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Production of Wine from Ginger and Indian Gooseberry and A Comparative Study of Them over Commercial Wine

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Abstract: Wine is one of the functional fermented foods that have many health benefits. Commercially, wine is produced by the fermentation of yeast which involves the conversion of sugar to alcohol. Wine can act as a nutrient supplement for seasonal fruits and vegetables throughout the year. Using fruits and vegetables having medicinal and nutritional value as a substrate for wine production, the health benefits of them can be improved widely. Ginger and Indian gooseberry, which are known for its high medicinal and nutritional value are used as the substrate here. Fermentation is carried out with Saccharomyces cerevisiae commonly known as bakers yeast. Daily monitoring was done to study the composition and characteristics of the wine. The wine produced resembled the commercial wine in terms of its composition, taste and aroma. During the fermentation period the wines were analyzed for pH, titratable acidity, specific gravity, biomass content, alcohol and reducing sugar on a daily basis. pH show a decreased trend then attains minima and then increased. As the fermentation days proceed, the specific gravity increased and the alcohol percentage increased gradually. Batch 1 Amla (A1) showed a pH range of 3.79-3.56, specific gravity ranges from 1.09 -1.17 and alcohol content was 10.5%. Batch 2 Amla (A2) showed a pH range of 3.81-3.30, specific gravity ranges from 1.09 -1.167 and alcohol content was 10.35%. Batch 3 Amla (A3) showed a pH range of 3.83-3.34, specific gravity ranges from 1.032 -1.0967and alcohol content was 8.64%. Batch 1 ginger (G1) showed a pH range of 3.77 -3.59, specific gravity ranges from 1.11 -1.178 and alcohol content was 7.94%. Batch 2 ginger (G2) showed a pH range of 3.89 -3.94, specific gravity ranges from 1.116 -1.162 and alcohol content was 6.81 %. Batch 3 ginger (G3) showed a pH range of 4.42 -4.01, specific gravity ranges from 1.144 -1.188 and alcohol content was 5.81%.

After the fermentation period parameters such as Tannin content, Phenol content, Free and Total SO_2, Alcohol content, Total Suspended Solids (^{o}Brix), pH, Titratable Acidity and Specific Gravity were analyzed. These parameters were compared with that of commercial wine. The tannin content of the 3 batches of amla and ginger wine ranges between 3.1 to 0.4mg/100ml but the commercial wine contain only 0.28mg/ml. When comparing phenol content, the commercial wine showed a value of 0.20mg/ml but the 3 batches of wine had a higher range of 0.7 to 0.9mg/ml. The total suspended solids of the amla and ginger wines were between 43 to 45^{o}brix. But for commercial wine the TSS was 32.23^{o}brix. The pH showed a different trend. pH of amla is between 3.3 and 3.5 but for ginger it ranges from 3.7 and for commercial its 3.56 which is relatively higher than amla. The specific gravity is lower for the 3 batches of amla and ginger wine which ranges from 1.2 to 1.21 but 1.24 is the specific gravity of commercial wine. The titrable acidity showed for ginger wine is 2 to 3.5mg/ml but for amla it is 8.9 to 5.5mg/ml. the commercial wine had a value higher than ginger i.e., 4.2mg/ml. Thus the studies showed that the pH (except ginger), specific gravity and alcohol content were higher for commercial wine. But the phenol, tannin content and total suspended solids is higher for homemade wine. By comparing the titratable acidity with commercial wine, ginger wine showed lower value.

Keywords: *ginger, amla, wine, product, substrate, biomass*

I. INTRODUCTION

Home winemaking is an enjoyable, educational and satisfying hobby. Winemaking recipes make the process easy and simple instructions ensure success. The basic steps are easy to learn and practice. The traditional homemade wine base ingredient is the grape because it naturally contains the correct mix of sugar, moisture, tannin, and nutrients required for fermentation and preservation, and it even carries its own yeast. But

in truth, wine can be made from almost any non-toxic plant or plant part if additional ingredients are supplied in the correct amount. So the process of making wines from various types of fruits, vegetables and spices is no more complicated than making wine from grapes and it is a good preservation method. It needs extra preparation steps and some adjustments in sugar content, acid levels etc. Fermentation can extract valuable components from the raw materials used for production. Yeast is the magical ingredient that turns fruit juices into wine. In spontaneous fermentations, the 1st stages invariably being dominated by the alcohol-tolerant strains of Saccharomyces cerevisiae. This species is universally known as the `wine yeast' and is widely preferred for initiating wine fermentations. The alcohol content of home-made wines is only about 7-8% which makes it consumable for persons of any age group. Though ginger wine contains small amounts of alcohol, it is not harmful, but health-giving, digestible, and stimulates the release of the hormone gastrin, which in turns stimulates the release of enzymes in the stomach. Thus, wine stimulates the release of digestive enzymes, which digest not only the alcohol but the many other nutrients found in wine. The proper dosage, or a moderate intake of wine, in addition to affecting cholesterol levels favourably, decreases the tendency of blood to clot and assists in dissolving clots, all important factors in protecting against heart disease. Research also indicates that moderate wine drinking may reduce the tendency of arteries to constrict during stress, lower blood pressure, and increase coronary artery diameter and blood flow. More recently, wine has been identified as a dependable source of quercetin, a potent anti-carcinogen, and of many flavonoids and other polyphenolic antioxidants.
Considering the importance and medicinal value of wine from some special raw materials, it was very interesting to conduct the production of wine in a batch reactor setup in the laboratory. We selected Indian Gooseberry and Ginger for our study. Indian gooseberry (Emblicaofficinalis Gaertn.), is one of the useful fruit. It is consumed as a fresh fruit or in the form of food products like preserve. The fruit also forms an important constituent of many Ayurvedic preparations such aschyvanprashand triphala and is regarded as “one of the best rejuvenating” herbs preparation of wine using the fruits of amla would be useful for imparting healthful properties to the wine. Ginger which act as a useful food preservative is a tuber that is consumed whole as a delicacy, medicine, or spice. It is the rhizome of the plant Zingiberofficinale.

II. MATERIALS AND METHODS

Winemaking, or vinification, is the production of wine, starting with selection of different fruits and ending with bottling the finished wine. We had developed a batch reactor in our lab for wine production as shown in the fig 2 and 3.

Fig.2: Ginger Wine

Fig.3: Amla Wine

The picking of the fruits and spices is the first step in wine production. Crushing is the process of gently squeezing the fruits and spices and breaking the skins to start to liberate the contents. In our project, ginger is grinded and amla is used as it is. To start primary fermentation yeast is added. During this fermentation, which often takes between one and two weeks, the yeast converts most of the sugars in the fruits into ethanol (alcohol) and carbon dioxide. In our case, ginger takes about 14 days and amla about 21 days. Filtration in winemaking is used to accomplish the objective of clarification. In clarification, large particles that affect the visual appearance of the wine are removed.

4.2 Daily Monitoring

pH was measured using digital pH meter. The total sugars were estimated in terms of glucose by Nelson Somogyi method. Estimation of titratable acids was done by titrimeteric method using 0.1N NaOH in terms of tartaric acid. Biomass was determined by dry weight method in g/ml. Alcohol percentage was calculated using specific gravity method. Specific gravity was also determined.

4.3 Final Analysis of Wine

Tannin content was estimated by Folins – Denis method in mg/100ml. Phenol content was determined by Folins Lowry method in mg/100ml. Free and total SO_2 was done by Ripper method in g/L. Total suspended solids was calculated in Degree Brix. Final analysis of all parameters such as pH, alcohol content specific gravity, sugar content, titratable acidity, and biomass were conducted using the methods described in daily analysis.

4.4 Analysis of Commercial Wine and Its Comparison

Estimate parameters such as pH, alcohol content specific gravity, sugar content, titratable acidity, biomass, tannin content, phenol content, free and total SO_2 and total suspended solids of the commercially available wine were conducted. The parameters of the homemade wine were compared with that of the commercially available wine.

III. RESULTS AND DISCUSSIONS

Production of wine from ginger and Gooseberry conducted in the lab in batch reactor set up. Process monitoring and final analysis of homemade wine has been conducted. Various parameters such as pH, Titratable acidity, biomass concentration, etc of homemade wine was determined. Experiments were conducted and results are given in tables 1 to 6 and figures 4 to 33. Final analysis of prepared wine and commercial wine was also conducted. Results are shown in Tables. The 1st batch ginger and amla wine samples were denoted as G1 and A1 respectively, similarly for 2nd batch G2 and A2 and for 3rd batch G3 and A3.

5.1 Process Monitoring (Daily)

Daily analysis of homemade wine (fermented medium) has been conducted. Various parameters such as pH, Titratable acidity, specific gravity, alcohol content, sugar concentration, biomass concentration, etc of each batch were determined day by day during the course of fermentation. Results are shown in tables 1-6 and shown in figures 4-33.

Parameters monitored during fermentation period:

- Variation in pH
- Sugar concentration
- Specific gravity
- Alcohol percentage
- Biomass
- Titratable acidity

Daily monitoring of G1, G2 and G3 were shown in tables – 4, 5, 6. And that of A1, A2 and A3 are shown in tables – 1, 2 and 3.

5.1.1 pH

Variation in pH in the fermentation medium during the course of process was as shown in the figure. pH showed a decrease trend then attains minima then increases. The initial pH of G1 was 3.77 which decrease to 3.41 on the 8th day and increased to 3.59 on 14th day. For G2, the pH started from 3.89 and decreased to 3.63 on 5th day and attains a steady value 3.94 on 18th day.On the 1st day the pH was4.4 for G3 and then it decreased to 3.79 on 7th day and increased to 4.01 on 13th day (fig: 19, 24 and 29).

In case of A1, pH was 3.79 on 1st day which decreased to 3.25 on 12th day and showed an increment to 3.56 on 24th day. pH for A2 on 2nd day was 3.81 and showed a trend to decrease to 3.16 then increased to 3.33 on 22nd day.3.83 was the starting pH of A3 which decreased to 3.16 on 12th day and then increased to 3.34 on 21st day (fig: 4, 9 and 14).

5.1.2 Substrate (Sugar) concentration

The sugar concentration of different wine samples – G1, G2, G3, A1, A2 and A3 has been obtained. As the figure shows, the sugar concentration of wine decreases as the fermentation days passed because of the utilization of substrate. The sugar concentration lies between 25 mg/100ml to 10mg/100ml.

