wort

The wort quality analysis were main important for suitable fermentation process and final beer quality it was conducted PH, SG, OG and color.

Table 2 Physico-chemical Analysis of Wort Result

Treatment	Color (EBC)	SG	OG	pH
FT_1	9.190±0.231[a]	1.021±0.01[a]	14.66±0 [b]	5.4166±0.021 [b]
FT_2	14.057±0.211[a]	1.033±0.02[a]	12.400±0 [c]	5.0493±0.0164 [c]
FT_3	12.400±0.468 [a]	1.018±0.010 [a]	15.1200±0 [a]	5.573±0.0404 [a]
Control	12.790±5.381 [a]	1.0133±0.0115 [a]	10.20±0 [d]	5.610±0.020 [a]
CV	22.341	1.085	0.483	1.6112
LSD	5.093	0.0209	0.049	$4E^{-8}$

4.1.1. Colour

Colour values were obtained from boiling of the wort for finger millet wort and the control samples in comparison reference color is best than our treatment wort colours, ranging between 4.25- 5.65 EBC Johnson, (1991) our sample color result 9 to 14. The Millard's reaction is the principal cause of colouring during wort boiling (O‟R ourke, 2002).The reducing sugars and α-amino acids present are the key factors for this reaction. Melanoidins, which are polymerized products of reductions, give rise to the colour (O‟R ourke, 2002). Amino acid levels in the barley substituted samples could be higher than that from finger millet. On the different sample there is no a significant difference.

4.1.2. pH

PH is very important during mashing since mashing is entirely an enzymatic process and therefore it plays an important role. (Fiseha. M 2014) it was interesting pH of wort 5.4 to 6.1 to our sample range 5.04 to 5.5 it less than reference because during wort processing and boiling not used chemical for pH calibrated. To note that the mash pH of finger millet was within the range (5.39-6.09), which fall within the required mash pH 5.6, even though 6.09 is slightly on the higher side. Temperature and pH is correlation on the wort (O‟R ourke, 2002). pH of wort lower and higher it affects the fermentation of yeast pH of the wort main important for fermentation activity and final beer quality based on shelf life. The control wort pH higher than finger millet wort control pH 5.61 and the finger millet 5.42 on the different treatment there is a significant difference.

4.1.3. Specific gravity (SG)

Specific gravity of the wort greater than final fermented beer this specific gravity is level of sugar for fermentation process (Palmer, 1989). (O.H. Raji et al., 2014) refer result 1.069 to 1.056 our sample range 1.021 to 1.01 between two results not difference. On the sample code there is not a significant difference from our product of finger millet to control. Specific gravities obtained for wort from finger millet starch grist were generally higher than that with barely .This suggests that a higher extract yield was obtained for finger millet–starch wort during mashing than for barely. This may be due to the fact that finger millet gave a higher Carbohydrate (78-80%) level than that of barely (77.93%) as shown in the results of the proximate Analysis (Yenagi *et al*., 2010).

4.2. Physico-chemical Analysis on Finished Beer

Table 3 Physico-Chemical Analysis on Finished beer Result

Treatment	Color (EBC)	SG	OG	PH	Acidity	A/C (%)
F1T1	7.44±0 ^{a}	0.97±0.021 ^{b}	8.94±0.058^{b}	4.34±0.04^{b}	0.003±0.002^{a}	5.37±0.32^{d}
F1T2	11.75±0 ^{a}	1.003±0.005^{a}	9.960±0 ^{a}	4.240±0.03^{c}	0.005±0.004^{a}	8.53±0.31^{b}
F1T3	10.4±0 ^{b}	1.0007±0.001^{a}	7.540±0 ^{c}	4.314±0.03^{b}	0.004±0.01^{a}	7.28±0.21^{c}
Control	10.79±0 ^{b}	1.001±0.001 ^{a}	7.05±0 ^{d}	4.482±0.01 ^{a}	0.012±0.02^{a}	10.13±0.32^{a}
CV	0	1.104	0.801	0.344	1.367	3.744
LSD	0	0.0207	0.065	0.0544	0.0157	0.552

4.2.1. Colour

Colour is one measurement of beer quality by using digital spectrophotometer EBC the range of colour standard of 4.26 and 5.61. Johnson, (1991). (Abdel MooneimE.Sulieman et al., 2017) 7 to 11 colour value less than finger millet beer colour. This result of the colour higher than standard range by lack of filtration our beer was filtered by muslin cloth. However other impact of the Millard reaction. The Millard's reaction is the principal cause of colouring during wort boiling (O‟R ourke, 2002).The reducing sugars and α-amino acids present are the key factors for this reaction. Composition of finger millet do not characteristic of brightness and golden colour obtained. Due to different treatment code there is significance difference between samples shows (Table 4).

