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## Development of beer from malted sorghum (*Sorghum bicolor*)

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**Abstract**

Sorghum (*Sorghum bicolor*) is a gluten free, whole grain rich in complex carbohydrates and minerals. Its consumption is limited due to lack of adoption in diversified food products and easy availability of other chief cereals. So study was undertaken to produce Beer using sorghum grain by malting technique. Beer, the complex brewed beverage made from malt (germinated grains), hops, water, and yeast, which provides hydrolytic enzymes (especially amylases) to ferment sugars into ethanol and carbon dioxide. Grain sorghum samples were procured and processed by malting at different periods, then ground into flour and analyzed for Starch, reducing sugar and amylase activity, It ranged from 56.33 to 37.44 percent, 25 to 53.25mg/g, 20.44 to 34.50  $\mu\text{mol}/\text{min}/\text{ml}$ , respectively. The Highest Amylase activity and Reducing sugar was obtained in 72hr germinated sorghum, So Beer was developed using 72hr malted sorghum at different proportion (40%, 60%, and 100%). 100% barley Beer was taken as control. And Chemical parameters such as  $\text{pH}$ , TSS, alcohol, color, and brightness were analyzed, PH ranged from 3.17-4.1, TSS Ranged from 15 to 7 brix, alcohol content ranged from 6.25 to 6.5 per cent. The Highest Alcohol Content Obtained in 60% Incorporated beer. Mean sensory scores revealed that incorporation of malted sorghum flour at 60 per cent is highly accepted viz. appearance, color, aroma, bouquet, flavor, astringency, general quality and overall acceptability. Therefore sorghum is best substitute for barley to develop Shelf Stable beverage to provide commercially viable products that will increase the utilization of sorghum in industrial purposes.

**Keywords:** Sorghum malting, amylase activity, beer production, sensory evaluation

**1. Introduction**

Sorghum (*Sorghum bicolor*) is considered as coarse cereal and is one of the staple cereals for millions of people, particularly in Africa, India and central Asia. Sorghum is small-grained, annual, warm weather cereals belonging to grass family, easily available and cheapest starting raw material for Beer production. They are highly tolerant of extreme weather conditions such as drought and are nutritious compared to the major cereals such as rice, barley and wheat. The major sorghum plantation areas in India are Maharashtra, Karnataka, Uttar Pradesh, and Tamil Nadu. Across world include Australia, Mexico and United States. (Jones, *et al.* 1997)<sup>[3]</sup>.

Beer, the complex brewed beverage made from malt (germinated grains), hops, water, and yeast, which provides hydrolytic enzymes (especially amylases) to ferment sugars into ethanol and carbon Dioxide is widely consumed all over the world. According to the FAO, In 2018, the global beer consumption was 188.79 million kiloliters (equivalent to approximately 298.2 billion 633 ml bottles), with an increase of about 1,540,000 kiloliters, which is equivalent to approximately 2.4 billion 633 ml bottles. In comparison with 2017, there was an annual increase of 0.8%. Beer ranked as the fifth world-consumed beverage, after tea, fizzy drinks, milk and coffee. The consumption of beer is of special interest because of its organoleptic and health-related characteristics and also due to its low cost as compared with other types of Western and European alcoholic beverages, such as wine.

The method employed in brewing sorghum beer involves, malting, mashing, wort boiling with hops, fermentation, (using brewer's yeast) and packaging. The tropical sourced hop extracts used here is aroma flavor and bitterness which has been found to contain an anti-bactericidal agent which is capable of extending the lifespan of these indigenous beers. (Hailu, and Asefa. 2017)<sup>[6]</sup>.

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Hence, by considering the above research work to develop shelf stable beverage using malted sorghum flour to provide commercially viable products that will increase the utilization of sorghum for industrial purposes, in turn helping to raise the living standards of Indian population.

## 2. Materials and Methods

### 2.1 Procurement of sample

Sorghum (*Sorghum bicolor*) was procured from Department of Agronomy, University of Agricultural Science, Gandhi Krishi Vignana Kendra, Bangalore. Other ingredients such as barley, hops, yeast are procured from Arishtam brewer store, Bangalore.

### 2.2 Malting of sorghum

Sorghum grains were soaked in water for 24 hours and the soaked water was changed twice. The soaked grains were germinated for 3 different periods of 24, 48 and 72 hours at room temperature in cotton cloth and then dried in hot air oven at 50°C for 3-4 hours until the moisture content reached 5-6 percent and then sprout portions were manually removed, milled into fine powder and packed in air tight container for further use.