In case of G1, the initial sugar concentration was 23.01mg/100ml which decreased to 11.63mg/100ml on 14th day. Sugar concentration for G2 on 2nd day was 24.81mg/100ml and shows a trend to decrease to 10mg/100ml on 18nd day.24.44mg/100ml was the starting sugar concentration of G3 which decreased to 12.4mg/100ml on 13th day (fig: 23, 28 and 33). Initial sugar concentration of A1 was 21.78mg/100ml which decreased to 9.29 on the 24th day. For A2, the sugar concentration started from 26.00mg/100ml and decreased to 12.82mg/100ml on 22nd day. On the 1st day the sugar concentration was 22.30mg/100ml for A3 and then it decreased to 11.4mg/100ml on 21st day (fig: 5, 13 and 18).

5.1.3 Specific gravity

Estimation of specific gravity of G1, G2, G3, A1, A2 and A3 has been conducted. It has been studied that as the number of day's increases, the specific gravity also increases gradually. Specific gravity ranges from 1.10 to 1.18. Specific gravity for G1 on 1st day was 1.119 and shows a trend to increase to 1.178 on 14th day. 1.116 was the starting specific gravity of G2 which increased to 1.162 on 18th day. The initial specific gravity of G3 was 1.144 which increased to 1.188 on the 13th day (fig: 21, 26 and 31).

For A1, the specific gravity starts from 1.092 and increased to 1.17 on 24th day. On the 1st day the specific gravity was 1.09 for A2 and then it increased to 1.167 on 22nd day. In case of A3, specific gravity was 1.032 on 1st day which increased to 1.092 on 21st day (fig: 6, 12 and 17)

5.1.4 Alcohol percentage

By studying the alcohol content in volume percentage of G1, G2, G3, A1, A2 and A3 it can be concluded that the alcohol volume percentage increased as the number of day's increases. The figure indicates that the % alcohol was between zeros to 8 during the fermentation period of each batch. The initial alcohol percentage was zero for all wine samples – G1, G2, G3, A1, A2 andA3.

Final alcohol content for G1 was 11.63% on 14th day
G2 was 6.81% on 18th day.
G3 was 5.81% on 13th day (fig: 23, 28 and 33)
A1 was 10.5% on 24th day.
A2 was 10.35% on 22nd day.
A3 was 11.4% on 21st day (fig: 5, 13 and 18)

5.1.5 Biomass

Biomass estimation was conducted. The figure shows a rapid increase of biomass initially and reaches a maximum then tends to be steady. The initial biomass of G1 was 0.0056g/ml which increased to 0.019g/ml on the 11th day and decreased to 0.0119 on 14th day. For G2, the biomass started from 0.0021g/ml and increased to 0.033 on 11th day and decreased to 0.0162 on 18th day. On the 1st day the biomass was 0.0045g/ml for G3 and then it increased to 0.0160g/ml on 12th day and decreased to 0.0158g/ml on 13th day (fig: 22, 27 and 32).

In case of A1, biomass was 0.0063g/ml on 1st day which increased to 0.0167g/ml on 12th day and decreased to 0.0076g/ml on 24th day. Biomass for A2 on 2nd day was 0.0025g/ml and showed a trend to increase to 0.00184g/ml then decrease to 0.0112 on 22nd day. 0.0047g/ml was the starting biomass of A3 which increased to 0.0177g/ml on 16th day and then decreased to 0.011g/ml on 21st day (fig: 7, 11 and 16).

5.1.6 Titratable acidity

Titratable acidity of G1, G2, G3, A1, A2 and A3 was determined. The titratable acidity of wine shows a fluctuating trend as the number of days increase. The titratable acidity ranges from 3.5g/L tartaric acid to 7g/L tartaric acid. Titratable acidity of G1 ranges between 4.3 to 7.81 g/L tartaric acid. For G2, the range was 6.0 to 6.98 g/L tartaric acid. Initial titratable acidity of G3 was 4.12g/L tartaric acid and on 13th days it becomes 5.43g/L tartaric acid (fig: 20, 25 and 30).

In case of A1, 1st day titratable acidity was 4.12g/L tartaric acid and 5.43 g/L tartaric acid on final day. Titratable acidity for A2 on 2nd day was 3.33g/L tartaric acid and 10.5 g/L tartaric acid on final day. 2.50 was the starting titratable of A3 which increased to 12.45g/L tartaric acid on 21th day (fig: 5, 10 and 15).

5.2 Analyses of wine

Alcohol percentage, tannin content, phenol content, free and total SO_2, pH, specific gravity, titratable acidity and total suspended solid were estimated. Final analysis of wine was conducted after the fermentation period (i.e. after 15 days).

5.2.1 Alcohol Content

The Alcohol content of different wines during the aging period was 13.86% for A1, 12.10% for A2 and 10.62% for A3. Similarly for G1, G2 and G3 alcohol content was 10.62%, 9.25% and 8.64%. (table – 12).

5.2.2 Tannin content

Tannin content for A1, A2, and A3 were 3.06mg/ml, 3.14mg/ml and 2.19 mg/ml. Similarly for G1, G2, and G3 were 0.74mg/ml, 0.52mg/ml and 0.32mg/ml respectively (Table 7).

5.2.3 Phenol content

Phenol content for A1-0.69mg/ml, A2-0.58mg/ml, A3-0.30mg/ml, G1-2.96mg/ml, G2-2.59mg/ml and for G3 was 0.89 mg/ml (Table 8).

5.2.4 pH of wine

pH of A1 was 3.29 and that for A2 and A3 were 3.33 and 3.48 respectively. Similarly for G1, G2 and G3 were 3.68, 3.96 and 4.09 respectively (Table 10).

5.2.5 Free and Total SO_2

Free SO_2 for A1, A2, and A3 were 1.2g/L, 2.7g/L and 4.6 g/L respectively ad this for G1, G2, and G3 were 6g/L, 31g/L and 48g/L.

2.5 g/L, 5.28 g/L, 15.6 g/L, 16.6 g/L, 39g/L and 78 g/L were the total SO_2 for A1, A2, A3, G1, G2 and G3 respectively (Table 9).

5.2.6 Titratable Acidity

Titratable acidity of different wine were 8.85, 8.4, 5.5, 3.45, 2.8 and 2.0 g/L tartaric acid forA1, A2, A3,G1 ,G2 and G3 respectively (Table 11).

5.2.7 Specific Gravity

Specific Gravity of different wine samples were 1.195 for A1 and 1.180 for A2, 1.114 for A3. Similarly specific gravity was 1.198 for G1, 1.180 for G2 and 1.204 for G3 (Table 13).

5.2.8 Total Suspended Solids

Total Suspended Solids in ^{o}Brix for A1, A2 and A3 was 42.7, 39.85 and 26.73. Similarly for G1, G2 and G3 were 43.18, 39.85 and 44.27 (Table 14).

5.3 Comparison

The comparison of final analysis of homemade wine with commercial wine was conducted and can be concluded that the pH (except ginger), specific gravity and alcohol content of commercial wine is higher than homemade wine. The pH of commercial wine (table- 15) was 3.56 but for A1, A2 and A3 (table- 10) were 3.29, 3.33, 3.48 whereas, for G1, G2 and G3 (table – 10) were 3.68, 3.96, 4.06 which is higher than commercial wine. 1.2407 is the specific gravity of commercial wine (table – 15) whereas for A1, A2, A3, G1, G2 and G3 (table – 13) were 1.195, 1.18, 1.14, 1.198, 1.1801 and 1.204.For commercial wine the percentage of alcohol is 80% (table – 15) but for homemade wines A1, A2, A3, G1, G2 and G3 (table – 12) is stated as 13.86%, 12.10%, 10.98%, 10.62%, 9.25% and 8.64%.

IV. CONCLUSION

Study mainly focused on the process monitoring of homemade wine during its fermentation period. The experimental investigation was aimed to study the variation in each parameter during the fermentation period. The final analysis of wine of various parameters – tannin content, alcohol content, pH, specific gravity were conducted. These studies were compared with that of commercially available wine. The study concludes that pH showed a decreasing trend and then attains minima then increases. The sugar concentration of wine decreases with increase in the number of days. It has been studied that as the number of day's passes, the specific gravity and volume percentage of alcohol also increases gradually. There was a rapid increase of biomass initially and reached a maxima then tend to decrease. The titrable acidity of wine showed a fluctuating trend as the number of days passes. Batch 1 Amla showed a pH range of 3.79-3.56, specific gravity ranges from 1.09 -1.17 and alcohol content was 10.5%. Batch 2 Amla showed a pH range of 3.81-3.30, specific gravity ranges from 1.09 -1.167 and alcohol content was 10.35%. Batch 3 Amla showed a pH range of 3.83-3.34, specific gravity ranges from 1.032 -1.0967and alcohol content was 8.64%. Batch 1 ginger showed a pH range of 3.77 -3.59, specific gravity ranges from 1.11 -1.178 and alcohol content was 7.94%. Batch 2 ginger showed a pH range of 3.89 -3.94, specific gravity ranges from 1.116 -1.162 and alcohol content was 6.81 %. Batch 3 ginger showed a pH range of 4.42 -4.01, specific gravity ranges from 1.144 -1.188 and alcohol content was 5.81%. The final analysis of wine was conducted. The pH of commercial wine was 3.56 but for A1, A2 and A3 were 3.29, 3.33, 3.48 whereas, for G1, G2 and G3 were 3.68, 3.96, 4.06 which is higher than commercial wine. 1.2407 is the specific gravity of commercial wine whereas for A1, A2, A3, G1, G2 and G3 were 1.195, 1.18, 1.14, 1.198, 1.1801 and 1.204. For commercial wine the percentage of alcohol is 80% but for homemade wines A1, A2, A3, G1, G2 and G3 is stated as 13.86%, 12.10%, 10.98%, 10.62%, 9.25% and 8.64%. Homemade wines have relatively low alcohol content than the commercially available wine and there is no usage of either any preservative or any additives, so homemade wines are not harmful for health and are acceptable for daily usage. The results of process monitoring and final analysis will help a small scale wine industry or can refer the results to develop a small scale wine industry.