4.2.2. Specific Gravity of Final Beer

Specific gravity of final beer was measured on first step of after fermentation it was very low compared to initial value of wort our sample specific gravity had fulfill standard of range it may high yeast performance activity on the fermentation1.0043 to 1.002 refer result 1.024 to 1.022 (Fiseha. M, 2014). Best specific gravity was conduct the starting level of fermentable sugars was finished on fermentation time and our product fermentation time one week. The specific gravity at the end of fermentation lower than wort gravity it gives a mouth feel of final beer (O‟Rourke, 2002).at the end of fermentation was obtained high value of specific gravity may low yeast activity. Sample code FT_1 and other sample there is significance difference was show (Table 4).

4.2.3. Original Gravity

Original gravity was calculated extracts sugar from a fermented beer which gives an idea of the initial level of sugar prior to the started day of fermentation. (Abdel MooneimE.Sulieman et al., 2017) original gravity range 1.026 to 1.025 our treatment result 12 to 15 between under result significant difference because of reference sample contain low amount of sugar it means nonalcoholic beverage. The original gravity is not equal to specific gravity. O‟R ourke (1984). The lower value of original gravity due to that reasons the first one is formation of certain acidity and alcohol produced. Our product high extracted level than control on fermentation. Due to different sample treatment code is there is significance difference between the sample it show the (table 4).

4.2.4. pH

PH of final yield beer were standard range (4.26 and 4.25) for millet and barely starch. Our final sample beer PH range was 4.3 and 4.2 (Ishrat Bano *et al*., 2015) It was interesting pH of wort 3.8 to 4.7 than reference because during wort processing and boiling not used chemical for pH and less fermentation time used. They may full fill the range, however the pH high and low it was affected final beer quality and it gives a mouth feel of final beer (O‟Rourke, 2002). Due PH during each sample there is a significance difference between sample show (Table 4).

4.2.5. Alcohol content

Alcohol content is a major end product of fermentation it was the end of byproduct of glycolytic activity of wort fermentation (Jain *et al.*, 2007). (Ishrat Bano *et al*., 2015). Result of alcohol 4.45 to 11.55 our sample 5.3 to 10.1 our sample less than literature value because of we used less fermentation time one weak than under literature two weak. Control sample greeter than our sample alcohol content level. The alcohol content level of final beer is amount of remain level of fermented and unfermented sugared and also the activity of yeast. Due to each sample there is significance difference between control sample and our sample it show in (Table 4).

4.2.6. Tiritable Acidity

Acidity determines presence of organic acid and carbonic acid in beer likes lactic, sulfuric acetic and malic mainly present in finger millet beer tannin acid it character of high amylase activity which lead a high alcohol concentration and also positive and negative ion of NaOH. (Fiseha .M. 2014) total acidity =0.0032 to 0.0052 our sample range 0.56 to 0.59. Our product low contents of organic acid because of used fermentation time less than literature and pH low acidity high our product high.

4.3. Sensory Analysis and Evaluation of Finger Millet Beer

Table 4 **Sensory Analysis and Evaluation of Finger Millet Beer Result**

Treatment	Color	Flavor	Bitterness	Aroma	Taste	OA
F1T1	7.40 ± 0.53^{a}	7.20 ± 0.26^{a}	6.28 ± 0.38^{a}	6.00 ± 0^{ba}	6.43 ± 0.40^{a}	6.90 ± 0.30^{ba}
F1T2	6.58 ± 0.12^{b}	6.28 ± 0.21^{b}	6.33 ± 0.31^{a}	6.43 ± 0.68^{ba}	6.83 ± 0.15^{a}	6.47 ± 0.42^{b}
F1T3	7.00 ± 0^{ba}	7.30 ± 0.44^{a}	6.73 ± 0.15^{a}	6.73 ± 0.30^{a}	6.50 ± 0.20^{a}	7.03 ± 0.06^{a}
Control	7.48 ± 0.451^{a}	6.98 ± 0.64^{ba}	6.60 ± 0.26^{a}	5.78 ± 0.68^{b}	6.58 ± 0.51^{a}	7.10 ± 0.10^{a}
CV	4.96	6.105	4.43	8.101	5.316	3.825
LSD	0.664	0.797	0.541	0.950	0.659	0.495

