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Effect of Process Parameters on Quality WIne Production from Jamun (*Syzygium cumini*)

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ABSTRACT

Considering the medicinal and therapeutic properties of jamun fruit and the surplus availability during peak period, an experiment has been undertaken to prepare quality wine from jamun fruit with varying process parameters and to compare it with the wine produced by traditional household method. Experiment was conducted to evaluate the effect of process parameters viz., fruit water ratio, fruit sugar ratio, nitrogen source and clarification methods on quality and storage stability of jamun wines. Sixteen different jamun wines were prepared using 1:1 and 1:2 fruit: Water ratio, sugar was mixed in 1:1 w/w and at 24° brix, with or without 0.1% di ammonium hydrogen phosphate (DAHP) as a source of nitrogen and by adopting clarification by pectinase @ 5g/ml and by settling. Wine produced using 1:1 fruit: Water ratio, 1:1 fruit: Sugar ratio, without nitrogen source and clarified by settling (common household practice) had 89.2% yield with 65.69% antioxidant activity, 4.39% alcohol content, but had least appearance score (1.5). Use of pectinase for clarification resulted in "extraordinary wine" with total sensory score of 18.5. Addition of a nitrogen source and clarification by pectinase could produce wine with highest yield (95.4%) and the highest antioxidant activity (95.64%) was obtained when dilution was increased to 1:2 along with usage of nitrogen source and pectinase. When the selected superior wines were subjected to storage study, the polyphenol and alcohol content were decreased in two months of storage under ambient condition.

Keywords Di ammonium hydrogen phosphate, Fruit wines, Jamun, Pectinase, Quality analysis.

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INTRODUCTION

Jamun (*Syzygium cumini*), popular indigenous fruit of India is an important member of the family Myrtaceaea. It is commonly known as black plum, Indian black cherry, Java plum, jambolan and is gaining popularity due to its balanced sugar, acid and tannin content (Das 2009). It is a rich source of iron and vitamin C and is also good source of glucose and fructose (Sagar and Dubey 2019). It is normally consumed fresh and is known to have nutraceutical and therapeutic values (Khurdiya and Roy 1985). Ripe jamun contains approximately 83% water with

14% solids containing a mixture of fermentable sugar, which can be used for alcoholic fermentation (Kraus 2003). A huge quantity of marketable surplus fruit is available in jamun growing areas which need to be processed into value-added products. As the fruit is a rich source of anthocyanin, it imparts antioxidant properties too. In view of many medicinal and therapeutic properties of jamun fruit and considering the surplus availability during peak period, an experiment has been undertaken to prepare quality wine from jamun fruit with varying process parameters and to compare with the wine produced by traditional household method.