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Table 1: Daily Monitoring Of Amla-1 (A1)

Days	pH	Titratable Acidity (g/Ltartaric acid)	Specific Gravity	% Alcohol	Sugar concentration (mg/ml)	Biomass (g/ml)
1	3.79	3.80	1.092	0	21.78	0.0063
4	3.65	3.33	1.103	1.013	19.92	0.0091
6	3.57	4.10	1.119	3.54	18.14	0.0116
8	3.47	4.56	1.123	3.71	17.26	0.0135
11	3.35	3.90	1.131	5.25	16.64	0.0154
12	3.25	5.33	1.136	5.94	15.55	0.0167
13	3.28	5.62	1.143	6.87	14.85	0.0168
14	3.33	6.23	1.149	7.6	14.12	0.0170
24	3.56	9.26	1.170	10.5	9.290	0.0172

TABLES AND GRAPHS

Table 2: Daily Monitoring Of Amla-2 (A2)

Days	pH	Titratable Acidity (g/Ltartaric acid)	Specific Gravity	% Alcohol	Biomass (g/ml)	Sugar concentration (mg/100ml)
2	3.81	3.3	1.09	0	0.0025	26.00
3	3.71	3	1.112	2.88	0.0040	25.91
4	3.70	2.4	1.119	3.95	0.0046	25.02
5	3.40	3.45	1.123	4.4	0.0057	24.37
8	3.2	6.45	1.136	6.16	0.0067	22.58
9	3.18	4	1.139	6.65	0.0082	20.67
10	3.16	3.75	1.143	7.1	0.0100	19.80
11	3.23	5.25	1.147	7.64	0.0146	19.11
15	3.25	5.4	1.155	8.72	0.0176	17.09
16	3.30	5.25	1.159	9.27	0.0184	16.48
17	3.31	7.05	1.16	9.4	0.0186	15.86
18	3.32	6	1.162	9.67	0.0188	15.20
22	3.3	10.5	1.167	10.35	0.0188	12.82

Table 3: Daily Monitoring Of Amla-3 (A3)

Days	pH	Titratable Acidity (g/Ltartaric acid)	Specific Gravity	% Alcohol	Biomass (g/ml)	Sugar concentration (mg/100ml)
1	3.83	2.50	1.032	0	0.0047	22.8
2	3.68	4.00	1.038	0.81	0.0067	22.0
5	3.27	7.80	1.040	1.35	0.0079	18.2
12	3.16	5.25	1.044	1.62	0.0122	16.8
13	3.25	9.30	1.00	2.62	0.0162	16.2
15	3.27	9.45	1.050	2.43	0.0195	16.0
16	3.30	10.05	1.055	3.10	0.0196	15.2
17	3.31	10.20	1.061	3.90	0.0198	14.8
19	3.32	11.11	1.069	5.00	0.0200	13.6
20	3.33	12.30	1.081	6.22	0.0210	12.2
21	3.34	12.45	1.096	8.64	0.022	11.4

Table 4: Daily Monitoring Of Ginger-1 (G1)

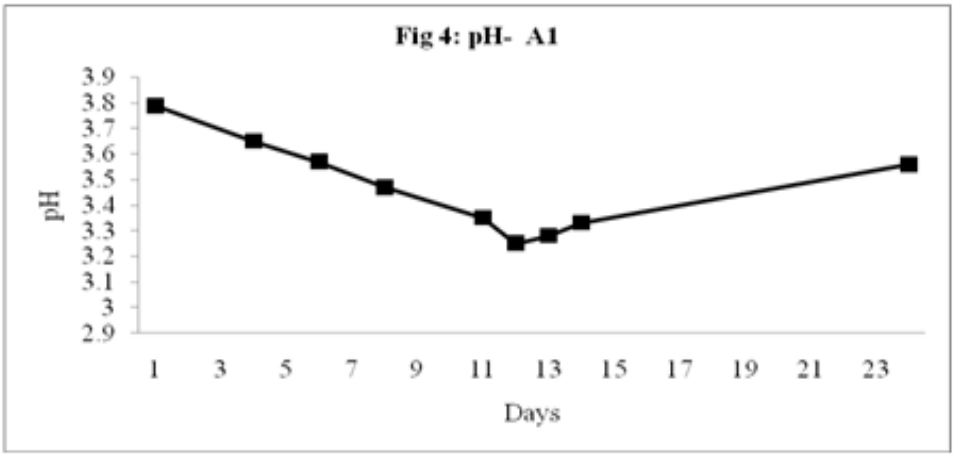
Days	pH	Titratable Acidity (g/L tartaric acid)	Specific gravity	% Alcohol	Sugar concentration (mg/100ml)	Biomass (g/ml)
1	3.77	4.30	1.119	0	23.01	0.0056
4	3.62	6.41	1.131	1.56	20.50	0.0109
6	3.57	5.87	1.147	3.12	18.67	0.0126
8	3.41	6.12	1.154	4.67	17.01	0.0139
11	3.52	5.89	1.164	6.02	15.39	0.0159
12	3.54	7.26	1.169	6.68	14.91	0.0160
13	3.55	7.56	1.172	7.14	13.13	0.0161
14	3.59	7.81	1.178	7.94	11.630	0.0163

Table 5: Daily Monitoring Of Ginger-2 (G2)

Days	pH	Titratable Acidity (g/L tartaric acid)	Specific Gravity	% Alcohol	Biomass (g/ml)	Sugar concentration (mg/100ml)
2	3.89	6.0	1.1160	0	0.0021	24.81
3	3.76	5.5	1.1186	0.945	0.0023	22.58
4	3.70	4.23	1.1237	1.54	0.0083	21.01
5	3.63	4.68	1.1240	1.67	0.0132	19.36
8	3.71	4.80	1.1267	2.04	0.0306	16.89
9	3.78	5.25	1.129	2.47	0.0310	16.13
10	3.80	5.55	1.133	2.93	0.032	15.62
11	3.83	5.78	1.142	4.14	0.033	14.89
15	3.89	6.3	1.149	5.05	0.038	12.00
16	3.91	6.52	1.153	5.59	0.039	12.52
17	3.92	6.70	1.157	6.13	0.040	11.88
18	3.94	6.98	1.162	6.81	0.04	10.01

Table 6: Daily Monitoring Of Ginger-3 (G3)

Days	pH	Titratable Acidity (g/L tartaric acid	Specific Gravity	% Alcohol	Biomass (g/ml)	Sugar concentration (mg/100ml)
1	4.4	4.12	1.144	0	0.0045	24.44
2	3.96	4.39	1.150	0.356	0.0069	22.00
3	3.81	4.56	1.158	1.256	0.0082	20.20
5	3.72	4.78	1.162	1.890	0.0090	18.4
6	3.75	5.39	1.168	2.36	0.0116	18.0
7	3.79	5.22	1.174	2.51	0.0128	16.2
8	3.81	5.00	1.174	3.98	0.0137	15.7
9	3.82	5.04	1.176	4.25	0.0145	14.6
12	3.90	5.32	1.184	5.33	0.0160	12.8
13	4.01	5.43	1.188	5.81	0.0160	12.4



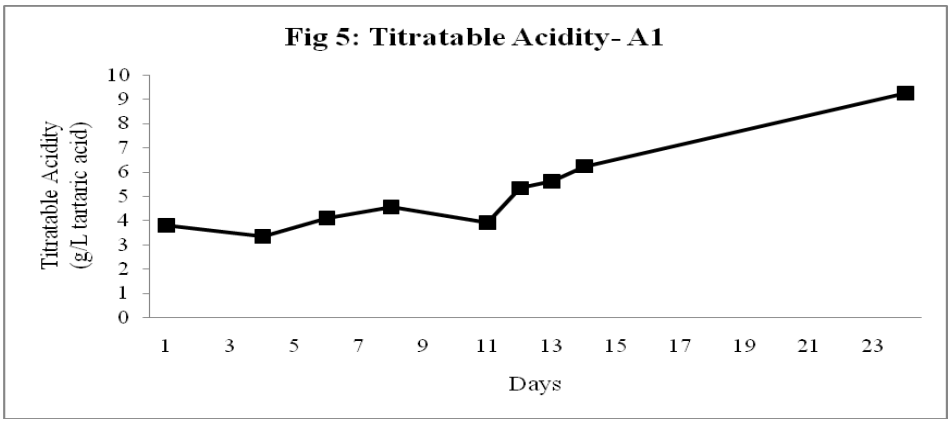


Fig 6: Specific Gravity-A1

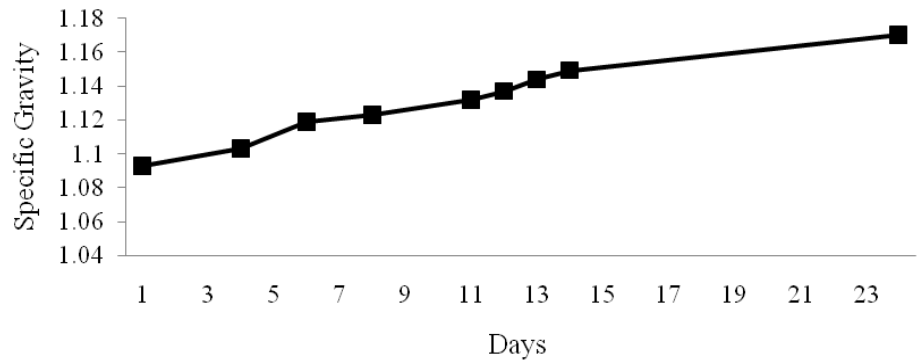


Fig 7: Biomass-A1

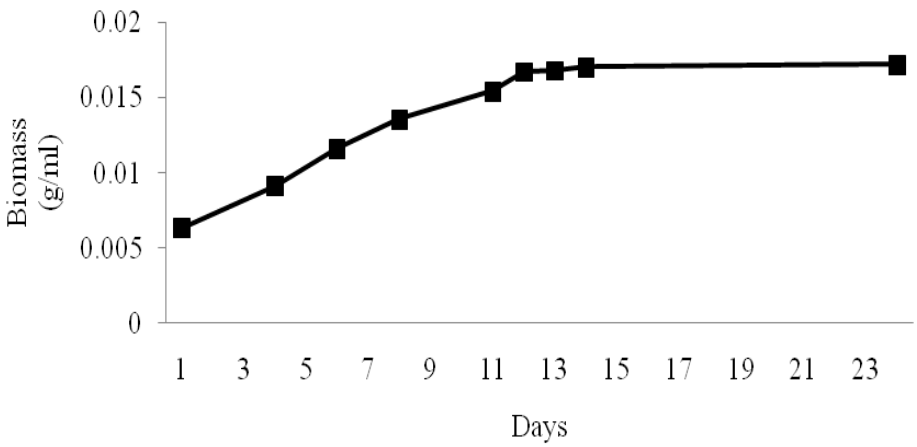
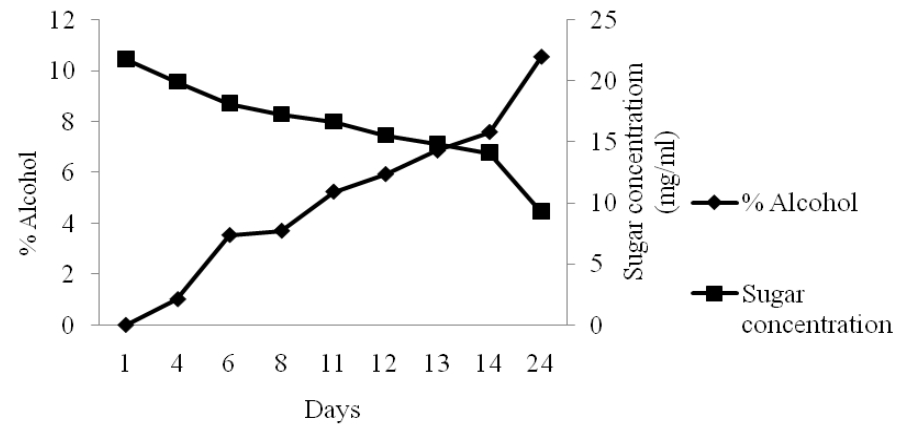