The sample sensory acceptability was analyzed used uptrend panelists. The scale were: like extremely =9 =8 , like very much =7, like moderately =6, like slightly =5 neither like nor dis like =4, dis like slightly =3, dis like moderately =2, dis like very much =1,dis like extremely. Main beer quality parameter is color, bitterness and test because beer was characterized by under parameters. The final beer color best it customer acceptability increase the same as other parameter. The non-trend panelist over all acceptability high both code FT_3 and control sample 7.03 and 7.10. There is a significance difference between samples.

CHAPTER FIVE

5. CONCLUSION AND RECOMRNDATION

5.1CONCLUSIONS

Beers are widely consumed throughout the world Standardization of the parameters for malting and mashing was also carried out along with optimization of fermentation parameters for good quality beer production. Our investigation was to determined appropriate mashing temperature of finger millet. The mashing temperature of analysis is 65 ^{0}C 75 ^{0}C and 85 ^{0}C however final product best at 75 ^{0}C was mashed based on quality analysis. The beer was found to have a pH of 4.24 an alcohol content of 8.53 percent and the color and brightness of the beer were 7.4 to 10.7 EBC however between each treatment due to alcohol and specific gravity. Based on color FT1 beast and with alcohol control others all most similar Similarly, the control beer was tested for the above mentioned parameters which much different present with that of finger millet beer. From the organoleptic evaluation, it was found that finger millet beer was Comparable with that of control beer except differing slightly in colour, acidity and flavor which can be further improved.

5.2. RECOMMENDATION

Determined the mashing profile of finger millet beer based on temperature, time and PH however on this process danger problem was experienced such electric power, lacked of equipment, supply of material by those problem not gave were expected finding out put. Finger millet having good amount of starch, and fermentable carbohydrates and also other mineral. But the grain was used in traditionally it come to in the industrial production like infant food and biscuit …etc. During the process of undergoing this thesis paper, there had been some constraints and results. From the result of the work carried out, we recommend the following;

1. Color of our product cannot gave completely on the golden brightness it modify the color
2. On this study work was lacked of some quality parameter like polyphenol, bitterness, Co2 and so on. In additional microbial count of final beer for product shelf life.

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APINDIX OF STUD

APINDIX 1 Sensory analysis

Teast

Table 5 sensory analysis

Source	DF	Anova SS	Mean square	F value	Pr>f
Treatment	3	0.277	0.092	0.75	0.551

Bitterness

Source	DF	Anona SS	Mean square	F Value	Pr > F
treatment	3	0.44	0.14	1.76	0.33

Overall acceptability

Source	DF	Sum of Squares	Mean square	F Value	Pr >F
Model	3	0.73	0.24	3.51	0.07
Error	8	0.55	0.07		
Corrected total	11	1.28			