### 2.3 Analysis of malted sorghum Flour

#### 2.3.1 Estimation of Amylase activity by DNSA method

The  $\alpha$ -amylase activity was assayed by 3, 5-dinitrosalicylic acid (DNS) method using 1 percent soluble starch as substrate (Bernfeld, 1955) [1]. One unit of  $\alpha$ -amylase activity was defined as the amount of enzyme required to produce reducing sugar equivalent to 1  $\mu$ mol of maltose per min from soluble starch at 40 °C and pH 6 in 1 ml of enzyme. Enzyme activity was calculated as the follows.

$$\text{Enzyme activity } (\mu\text{mol min}^{-1}\text{ml}^{-1}) = \frac{A \times 1000 \times \text{Dilution}}{M \times T \times VE}$$

A = amount of maltose released (mg) M = molecular weight of maltose (360.32 g mol<sup>-1</sup>) T = incubation time (min) VE = volume of enzyme used (ml)

#### 2.3.2 Estimation of Reducing Sugars by Dinitrosalicylic acid (DNSA) method

The reducing sugar of the sample was estimated by Dinitrosalicylic Acid (DNSA) method (Sadasivam and Manickam., 1991) [10]. Result were expressed as mg/100g of the sample. This involves the conversion of reducing sugar to furfural under alkaline conditions, which reduces one of the nitro group (-NO<sub>2</sub>) of DNSA to amino group (-NH<sub>2</sub>) to produce orange brown color 3-amino-5-nitrosalicylic acid, with absorbance maxima at 540nm

#### 2.3.3 Estimation of Starch by anthrone method

The starch content was estimated by anthrone method (Sadasivam and Manickam. 1991) [10]. Using sulfuric acid, carbohydrates are hydrolyzed into simple sugars. In warm acidic medium, the glucose is dehydrated by hydroxymethyl furfural. The anthrone reagent is used as a color agent that responds with furfural derivatives to make the blue-green complex. The absorption of these compounds is measured by a spectrophotometer at 630 nm and the results were expressed in mg/100g of the sample.

## 2.4. Development of Beer from malted sorghum

Beer were developed from 72hr germinated sorghum flour as its rich in Amylase activity and reducing sugar compared to 24 and 48hr germinated sorghum.

Malting, mashing, boiling, souring, and fermenting, are the general steps of the beer brewing process. Beer were produced using malted sorghum flour at different proportion (40%, 60%, and 100%) with barley, hops and yeast. Using 100% barley Beer as a control. Steps followed for preparation of beer is as follows.

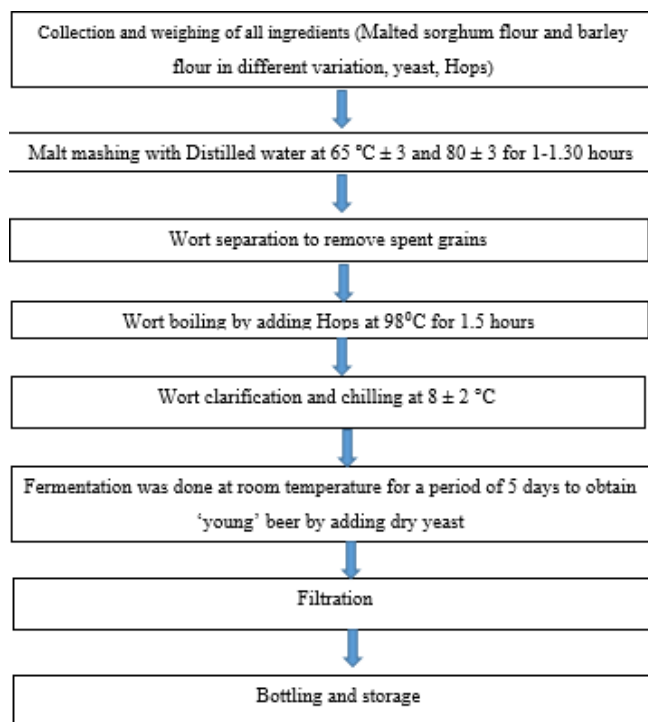


Fig 1: Flow chart for preparation of bread

## 2.5 Sensory evaluation of developed products

Organoleptic evaluation of beer was done in twenty-point hedonic scale by test panel judges mainly for color, appearance, acidity, vinegar, boutique, sweetness, flavor and taste of the product.