Fig 8: Alcohol content & Sugar concentration -A1



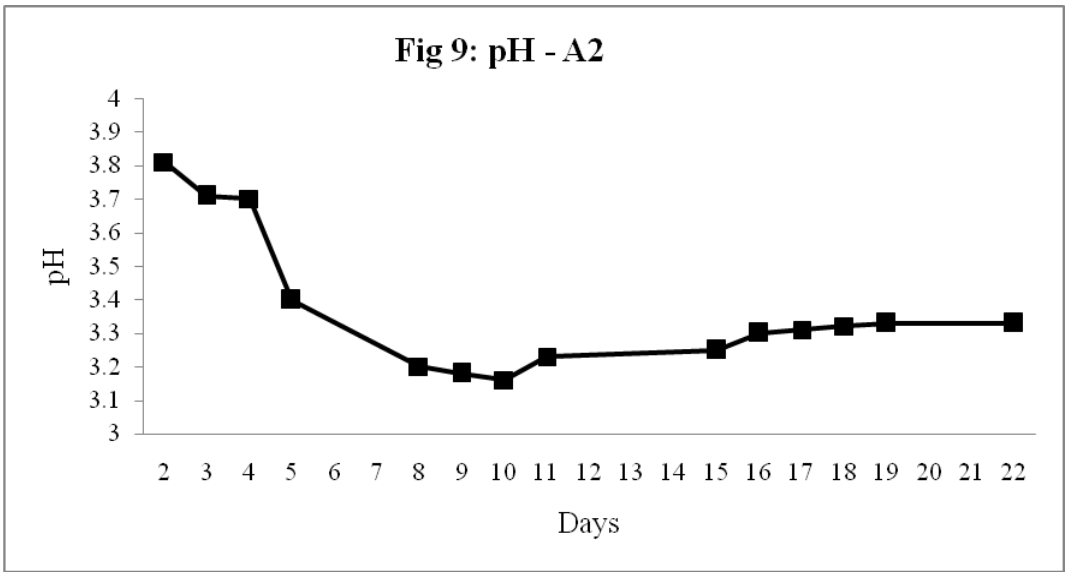


Fig 9: pH - A2
pH
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
Days

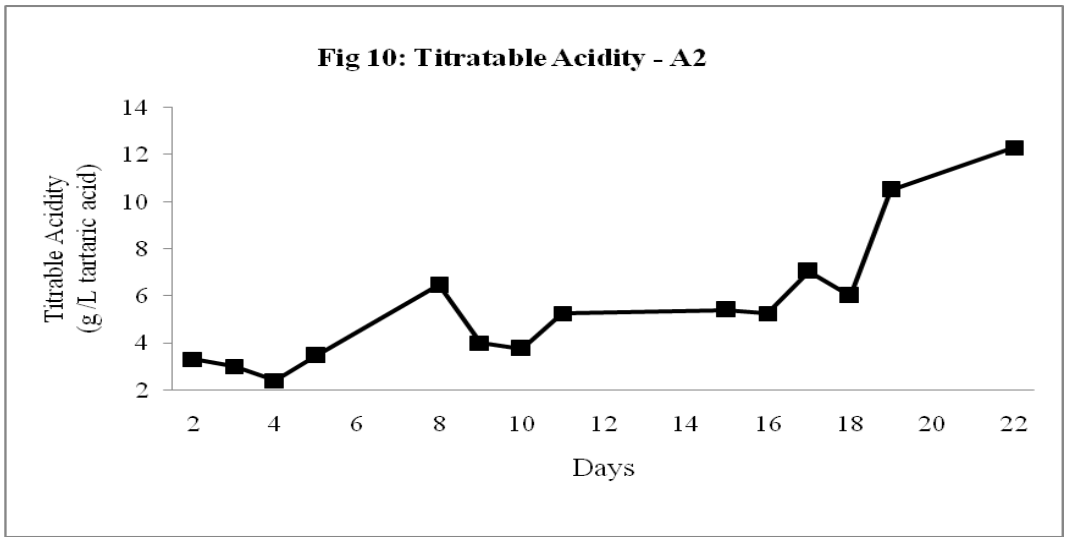


Fig 10: Titratable Acidity - A2
Titrable Acidity (g/L tartaric acid)
14
12
10
8
6
4
2
2 4 6 8 10 12 14 16 18 20 22
Days

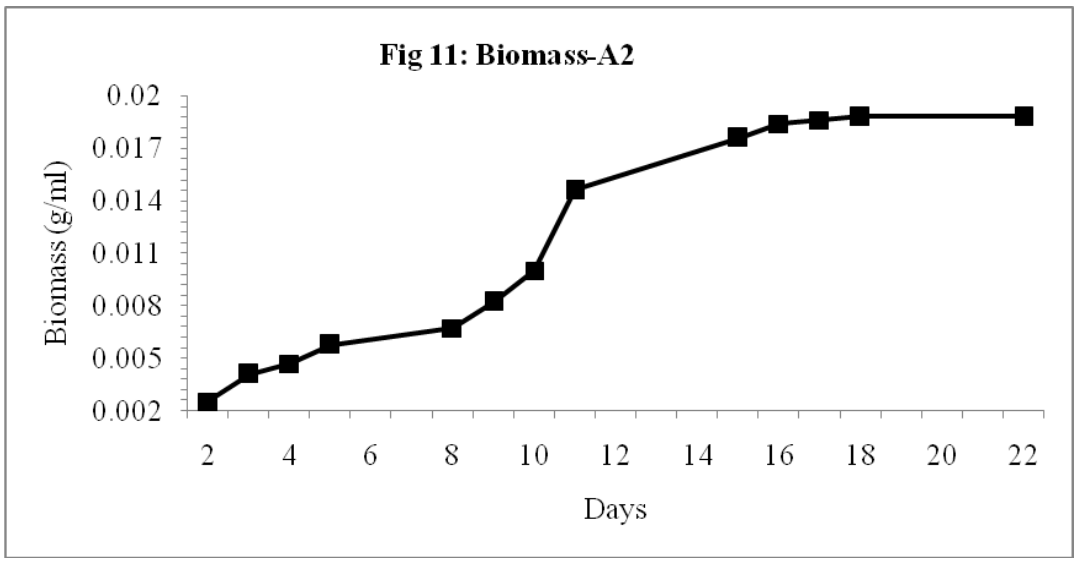


Fig 11: Biomass-A2
Biomass (g/ml)
0.02
0.017
0.014
0.011
0.008
0.005
0.002
2 4 6 8 10 12 14 16 18 20 22
Days

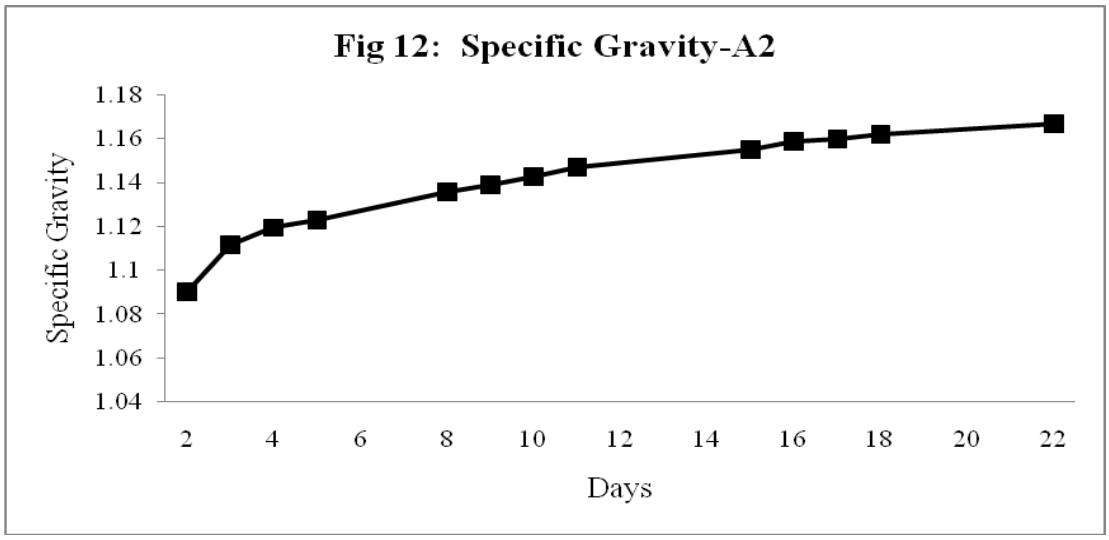


Fig 12: Specific Gravity-A2
Specific Gravity
1.18
1.16
1.14
1.12
1.1
1.08
1.06
1.04
2 4 6 8 10 12 14 16 18 20 22
Days