Sensory analysis of chart

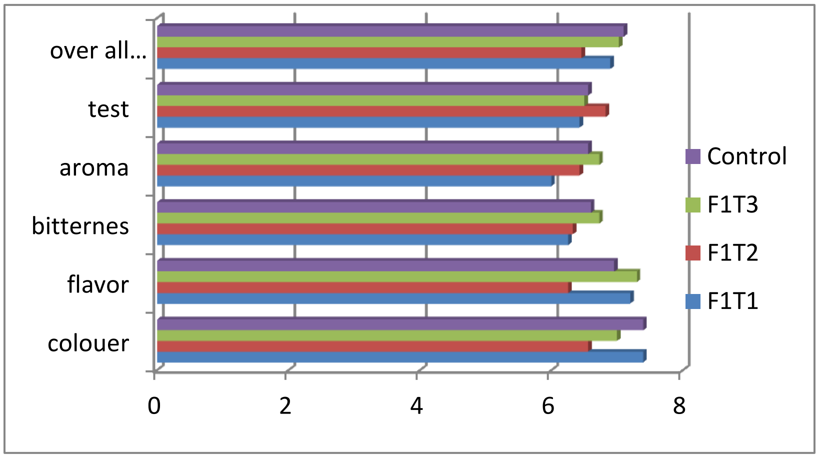

Figure 2 sensory analysis carts

APINDIX 2 WORT ANALYSIS

pH

Table 6

Source	DF	Anova SS	Mean square	F Value	Pr > F
Treatment	3	0.59	0.21	287.59	<.0001

Colour

Source	DF	Anova SS	Mean Square	F value	Pr > F
Treatment	3	38.59	12.86	1.76	0.23

APINDIX 3 FINAL BEER ANALYSIS

PH

Table 7

Source	DF	Anova SS	Mean Square	F value	Pr > f
Treatment	3	0.092	0.031	25.57	0.0002

Acidity

Source	DF	Anova SS	Mean Square	F Value	Pr > F
Treatment	3	0.00012	0.0005	0.73	0.57

APINDIX 5 SPECIFIC GRAVITY and ORGINAL GRAVITY on MATMATICAL

TSS= 263.3 $\left(1 - \frac{1}{SG}\right)$ where, TSS =total soluble solid

OG =259 $- \frac{259}{SG}$ OG = original gravity

SG= specific gravity

$SG = \frac{\text{density of material}}{\text{density of water}} =$ where; SG = Specific gravity

DM = Density of material

$DM = \frac{\text{Mass of material}}{\text{volume of material}}$

APINDIX 6 FIG URE OF PRODUCT BY DIFFERENT TEMPERATURE

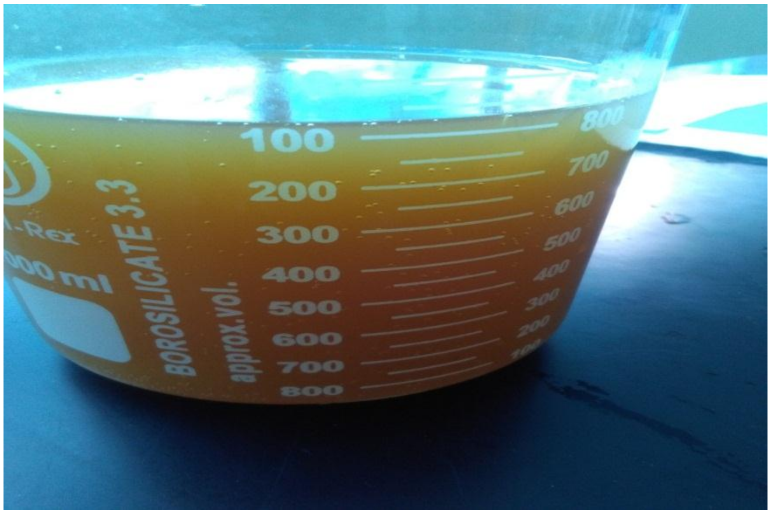

Fig. 3 during filtration beer

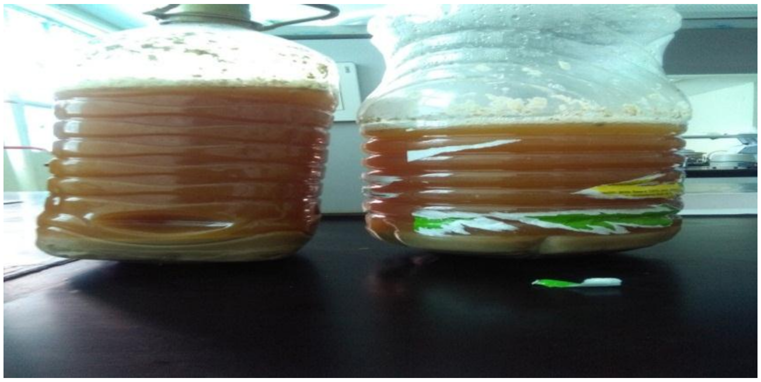

Fig. 4 during fermentation

Figure. 5 Final beer


F1T1