## 2.6 Chemical parameters of sorghum beer

Chemical analysis of beer i.e. P<sup>H</sup>, TSS, Color, Brightness and alcohol content was carried out in all the variations in beer preparation, was reviewed by Martinez *et al.*, 2017. And Caputi *et al.*, 1968 [2]. The PH of beer was recorded by using the digital and hand pH meter, Total Soluble Solids (TSS) was determined using hand refractometer having range of 0-32°Brix at 20°C. The ethanol was estimated by colorimetric method using 0.23 N Potassium dichromate solution. The colors and brightness of beer samples were measured using spectrophotometer, after diluting the samples with 1: 1 water, beer samples were measured in 420 nm and 520 nm. The Analysis was carried out in food science and nutrition department, UAS GKVK Bangalore.

## 2.7 Cost estimation of malted Beer

Cost of the best-accepted beer was calculated by considering cost of the raw material purchased from the market, 30 per cent overhead costs which include labor charge, electricity,

machinery, packaging cost, etc. and 15 per cent of profit was added to the production cost, then the total price was calculated for 100ml for beer.

### 2.8 Statistical analysis

Data was analyzed using one-way analysis of variance (ANOVA) was applied on the sensory mean score in order to find the difference between the sensory characteristics of products developed. The statistical analysis was done using SPSS software and Microsoft Excel work sheet. Significant difference was defined as  $p \leq 0.05$ .

### 3. Result and Discussion

Research findings pertaining to Amylase Activity, Starch, Reducing sugar of malted sorghum flour, chemical analysis and sensory evaluation of variation in beer production is presented with following subheadings.

#### 3.1 Malting of Sorghum

Sorghum grain was subjected to different processing technique like soaking for 24 hr, and germination for 24hr, 48hr and 72hr. and drying at 50<sup>o</sup> c for 3-4hr in hot air oven and milled to fine powder. The initial and final weight, before and after the processing of sorghum grain were compared to determine the weight gain or weight loss. Weight loss was observed in drying and milling process of 5 and 7g, except germination which showed significant weight gain of 20g. Sorghum grain showed less percentage recovery in drying and milling due to removal of vegetative growth during milling and reduction of moisture content was one of the reasons for the weight loss.

**Table 1:** Recovery of malted sorghum flour

Parameters	MSF1	MSF2	MSF3
Initial weight of sorghum(g)	100	100	100
Weight of sorghum after germination(g)	120	116	117
Weight of sorghum after drying	95	96	95
Milling loss(g)	7	6.5	7
Recovery of powder after sieving(g)	93	93	93
Per cent recovery (%)	93	93	93

#### 3.2 Amylase activity and reducing sugar of malted sorghum

The Enzyme amylase activity ranged from 20.44 to 34.50  $\mu\text{mol}/\text{min}/\text{ml}$ . The highest amylase activity was obtained in 72hr germinated sorghum (34.50) followed by 48 and 24hr germinated sorghum (31.9 and 20.4  $\mu\text{mol}/\text{min}/\text{ml}$ ). The difference observed in amylase activity was statistically Significant  $P \leq 0.05$ .

Reducing sugar content of malted sorghum varied from 25 to 53.25mg/g. The highest reducing sugar obtained in 72hr germinated sorghum (53.25mg) followed by 48hr and 24hr germinated sorghum (35 and 25.17mg). The difference observed in variation were statistically significant.

Mesta (2018) [9] reported that high amylase activity (1213.23  $\mu\text{g}$  of protein/15 min/g sample) and reducing sugars (28.04 mg/g) was obtained on the third day of germination. These finding are in supportive regarding high amylase activity and reducing sugar obtained in 72hr germinated grain in present research work This difference in value due to the usage of different method and materials for estimation.

**Table 2:** Amylase activity and reducing sugar content of malted sorghum flour

Sorghum samples	Amylase activity( $\mu\text{mol}/\text{min}/\text{ml}$ )	Reducing sugar(mg/g)
MSF1	20.44	25.17
MSF2	31.90	35
MSF3	34.50	53.25
F-Value	*	*
S.Em $\pm$	0.245	0.255
CD at5%	0.848	0.881

\*Significant at 5% MS1-24hr malted sorghum FLOUR, MS2- 48hr malted sorghum flour, MS3- 72hr malted sorghum flour.