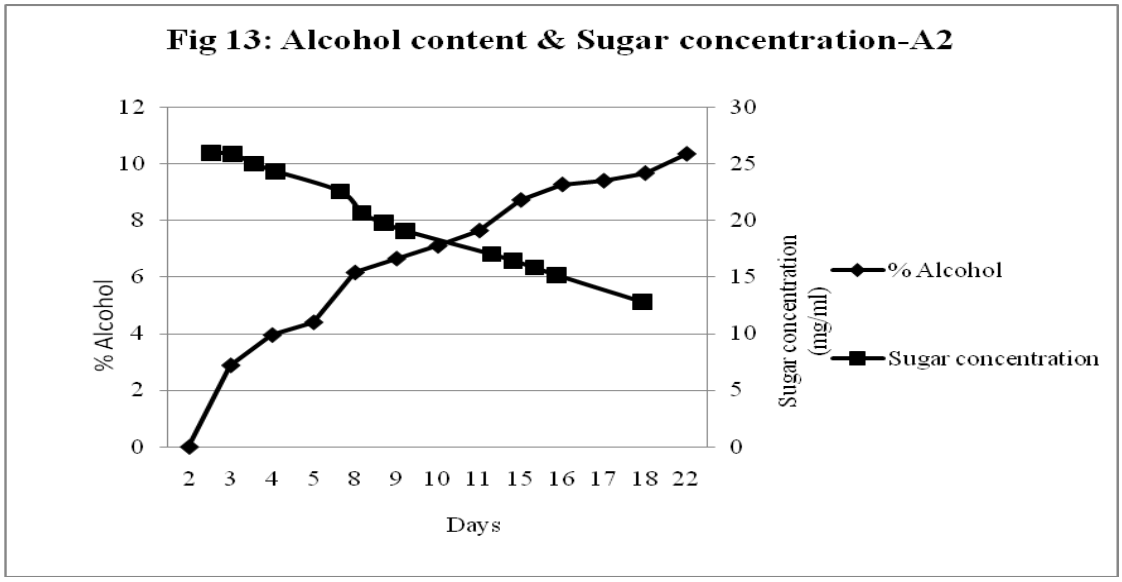


Fig 13: Alcohol content & Sugar concentration-A2
% Alcohol
12
10
8
6
4
2
0
30
25
20
15
10
5
0
Sugar concentration (mg/ml)
% Alcohol
Sugar concentration
2 3 4 5 8 9 10 11 15 16 17 18 22
Days

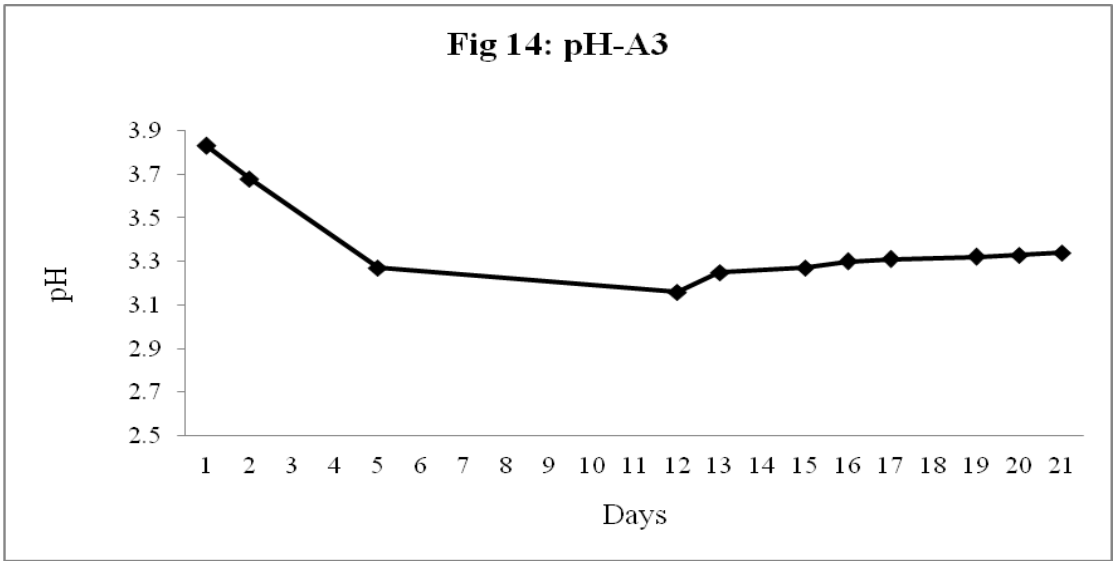


Fig 14: pH-A3
pH
3.9
3.7
3.5
3.3
3.1
2.9
2.7
2.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Days

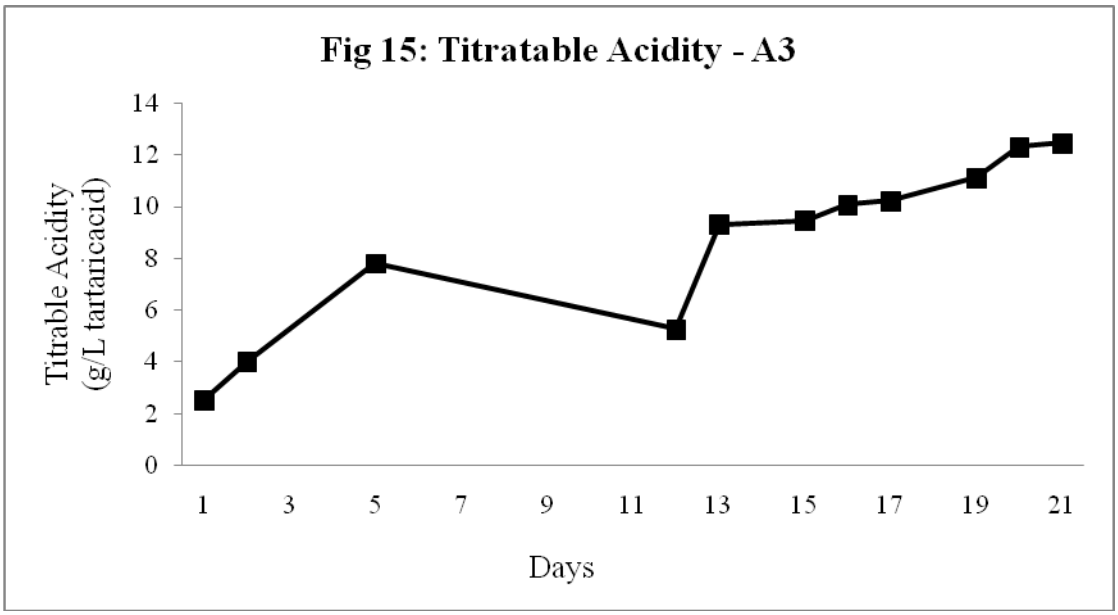


Fig 15: Titratable Acidity - A3
Titrable Acidity (g/L tartaricacid)
14
12
10
8
6
4
2
0
1 3 5 7 9 11 13 15 17 19 21
Days

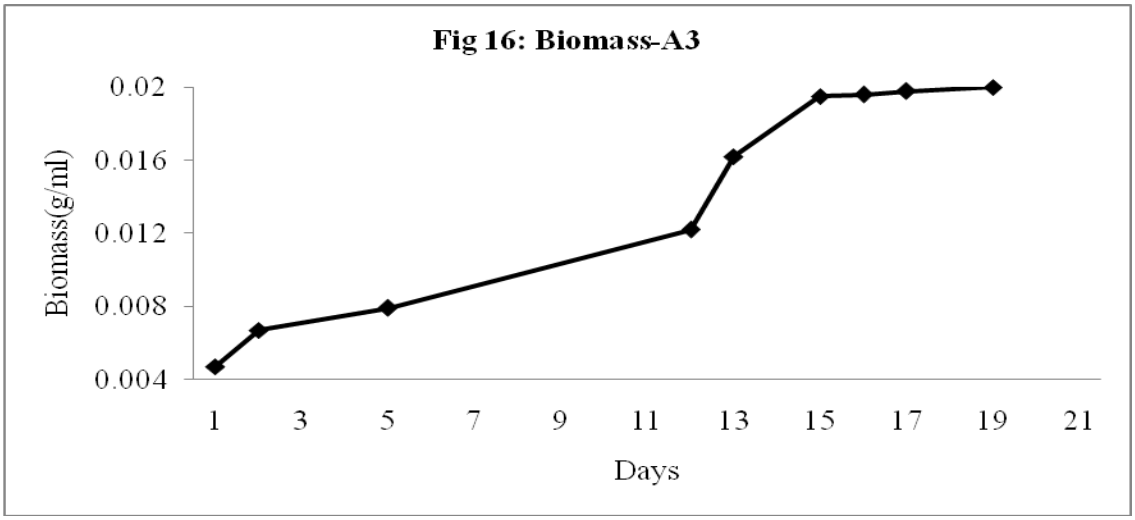


Fig 16: Biomass-A3
Biomass(g/ml)
0.02
0.016
0.012
0.008
0.004
1 3 5 7 9 11 13 15 17 19 21
Days

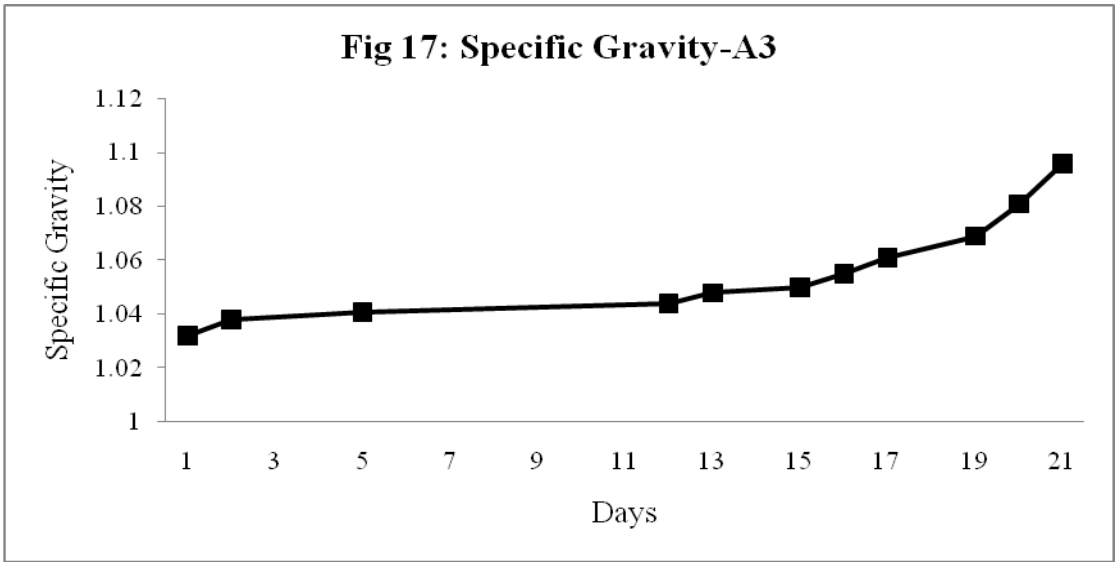


Fig 17: Specific Gravity-A3
Specific Gravity
1.12
1.1
1.08
1.06
1.04
1.02
1
1 3 5 7 9 11 13 15 17 19 21
Days

