Development of the Process for Banana Beer by Innovative Approach with Process Optimization

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Abstract

Jalgaon is the largest banana producing city in the world and production of beer from banana may be useful for the local cultivators of banana in terms of value addition to banana and their preservation. The present work was therefore undertaken with the aim to develop beer from local variety of banana by innovation in existing method of banana beer preparation with fermentation process optimization. In this work the beer was prepared from banana pulp by dilution with water (1:3)which was subjected to depectinization using pectinase enzyme (0.0003 %) for 6 hr. at 38 ^{0}C. The depectinized banana pulpwas then with mixed barley malt. In this mixture (wort) the hops were added (0.11 %) and subjected to boiling for 60 ^{0}C for 60 min. The said mixture was then subjected to fermentation by adding 0.5 % yeast at 15^{0}C for 72 hrs. At the end of fermentation the mixture was filtered and pasteurized at 60 ^{0}C for 1 min. The various parameters for fermentation was optimized by varying in period of incubation period (1, 2, 3, 4, 5 and 6 days), wort pH (4, 4.5, 5 and 5.5), inoculums size (0.3, 0.5, 0. 7 and 0.9%), temperature of incubation (15, 20, 25 and 30ºC) and brix of wort (10, 12, 14 and 16 ºB). The studied fermentation parameters were optimized on the basis of alcohol produced. The work concluded optimized condition of fermentation for banana beer preparation as fermentation period: 4 days, Wort pH: 5.5, Inoculums Size: 0.7 %, Incubation Temperature: 25 ^{0}C and Wort TSS: 14 ^{0}B.

Keywords: *Beer, fermentation, banana, optimization*

1. Introduction

The word banana came from Arabic word 'banan', meaning finger. Banana is one of the most popular fruit all over the world as high in nutrition (rich in sugar, carbohydrate, vitamins particularly vitamin B, potassium, calcium, magnesium and phosphorus), easy to digest and low price [1]. Banana is perishable fruit and hence to avoid their spoilage bananas are processed and converted into various food products like Banana Jam, Chips, Flour or Powder. Apart from these products, banana can also be utilized to produce beer and wine as banana are high in fermentable sugar and other nutritional content like mineral.

Beer is an alcoholic beverage and alcoholic fermentation of grain is the main process used it's preparation. Beer is brewed from any cereal grain like rice, maize (corn), wheat malted barley etc. Barley is generally used as grain in varieties and types of beer production process. Fruit beer is a kind of beverage in which the fruit is added to enhance the flavor of the beer. So in fruit beer the fruit is added as an adjunct. The standard beer found to contain alcohol (ethanol) from 4 to 8%.

The banana beer may be unique, due to characteristic aroma or flavor. As banana contains enough fermentable sugar (source of good energy for yeast growth), and other nutrients like carbohydrates, proteins, minerals and characterized by excellent attractive flavor or aroma, banana fruit is therefore chosen for beer making in this work. The

another reason for selecting banana as raw material for beer development in this work was that India is the largest producer of Banana in the world and Jalgaon is the banana city of India, producing good quality banana with 66% of Maharashtra state land under *banana* crop. So the development of beer from banana with innovative approach with process optimization may be the kind of value addition to banana and may prove beneficial, particularly farmers or banana grower of Jalgaon.

The main limitation of using banana in making beer is it's high amount of pertinacious material t, which may get converted into methanol. Also the pectin material is highly water absorbent and make juice extraction difficult. Therefore banana needs to be subjected to enzymatic treatment for degrading pectin [2]. The literature review on beer from banana reveled that very less work was carried on the same and hence felt need for giving attention for developing some innovative process for beer making from banana.

The present work was therefore carried out with the aim to develop innovative process for making acceptable quality beer form local variety of banana by optimizing the various fermentation parameters like inoculums sizes, period of incubation, temperature of incubation, wort pH, TSS concentration.

2. Materials and Methods

2.1 Raw material:

The basic raw material for the present work was banana fruit, purchased from local market of Jalgaon, Maharashtra (India). The other raw materials like barley were purchased from the super market, Navjeevan shop, Jalgaon. The chemicals used for analysis were of standard brand. The yeast strain used in this work was a commercial lager brewing strain (*Saccharomyces Cerevisiae NCIM No.3594*) maintained on malt agar slant at 4°C. Malt Extract Glucose Yeast Extract Peptone (MGYP) medium was used for isolation and cultivation of the said yeast strain [3].

2.2 Preparation of Beer [4, 9]

The beer was prepared by innovative method including following steps:

2.2.1 Banana Pulp Preparation

The ripe bananas were first washed with clean tap water, followed by cleaning with de-mineralized water. The bananas were then peeled mashed and pulp was prepared (semi solid in nature) using mixer grinder. Water was added with a ratio of 1:3 dilutions into the prepared pulp (1 part banana pulp + 3 parts water) to attain 12°Bx and pH was checked.