MATERIALS AND METHODS

The experiment was conducted in the Department of Post Harvest Technology, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala during the period 2019-2021. Uniform ripe, fresh and good quality jamun fruits were collected from Instructional Farm of the college and utilized for preparation of wines using baker's yeast (*Saccharomyces cerevisiae*) by adopting different process parameters such as fruit: Water ratio, fruit: Sugar ratio, nitrogen source and clarification methods. Fruits were cleaned; seeds removed, crushed and filled in clean porcelain pots. Crushed fruits and lukewarm water were mixed in two different ratios viz., 1:1 w/v (R_1) and 1:2 w/v (R_2). Crushed fruit and sugar were mixed in two different proportions. Initial TSS of the fruit-water mixture was recorded using a hand refractometer and refined sugar was added for maintaining 24° brix (C_2) and in 1:1 w/w (C_1). Fermentation was carried out with (N_1) or without (N_2) di ammonium hydrogen phosphate (DAHP 0.1%), a source of nitrogen. Starter solution was prepared by mixing yeast with sugar and lukewarm water. Handful of crushed wheat was added to the mixture to act as a source of food material to the yeast. Potassium meta bisulphite was added to the mixture to supply 50-70 ppm SO_2 to control wild yeast and undesirable bacteria. During primary fermentation the contents were stirred on alternate days to provide the uniform air and to maintain a sufficient temperature and primary fermentation was allowed till the frothing ceased. The alcoholic ferment produced after primary fermentation was filtered, rate of fermentation (°Brix/24 hr) recorded (Vikas *et al*. 2011) and subjected to secondary fermentation for another 15 days after adopting two different clarification methods viz., using pectinase @ 5g/ml (Cl_1) and by settling (Cl_2).The parameters viz., strain and concentration of yeast, pH of the must and concentration of SO_2 were maintained uniformly. The resulting fruit wines were filtered after secondary fermentation, pasteurized at 85-88°C for two minutes and bottled in amber colored glass containers. Thus the experiment was carried out with 16 treatments replicated twice in Completely Randomized Design. The wines were analyzed for yield, chemical characteristics viz., total soluble solids, acidity (as citric acid), sugars (Ranganna 1986), alcohol and polyphenol content (Sadasivam and Manickam,1992) and antioxidant activity using 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay (Sharma and Bhat 2009). Wines were evaluated by a 30 member semi-trained panel using the AWS Wine Evaluation Form developed by American wine Society (2020) based on modified "Davis system", which is a 20 point evaluation scale comprising of five categories, viz., appearance (0-3), aroma and bouquet (0-6), taste and texture (0-6), aftertaste (0-3) and overall impression (0-2). Wines were rated based on the total score as 18–20 extraordinary, 15–17 excellent, 12– 4 good, 9 – 11 commercially acceptable, 6 – 8 deficient and 0 – 5 as poor and objectionable. Based on quality analysis, three superior wines were selected, stored in amber coloured glass bottles under ambient condition (27-35^{0}C and 70-83%RH) for two months for analysing the storage stability by evaluating the polyphenol and alcohol content. Data generated in the experiment were statistically analyzed using Completely Randomized Design (CRD) and significance was tested using analysis of variance. The sensory scores of various wines were analyzed using the Kruskall-wallis test (Shamrez *et al*. 2013).

RESULTS AND DISCUSSION

Jamun (*Syzygium cumini*) could be processed into attractive dark purple wines. The highest rate of fermentation (0.056°Brix/24 h) was obtained for the wine prepared with 1:2 fruit: Water ratio, maintaining 24° brix and with nitrogen source and the lowest rate of fermentation (0.029°Brix/24 h) was obtained for wine produced with 1:1 fruit: Water ratio, 1:1 fruit:

Table 1. Effect of process parameters on rate of fermentation of jamun wines.

Rate of fermentation (°Brix/24 h)				
Fruit water ratio (R)	With nitrogen source (N_1)		Without nitrogen source (N_2)	
	Fruit: Sugar 1:1 (C_1)	Fruit: Sugar to maintain 24 °Brix (C_2)	Fruit: Sugar 1:1 (C_1)	Fruit: Sugar to maintain 25 °Brix (C_2)
R_1 (1:1)	0.029	0.051	0.04	0.051
R_2 (1:2)	0.048	0.056	0.044	0.054
Mean R	R_1=0.043		R_2=0.050	
Mean C	C_1=0.040		C_2=0.053	
Mean N	N_1=0.046		N_2=0.047	
CD	R= NS	C= 0.003	N= NS	R×C×N= 0.007

sugar ratio and with nitrogen source (Table 1). Better fermentation conditions provided by the dilution of thick jamun pulp had resulted in increased rate of fermentation as reported by Joshi *et al.* (2012). Increased fermentation with addition of DAHP irrespective of dilutions had been reported by Vikas *et al.* (2011). Highest yield (95.4%) was obtained for the wine prepared using 1:1 Fruit: Water ratio, 1:1 fruit: Sugar ratio, with nitrogen source and clarified by pectinase and the lowest yield (82.7%) was obtained for wine produced using 1:1 fruit: water ratio, maintaining 24° brix, with nitrogen source and clarified by settling (Fig. 1).