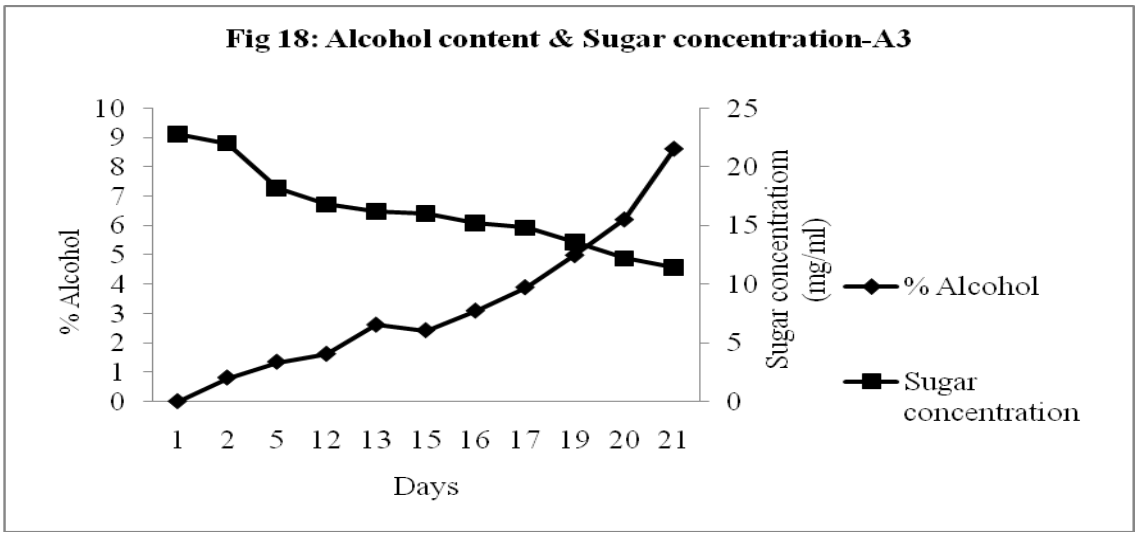


Fig 18: Alcohol content & Sugar concentration-A3
% Alcohol
Sugar concentration (mg/ml)
Days
% Alcohol
Sugar concentration

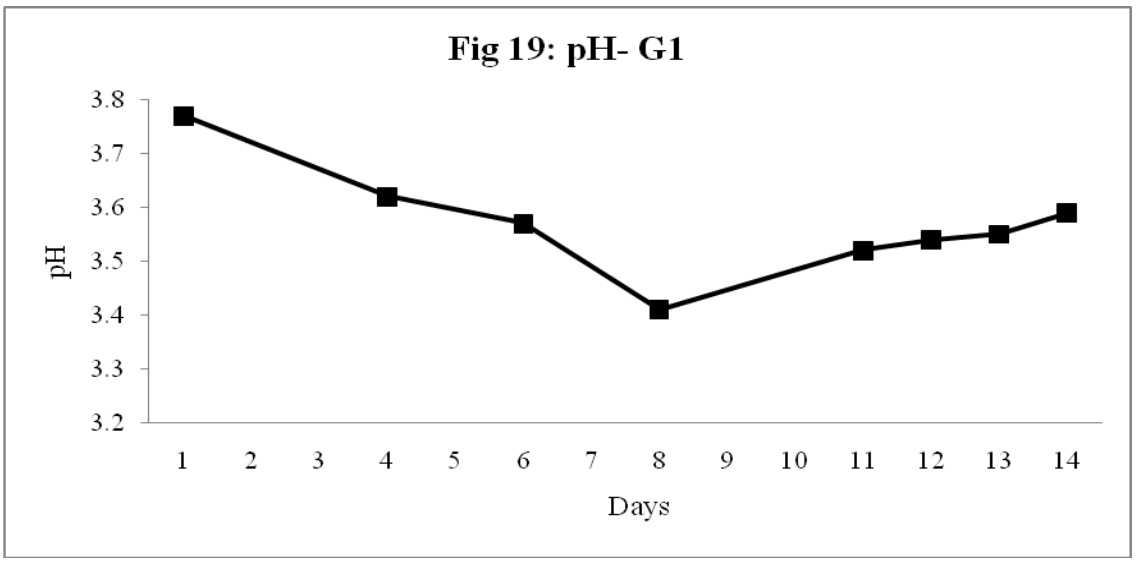


Fig 19: pH- G1
pH
Days

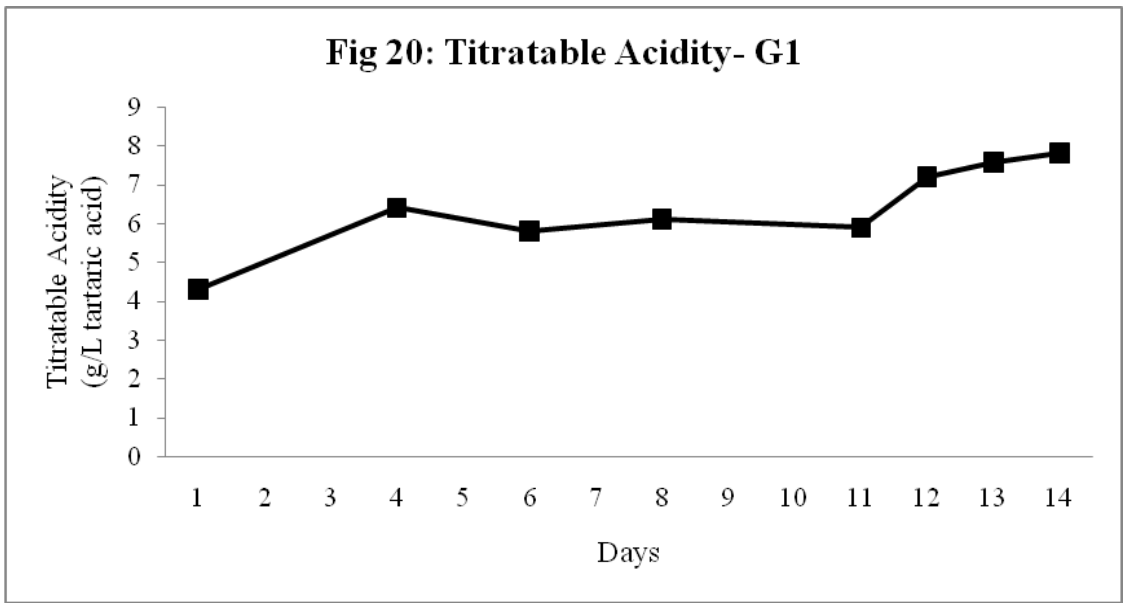


Fig 20: Titratable Acidity- G1
Titratable Acidity (g/L tartaric acid)
Days

Fig 21: Specifc Gravity-G1

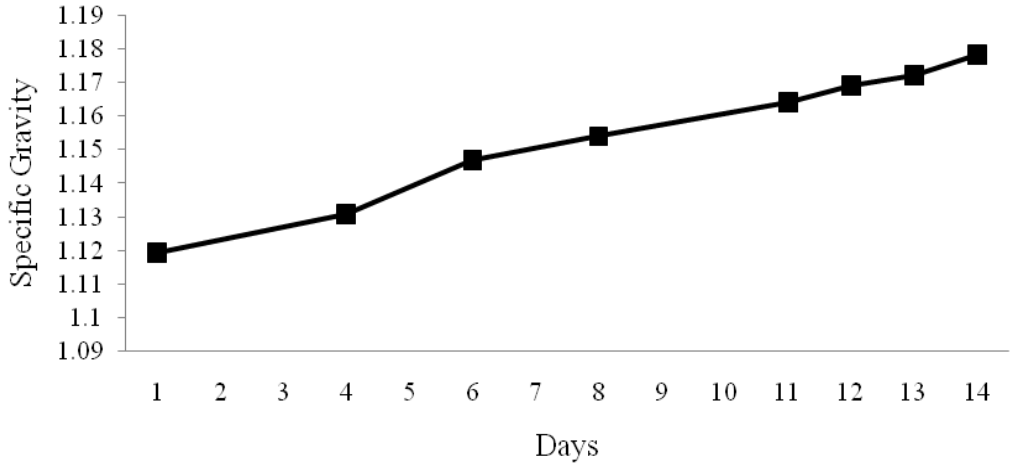


Fig 22: Biomass-G1

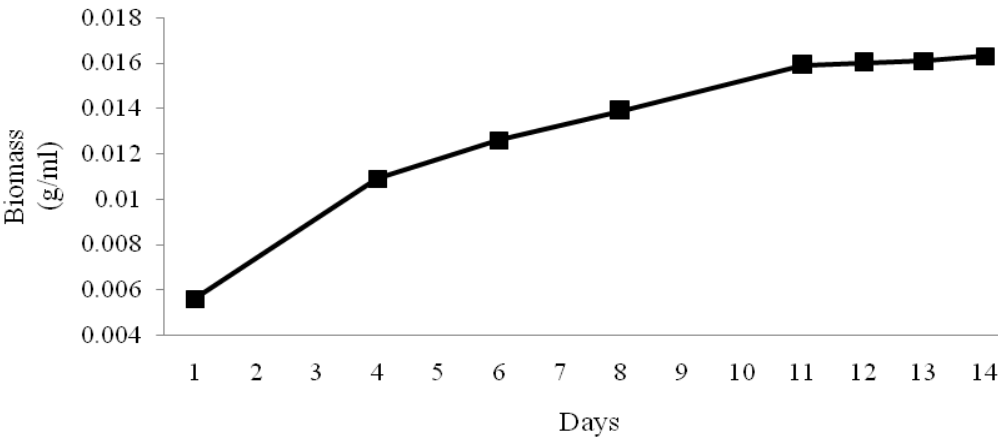
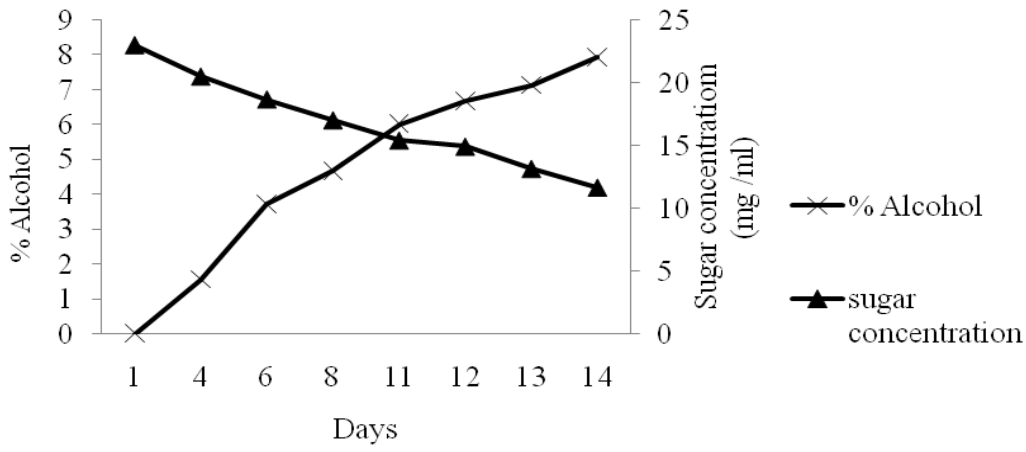