2.2.2 Enzymatic Treatment to Banana Pulp

The enzymatic treatment to banana pulp was given by following method prescribed by P. Dhar (2013). Pectinase enzyme from *Aspergillus niger* was added to the banana pulp 0.0003% (w/v) for depectinization of pectin, incubated for 6 hr. at 38 ^{0}C. Filtration was done by muslin cloth, to extract out non fibrous portion from the liquefied banana pulp and the Brix (°Bx) and pH was checked.

2.2.3 Preparation of Malt

Barley was mixed with water in the ratio 1: 4 and mashed and subjected to step heating (First heating: 50^{0}C for 30 min., Second heating: 65^{0}C for 10 min., 75^{0}C for 20 min.).

2.2.4 Wort Preparation

In this enzyme treated banana pulp was mixed with prepared malt. In the resulted mixture the hops was added (0.11 %) and subjected to boiling for 60 ^{0}C for 60 min.

2.2.5 Fermentation of Wort

In this 0.05 % hops was again added in obtained wort for flavor retention and the pH and TSS of mixture was maintained at 5 and 12 ^{0}B respectively. The said mixture was then subjected to fermentation by adding 0.5 % yeast at 15^{0}C for 72 hrs. At the end of fermentation the mixture was filtered and pasteurized at 60 ^{0}C for 1 min. The pasteurized beer was then cooled and bottled and stored at 4 ^{0}C for further study.

2.3 Optimization of Fermentation Parameter

The various parameters for fermentation was optimized by varying in period of incubation period (1, 2, 3, 4, 5 and 6 days), wort pH (4, 4.5, 5 and 5.5), inoculums size (0.3, 0.5, 0. 7 and 0.9%) (Inoculum size was selected on the basis of total wort), temperature of incubation (15, 20, 25 and 30ºC) and brix of banana juice (10, 12, 14 and 16 ºB), Ethanol content, TSS, pH and acidity were recorded for all the variables on completion of fermentation period. The parameters were optimized on the basis of alcohol yield. The pH of wort is one of the key parameter for the beer fermentation and was important for the reasons as in acidic conditions yeast grows well and acidic solution also retard the growth of harmful bacteria.

Yeast lowers the pH of wort naturally during fermentation by CO_2 production and hence banana juice for different pH ranges from 4 to 5.5 was tested. Yeast is believe to be one of the important contributor to flavor development in beer. The size or level of inoculum is therefore also importance in beer fermentation process. The different levels of yeast inoculum from 0.3 to 0.9 % were therefore used to inoculate the fermentation mixture. Control over temperature for beer fermentation can have a foremost effect on beer flavor. Therefore temperature of fermentation was also optimized by variation in temperature from 15 to 30 ^{0}C.

3. Results and Discussions [10, 11]

3.1 Optimization of Incubation Period for Banana Beer Preparation:

The incubation time standardized for Banana Beer is given in the table 1. The highest level of ethanol was obtained on 4thday (96 hrs.) with ethanol content of 7.13%. Therefore the incubation period for banana beer preparation was optimized as 4 days..

Table 1: Optimization of Incubation Period for Banana Beer Preparation

Days	pH	TSS (°Bx)	Acidity (%)	Ethanol (%)
1	5.03±0.04	12±0.00	0.48±0.00	0
2	4.6±0.01	9.26±0.04	0.49±0.00	1.04±0.04
3	4.3±0.00	6.2±0.00	0.51±0.00	4.32±0.00
4	**3.7±0.46**	**3.1±0.08**	**0.54±0.00**	**7.13±0.05**
5	3.61±0.00	3.06±0.04	0.53±0.00	6.98±0.00
6	3.61±0.01	3.03±0.04	0.52±0.00	6.96±0

(All values are means ± standard deviation (SD) of three determinations)
Process parameters: Wort pH=5, Incubation Temperature =15°C, Size of inoculums= 0.5 %, Wort TSS= 12 ^{0}B

3.2 Effect of pH of wort on Banana Beer Preparation:

The pH of wort optimized for banana beer production is shown in the table 2. The maximum alcohol content (7.41 %) was achieved with pH of 5.5, therefore the pH optimized was 5.5 and maintained in the further study.

Table 3: Optimization of pH of Wort for Beer Making

pH of the Wort	pH	TSS (%)	Acidity (%)	Ethanol (%)
4	4.55±0.03	3.83±0.04	0.68±0.00	6.9±0.00
4.5	3.92±0.01	3.36±0.04	0.6±0.00	7.13±0.03
5	3.60±0.01	3.06±0.04	0.54±0.00	7.32±0.01
5.5	**4.20±0**	**3.26±0.04**	**0.52±0.00**	**7.41±0**

(All values are means ± standard deviation (SD) of triplets determination)
Process parameters: Incubation period: 4 days, Incubation Temperature =15°C, Size of inoculums= 0.5 %, Wort TSS= 12 ^{0}B

3.3 Size of Inoculums on Banana Beer Production

Table 3 is showing the ethanol production for various yeast inoculums size. It can be observed from the table 3 that maximum ethanol production was at 0.7% inoculum size. Further increase in size of yeast inoculums, not favored the ethanol production. It was, therefore, concluded that 0.7% inoculums size was the optimum for beer fermentation under consideration and was selected for the further studies.