Quality analysis of wines: When the chemical quality parameters of the prepared jamun wines were recorded after secondary fermentation, the highest TSS content (27.9° brix) was noticed in wine produced using 1:1 fruit: Water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified by settling (Fig. 2). Reduction in fermentation with decreased dilution level is the reason for enhanced TSS content, which is in accordance with the findings of Joshi *et al*. (2012) who had revealed a significant reduction in TSS with increase in dilution level of jamun wines. Higher TSS content was recorded with higher initial sugar concentration in the mist of cashew apple (Attri, 2009). There was no significant difference between the acidity content of wines (Fig. 3). Highest reducing sugar (10 g 100 g^{-1}) was recorded in wine produced with 1:1 fruit: water ratio, 1:1 fruit: Sugar ratio, with nitrogen source and clarified by pectinase (Fig. 4). Highest total sugar (20.90 g 100g^{-1}) was also observed in the wine prepared by same method (Fig. 5). The lowest reducing sugar (0.59 g 100 g^{-1}) and total sugar (3.05 g 100 g^{-1}) were observed in wine produced with 1:1 fruit: water ratio, maintaining 24° brix, without nitrogen source and clarified by pectinase. Joshi *et al.* (2012) reported that there was significant reduction in reducing sugars with increase in dilution level of jamun wines. Ethyl alcohol content was maximum (15.82%) in wine produced using 1:2 fruit: Water ratio, maintaining 24° brix, without nitrogen source and clarified by pectinase (Fig. 6). and the lowest alcohol content (3.52%) was recorded in wines prepared with 1:1 fruit: water ratio, 1:1 fruit: sugar ratio and clarified using pectinase irrespective of nitrogen source. There was significant increase in ethanol

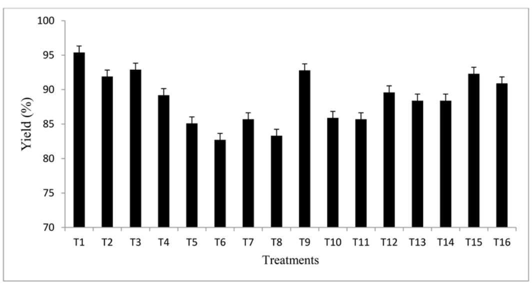


Fig. 1. Effect of process parameters on yield of jamun wines.

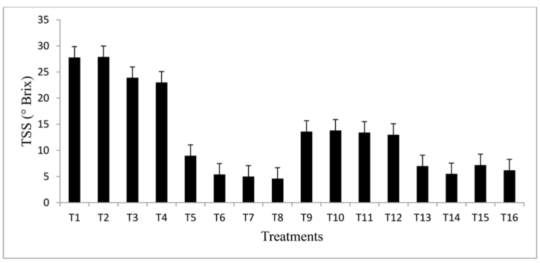


Fig. 2. Effect of process parameters on TSS of jamun wines.

Table 2. Effect of process parameters on sensory quality of jamun wines.

Treatments	Appearance	Aroma	Taste/ Texture	After taste	Overall impression	Total score
	Mean score	Mean score	Mean score	Mean score	Mean score	Mean score
T_1 –1:1 F-W+1:1 F-S+N_1+Cl_1	3.0	5.5	5.1	2.7	1.8	18
T_2–1:1 F-W+1:1 F-S+N_1+Cl_2	1.9	5.4	4.8	2.5	1.7	16.5
T_3 –1:1 F-W+1:1 F-S+N_2+Cl_1	2.9	5.6	5.4	2.7	2.0	18.5
T_4 –1:1 F-W+1:1 F-S+N_2+Cl_2	1.5	5.4	4.8	2.4	1.8	16
T_5 –1:1 F-W+24°Brix+N_1+Cl_1	2.1	3.9	2.9	1.2	1.0	11
T_6 –1:1 F-W+24°Brix+N_1+Cl_2	2.0	3.8	3.1	1.3	1.0	11.5
T_7 –1:1 F-W+24°Brix+N_2+Cl_1	2.5	4.0	2.9	1.3	0.9	11.5
T_8 –1:1 F-W+24°Brix+N_2+Cl_2	2.1	3.8	3.3	1.5	1.0	11.5
T_9 –1:2 F-W+1:1 F-S+N_1+Cl_1	3.0	5.1	5.3	2.7	1.7	18
T_{10} –1:2 F-W+1:1 F-S+N_1+Cl_2	1.8	3.8	4.4	2.0	1.4	13
T_{11} –1:2 F-W+1:1 F-S+N_2+Cl_1	2.2	4.6	5.2	2.5	1.7	16
T_{12} –1:2 F-W+1:1 F-S+N_2+Cl_2	1.9	4.8	5.1	2.5	1.7	16
T_{13} –1:2 F-W+24°Brix+N_1+Cl_1	2.8	4.6	3.7	1.7	1.3	14
T_{14} –1:2 F-W+24°Brix+N_1+Cl_2	2.0	4.2	3.6	1.6	1.2	13
T_{15} –1:2 F-W+24°Brix+N_2+Cl_1	2.8	4.9	3.5	1.6	1.2	14
T_{16} –1:2 F-W+24°Brix+N_2+Cl_2	2.1	3.9	3.4	1.5	1.0	12
K value	84.42	64.38	77.72	69.29	66.59	86.24
□2	24.99					