Fig 23: Alcohol content & Sugar concentration-G1



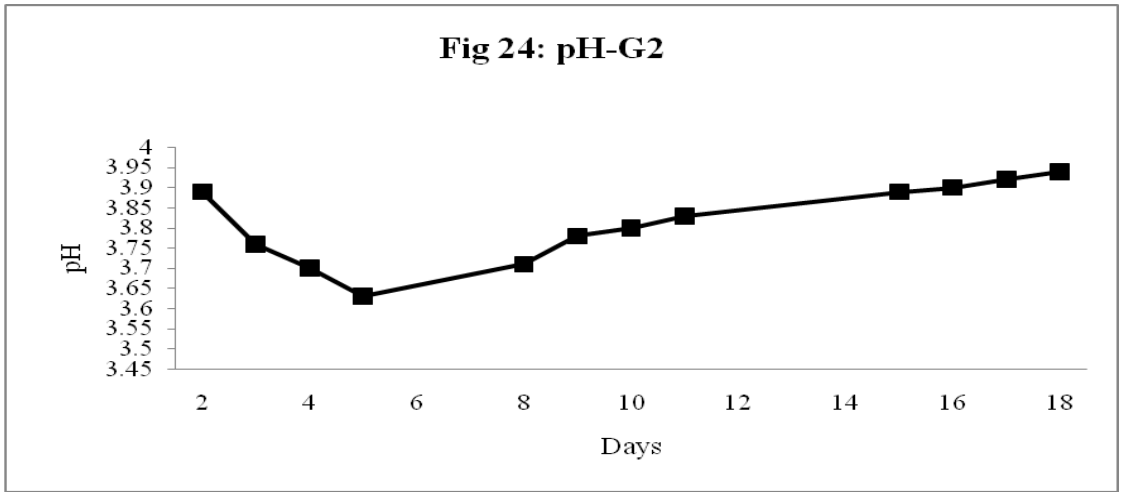


Fig 24: pH-G2
pH
4
3.95
3.9
3.85
3.8
3.75
3.7
3.65
3.6
3.55
3.5
3.45
2 4 6 8 10 12 14 16 18
Days

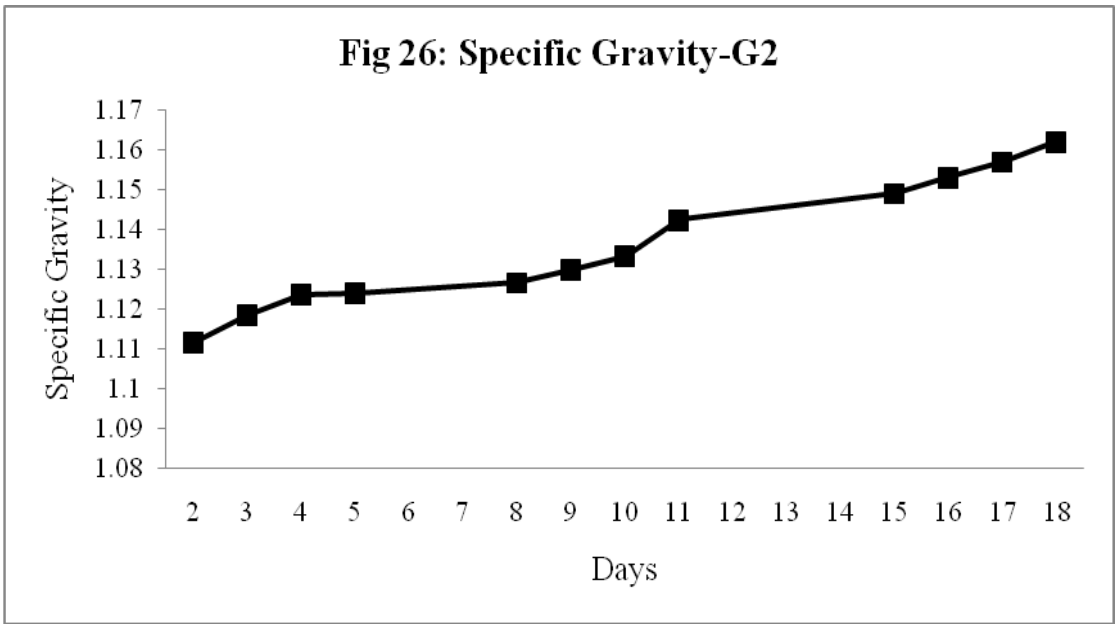


Fig 26: Specific Gravity-G2
Specific Gravity
1.17
1.16
1.15
1.14
1.13
1.12
1.11
1.1
1.09
1.08
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Days

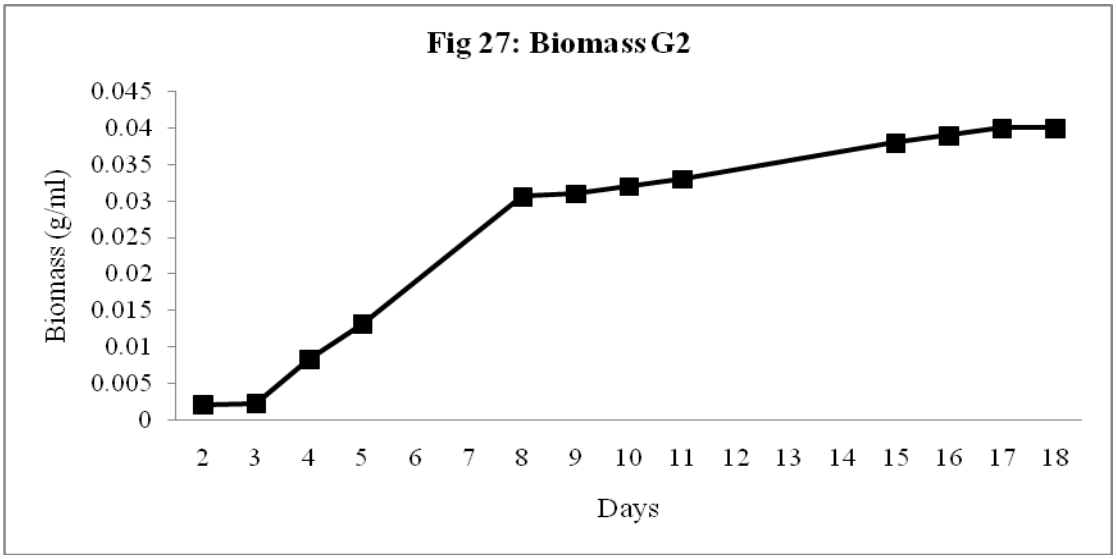


Fig 27: Biomass G2
Biomass (g/ml)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Days

Fig 28: Alcohol content & sugar concentration-G2

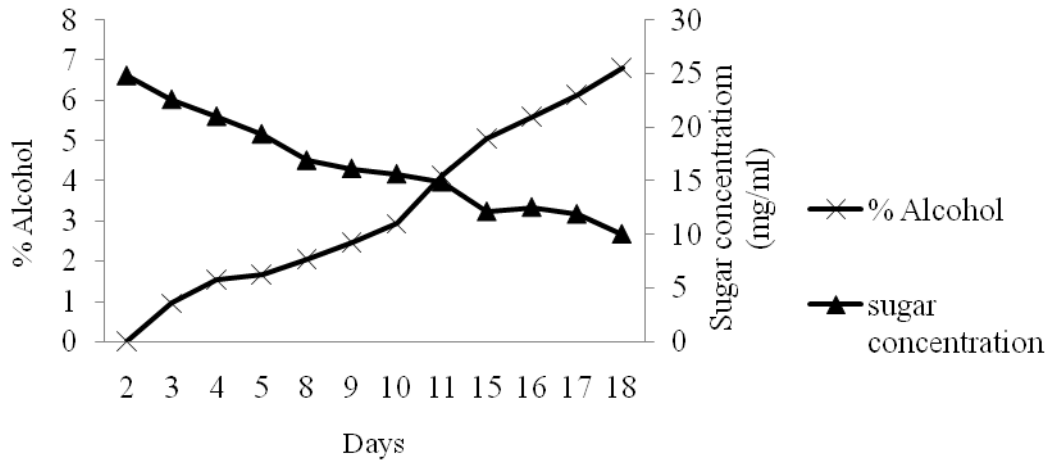


Fig 29: pH- G3

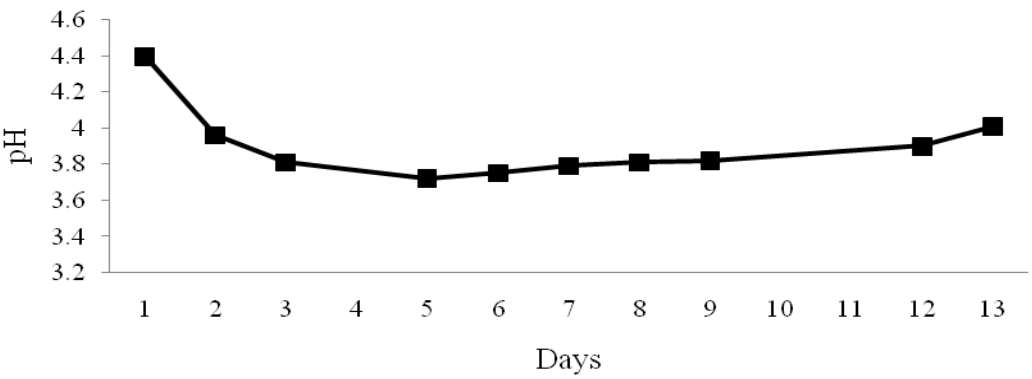
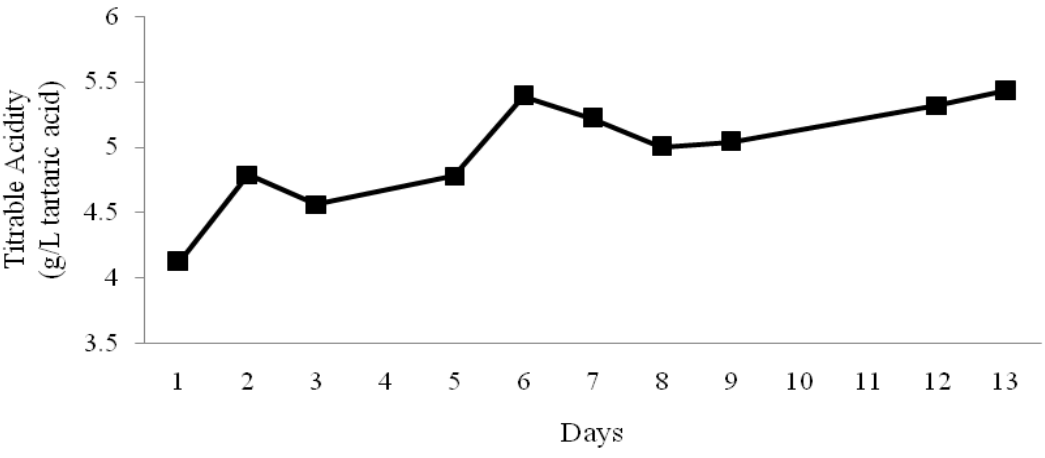