#### 3.3 Starch content of malted sorghum flour.

It was observed that starch is converted in to sugar by germination. The starch content ranged from 56.33 to 37.44 per cent. In the malted sorghum flour, the highest starch content was observed in 24hr germinated sorghum (56.33) followed by 48hr and 72hr germinated sorghum (48.42 and 37.44%). The difference observed in starch content was statistically significant  $P \leq 0.05$  at 5 per cent level.

Dicko *et al.* (2006) [4] reported that starch content in germinated and ungerminated sorghum shows decreased in starch content from 66.1 to 55.2% and amylase activity increased from 3.1 to 20 U mg<sup>-1</sup>, which is in accordance with the present study however slight variation due to processing methods was found.

Chavan *et al.* (2015) reported that starch content of 24hr germinated sorghum was 64.5% and in 48hr germinated sorghum it was 55.1 percent, for 48hr germinated sorghum was 43 per cent which are much higher to the values of present study.

**Table 3:** Starch content of variation in malted sorghum

Sorghum Sample	Starch (%)
MSF1	56.33
MSF2	48.42
MSF3	37.44
F-Value	*
S.Em $\pm$	1.053
CD at 5%	3.64

\*Significant at 5% MS1-24hr malted sorghum flour, MS2- 48hr malted sorghum flour, MS3- 72hr malted sorghum flour

#### 3.4 Sensory evaluation of sorghum beer

The mean Sensory scores of beer product is presented in Table 4. Sensory evaluation was done by using 20- point hedonic scale. Sorghum beer the score for appearance ranged from 1.04 to 1.79 out of 2, color ranged from 0.80 to 1.82 out of 2, aroma ranged from 1.29 to 1.91, bouquet ranged from 1.12 to 1.90, vinegar ranged from 1.34 to 1.75, total acidity ranged from 1.29 to 1.70, sweetness ranged from 0.34 to 0.48 out of 1, body ranged from 0.7 to 1, flavor ranged from 1.19 to 1.70, astringency ranged from 1.21 to 1.73, general quality ranged from 1.1 to 1.77 and overall acceptability ranged from 12.50 to 18.45 out of 20. The SB2 had highest score for aroma, bouquet, vinegar, body, flavor, astringency, general quality and overall acceptability whereas appearance and color acceptability was high in SB1. Among three variation of sorghum beer, SB2(60%) scored higher for all sensory characteristics and SB3(100%) scored least.

The difference in all sensory characteristics viz. appearance, color, aroma, bouquet, flavor, astringency, general quality, overall acceptability among the variation was found to be statistically significant at 5 per cent. Except vinegar, sweetness, body, total acidity which was found to be non significant. With respect to overall acceptability, there is a difference in sample variations with respect to color, aroma,

bouquet, flavor, astringency and overall acceptability. Compared to Control, 60% sorghum beer scored higher based on their mouth feel. The results confirm that beer from sweet sorghum cannot totally replace barley beer but the beer was comparable organoleptically with barley beer and was acceptable by panel judges.

**Table 4:** Mean sensory score of sorghum beer from malted sorghum

Variations	Appearance	Color	Aroma	Bouquet	Vinegar	Total acidity	Sweetness	Body	Flavor	Astringency	General quality	Overall acceptability
Scores	2	2	2	2	2	2	1	1	2	2	2	20
BB	1.42	1.46	1.48	1.41	1.39	1.42	0.48	0.79	1.45	1.73	1.53	15.50
SB1	1.79	1.82	1.46	1.45	1.29	1.43	0.44	0.85	1.32	1.40	1.55	16.10
SB2	1.61	1.8	1.91	1.90	1.75	1.70	0.46	1	1.70	1.76	1.77	18.45
SB3	1.04	0.80	1.29	1.12	1.34	1.29	0.34	0.80	1.19	1.21	1.10	12.50
F-Value	*	*	*	*	NS	NS	NS	NS	*	*	*	*
S.Em± (0.05)	0.122	0.106	0.104	0.116	0.136	0.141	0.079	0.080	0.125	0.120	0.107	0.663
CD Value	0.349	0.304	0.298	0.333	0.389	0.405	0.228	0.229	0.359	0.343	0.308	1.901

#### 4. Chemical parameters of sorghum beer in comparison with barley beer

Chemical parameters such as P<sup>H</sup>, TSS, alcohol, color, and brightness of the fermented beer were analyzed and the results are depicted in Table 5.