Table 3: Effect of Inoculums Size on Banana Beer Production

Inoculum Size (%)	pH	TSS (°Bx)	Acidity (%)	Ethanol (%)
0.3	3.10±0	10.06±0.09	1.14±0.11	2.22±0.03
0.5	3.66±0.01	3.16±0.09	0.53±0.01	7.31±0.01
0.7	**4.12±0.14**	**3.06±0.04**	**0.48±0.00**	**7.83±0.04**
0.9	3.72±0.03	3.83±0.04	0.31±0	6.7±0

(All values are means ± standard deviation (SD) of triplets determination)
Process parameters: Incubation period: 4 days, pH: 5.5, Incubation Temperature =15°C, Juice TSS= 12 ^{0}B

3.4 Optimization of Incubation Temperature

Table 4 is illustrating the result of study of beer fermentation at different levels of temperature.

Table 4: Optimization of Incubation Temperature for Beer Making

Temp. °C	**pH**	**TSS %**	**Acidity**	**Ethanol %**
15	4.11±0.00	8.06±0.04	0.58±0.01	3.34±0.29
20	3.65±0.08	3.1±0.01	0.54±0.00	7.26±0.06
25	4.02±0	2.90±0.04	0.51±0.00	7.6±0.01
30	4.02±0	4.16±0.09	0.62±0.01	5.41±0.01

(All values are means ± standard deviation (SD) of triplets determination)
Process parameters: Incubation period: 4 days, Wort pH: 5.5, Size of inoculums: 0.5 %, Wort TSS: 12 ^{0}B

It can be seen in table 4, as the temperature increased the alcohol production also increased up to 25 ^{0}C. The reason for the same may be the increase in fermentation rate due to the increase in the enzymatic activity of yeast through their metabolic pathway. The maximum ethanol production of 7.6 % was observed for temperature 25 ^{0}C. Further increase in temperature was found to had no positive effect on ethanol production. It may be due to negative effect on important biomolecules or denaturation of enzymes which might had decreased the enzyme activity. It was accomplished from the study that 25 ^{0}C temperature was the appropriate for said beer fermentation and was optimized for the further experiment.

3.5 Effect of Total Soluble Solid of Wort on Banana Beer Production

The effect of total soluble solid of wort on banana beer production is presented in Table 5. It can be seen that initial sugar level had great affected on the rate of fermentation or alcohol production. The increase in ethanol production was observed with increase in total soluble solid up to 14 ^{0}B and then decreased. The use of high sugar supports the high ethanol production as it act as substrate during fermentation. However sugar concentration higher than optimum, may prove inhibitory to alcoholic fermentation due to stress on microbial or yeast cells from osmosis. The TSS of wort was therefore finalized or optimized as 14° Brix for beer fermentation and was used for further study.

Table 5: Effect of Total Soluble Solid (TSS) on Alcohol Content

Brix (%)	pH	TSS (%)	Acidity	Ethanol (%)
10	4.0±0.00	3.16±0.04	0.59±0.00	5.60±0.00
12	3.65±0	3.1±0	0.54±0.00	7.36±0.00
14	3.80±0.01	4.13±0.09	0.52±0.00	8.2±0.01
16	4.22±0.00	4.76±0.04	0.62±0.00	7.6±0.00

(All values are means ± standard deviation (SD) of triplets determination)
Process parameters: Incubation period: 4 days, Wort pH: 5.5, Size of inoculums= 0.5 %, Incubation Temperature: 25 ^{0}C

3.6 Optimized Conditions for Banana Beer Production

The findings of present study states that as the fermentation parameters altered, had impact on the ethanol production during the banana beer fermentation. Following table 6 is showing the various parameters optimized for banana beer fermentation.

Table 6: Parameter Optimized for Banana Beer Production

Parameter of Optimization	Condition Optimized
Incubation Period	4 days
pH of Wort	5.5
Inoculums Size	0.7 %
Incubation Temperature	25 ^{0}C
Wort TSS	14 ^{0}B

The banana beer prepared with the above optimized fermentation condition found to contain alcohol (ethanol) 8.2 %.

4. Conclusion

The work concluded that, it is possible to prepare a banana beer of acceptable quality with slight modification in the existing process of banana beer. The condition of fermentation optimized for banana beer preparation were Incubation Period of 4 days, pH of Wort 5.5, Inoculums Size 0.7 %, Incubation Temperature 25 ^{0}C and Wort TSS of 14 ^{0}B.

5. References

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