Fig 30: Titrable Acidity-G3



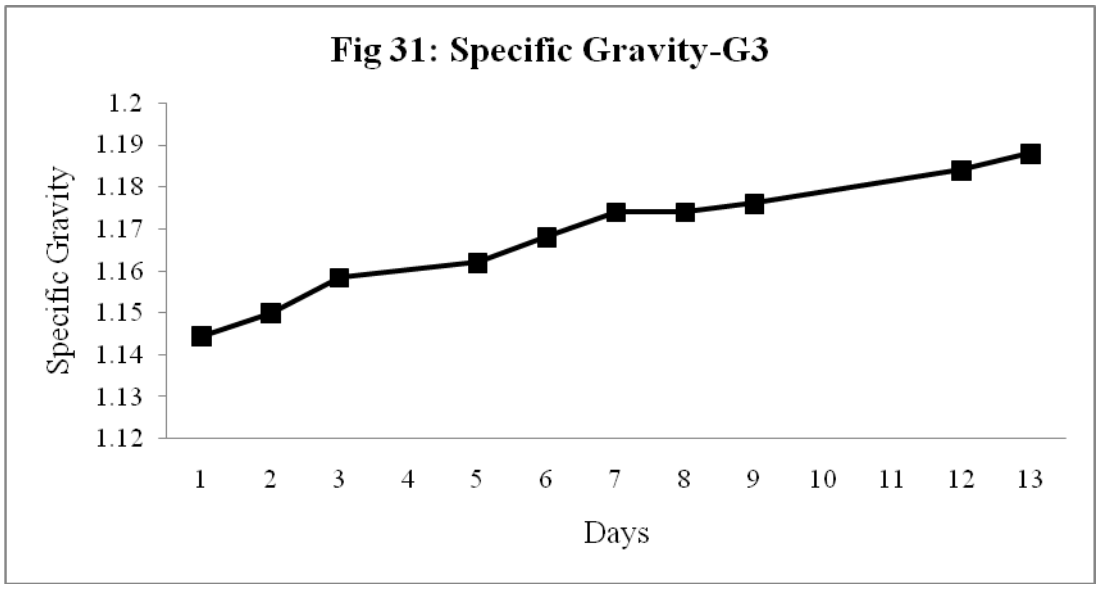


Fig 31: Specific Gravity-G3
Specific Gravity
1.2
1.19
1.18
1.17
1.16
1.15
1.14
1.13
1.12
1 2 3 4 5 6 7 8 9 10 11 12 13
Days

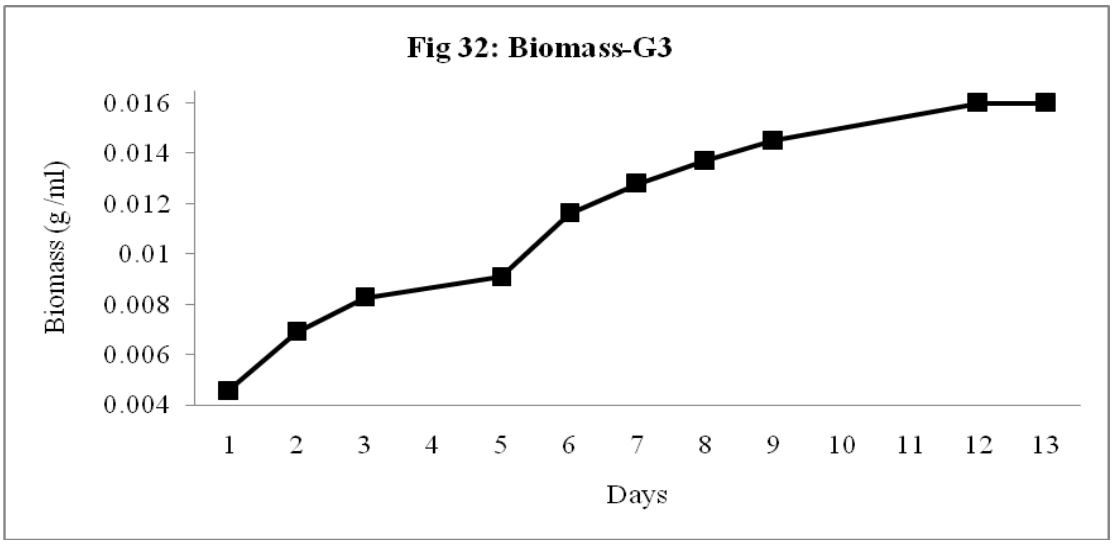


Fig 32: Biomass-G3
Biomass (g /ml)
0.016
0.014
0.012
0.01
0.008
0.006
0.004
1 2 3 4 5 6 7 8 9 10 11 12 13
Days

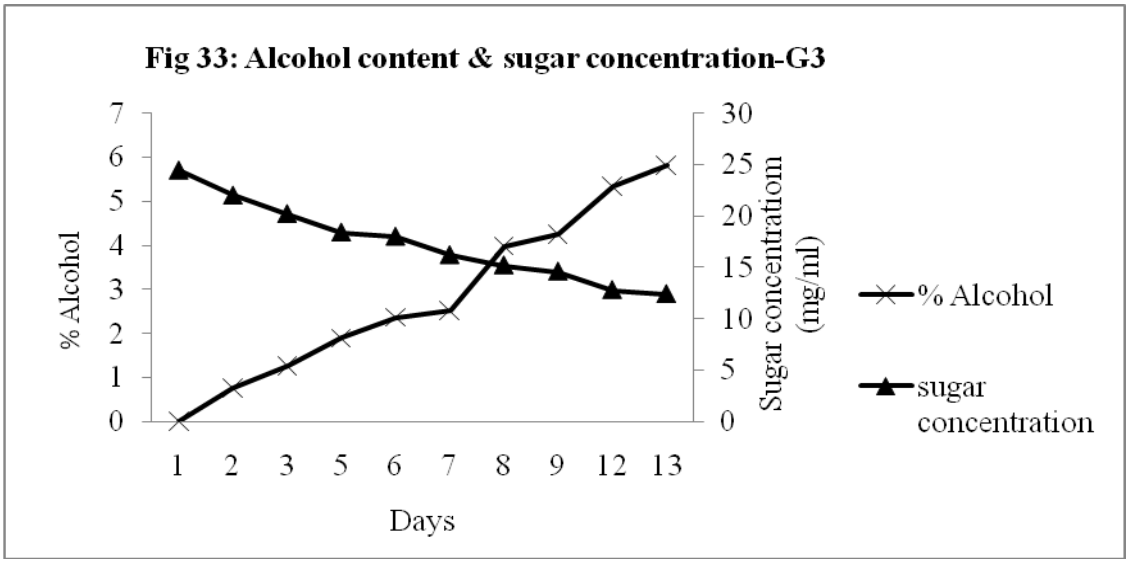


Fig 33: Alcohol content & sugar concentration-G3
% Alcohol
7
6
5
4
3
2
1
0
Sugar concentration (mg/ml)
30
25
20
15
10
5
0
1 2 3 5 6 7 8 9 12 13
Days
% Alcohol
sugar concentration

Table 7: Tannin content in wine

SL.No	Wine Sample	Tannin Content (mg/ml)
1	Amla-1	3.06
2	Amla-2	3.14
3	Amla-3	2.91
4	Ginger-1	0.74
5	Ginger-2	0.52
6	Ginger-3	0.32

Table 8: Phenol content in wine

SL.No	Wine Sample	Phenol Content (mg/ml)
1	Amla-1	0.69
2	Amla-2	0.58
3	Amla-3	0.30
4	Ginger-1	2.96
5	Ginger-2	2.59
6	Ginger-3	2.89

Table 9: Free and Total SO_2 content in wine

SL.No	Wine Sample	Free SO_2 (g/L)	Total SO_2 (g/L)
1	Amla-1	1.2	2.5
2	Amla-2	2.7	5.28
3	Amla-3	4.6	15.6
4	Ginger-1	6	16.6
5	Ginger-2	31	39
6	Ginger-3	48	78

Table 10: pH of wine

SL.No	Wine Sample	pH
1	Amla-1	3.29
2	Amla-2	3.33
3	Amla-3	3.48
4	Ginger-1	3.68
5	Ginger-2	3.96
6	Ginger-3	4.09

Table 11: Titratable Acidity of wine

SL.No	Wine Sample	Titratable Acidity (g/L tartaric acid)
1	Amla-1	8.85
2	Amla-2	8.4
3	Amla-3	5.5
4	Ginger-1	3.45
5	Ginger-2	2.8
6	Ginger-3	2.0

Table 12: Alcohol content in wine

SL.No	Wine Sample	% Alcohol
1	Amla-1	13.86
2	Amla-2	12.10
3	Amla-3	10.98
4	Ginger-1	10.62
5	Ginger-2	9.25
6	Ginger-3	8.64

Table 13: Specific Gravity of wine

SL.No	Wine Sample	Specific Gravity
1	Amla-1	1.195
2	Amla-2	1.180
3	Amla-3	1.114
4	Ginger-1	1.198
5	Ginger-2	1.1801
6	Ginger-3	1.204

Table 14: Total Suspended Solids in wine

SL.No	Wine Sample	Total Suspended Solids °Brix
1	Amla-1	42.7
2	Amla-2	39.85
3	Amla-3	26.73
4	Ginger-1	43.18
5	Ginger-2	39.85
6	Ginger-3	44.27

Table 15: Analysis of Commercial Wine

Commercial Wine		
1	pH	3.56
2	Specific Gravity	1.2407
3	Titratable Acidity (g/L tartaric acid)	4.2
4	% Alcohol	18
5	Tannin Content (mg/ml)	0.28
6	Phenol content (mg/ml)	0.20
7	Total Suspended Solids (°Brix)	32.23