##### 4.1 pH

There was a fall in the pH from 5.00 to 3.1 at the end of fermentation in sorghum beer. The pH of the beer ranged from 3.17 to 4.1. The pH of barley beer was 4.1. In sorghum beer, SB3 had very low pH (3.17), compared to SB1 and SB2 (4.1 and 4.03). The difference observed in P<sup>H</sup> was statistically significant ( $P \leq 0.05$ ) among variations.

##### 4.2 TSS(Brix)

There was a reduction in the TSS (Total soluble solid) content in beer after fermentation by conversion of sugar in to alcohol ranged from 15 to 7 brix in sorghum beer. SB3 has very low

TSS content (7.01brix) followed by SB1 and SB2(12.17brix). The difference observed in TSS was statistically significant ( $P \leq 0.05$ ) among variations.

##### 4.3 Alcohol (per cent)

The alcohol content of sorghum beer ranged from 6.25 to 6.5 per cent. The highest alcohol content was found in SB2 and SB3(6.45%) followed by SB1(6.39). The difference observed in alcohol content was statistically significant at 5% level.

##### 4.4 Colour and brightness

The beer prepared from the sorghum and barley recorded a colour intensity ranging from 0.6 to 1.7 (optical density at 420 nm) and brightness ranged from 1 to 2.45 (optical density at 420 + 520 nm). The highest colour and brightness was found in barley beer (1.7 and 2.45) followed by SB1(1.45 and 1.91) and the least was found in Sample SB3(0.6 and 1) respectively.

**Table 5:** Chemical parameter of Sorghum beer in comparison with barley beer

Product Variations	PH	TSS (Brix)	Alcohol (%)	Color (optical density)	Brightness (optical density)
BB	4.1	10.33	6.27	1.71	2.45
SB1	4.03	13.17	6.39	1.45	1.91
SB2	4.0	12.17	6.4	1.43	2.11
SB3	3.17	7.1	6.45	0.6	1
F-Value	*	*	*	*	*
S.Em±	0.085	0.220	0.006	0.004	0.004
CD at 5%	0.277	0.719	0.018	0.013	0.013

\*significant, BB- Barley beer, SB1- 40% sorghum beer, SB2- 60% Sorghum beer, SB3- 100% Sorghum beer.

#### 5. Cost of production for the developed products

Table 6 depicts the cost calculation for the best accepted products made out of malted sorghum flour for 100 g. Cost was calculated taking into consideration the cost of ingredients from local market, and 30 per cent overhead

charges, Fifteen per cent profit was added to the production cost. The cost of production for Sorghum beer ie. Rs 62, Cost of Beer were less than that of the products available in the market with extended nutrient content.

**Table 6:** Production cost of sorghum beer

Sl. No.	Ingredients	Amount (Rs)	Quantity	Cost (Rs)
1	Sorghum(g)	40/kg	60	2.4
2	Barley(g)	55/kg	40	2.2
3	Hops(g)	208/25g	1.5	12.48
4	Yeast(g)	246/5g	0.5	24.6
5	Water(ml)	20/lit	1000ml	20
Overhead charges @ 30			Cost of production	
Malted sorghum beer(Rs)			72	

## 6. Conclusion

Sorghum grain has good nutritional value but its utilization is limited due to its grittiness and high fiber coating interfering with protein and starch digestibility. Malting is one of the processing method help to increase the amylase activity and reducing sugar for brewing purpose, Hence the study was conducted to develop a Beer from Malted sorghum flour, Beer was produced using malted sorghum flour at different proportion (40%, 60%, and 100%) with barley, hops and yeast. Using 100% barley Beer as control. With respect to overall acceptability, there is a difference in sample variations with respect to color, aroma, bouquet, flavor, astringency and overall acceptability. Compared to Control, 60% sorghum beer scored higher based on their mouth feel. From the organoleptic evaluation, it was found that sorghum beer was comparable with that of commercial beer except differing slightly color, acidity and flavor which can be further improved. Thus, grains of sorghum can be used for commercial beer production as an alternate to barley. Production of beer from sorghum is feasible from the economic point of view. That will increase the utilization of sorghum for food and industrial purposes, in turn helping to raise the living standards of Indian population.

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