F-W: Fruit: Water ratio F-S: Fruit: Sugar ratio. N_1: With nitrogen source, N_2: Without nitrogen source, Cl_1: Clarified by pectinase, Cl_2: Clarified by settling.

content with increase in dilution level of wild apricot and jamun wines (Joshi *et al.* 1990 and Joshi *et al.* 2012). In a study by Vikas *et al*. (2011), the custard apple wine of 1:4 dilution with DAHP recorded higher alcohol content compared to 1:3 and 1:2 dilution with DAHP. Lowest polyphenol content (95.93 mg g^{-1}) was recorded when wine was prepared with 1:2 fruit: water ratio, 1:1 fruit: sugar ratio, without nitrogen source and clarified by settling (Fig. 7). Highest polyphenol content (253.29 mg g^{-1}) was recorded in the wine prepared with 1:1 fruit: water ratio, 1:1 fruit: sugar ratio, without nitrogen source and clarified by pectinase. Highest antioxidant activity (95.64%) was recorded in the wine produced with 1:2 fruit: water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified using pectinase (Fig. 8). The wine which was produced with 1:1 fruit: water ratio, 1:1 fruit: sugar ratio, without nitrogen source and clarified by settling had the lowest antioxidant activity (65.69%). Highest antioxidant activity was earlier reported in jamun wines produced with high fruit: water ratio of 1:2 (Das 2019). The antioxidant activity of wines is attributed to bioactive compounds especially polyphenols (Rivero Perez *et al*. 2008). Sensory analysis

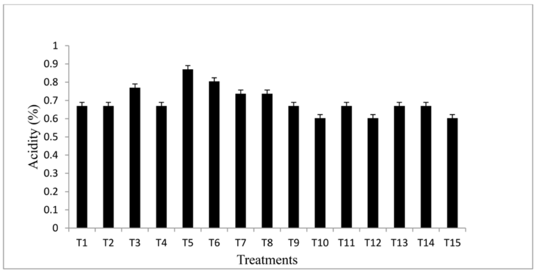


Fig. 3. Effect of process parameters on acidity of jamun wines.

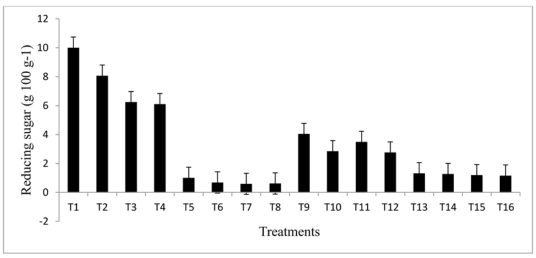


Fig. 4. Effect of process parameters on reducing sugar of jamun nes.

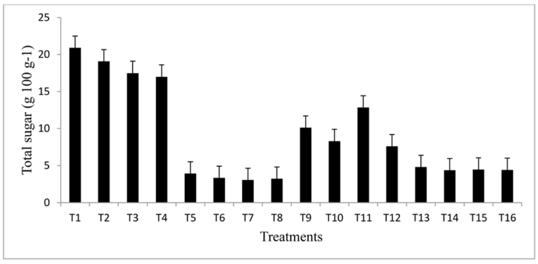


Fig. 5. Effect of process parameters on total sugar of jamun wines.

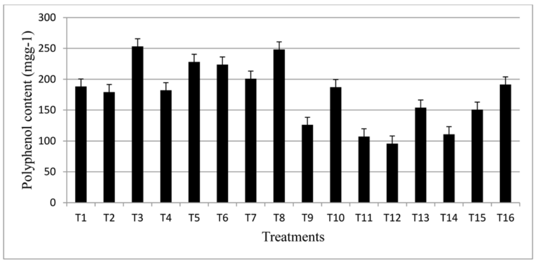


Fig. 7. Effect of process parameters on polyphenol content of jamun wines.

of jamun wines showed significant difference in the sensory quality parameters of jamun wines (Table 2). Maximum mean score for appearance (3.0) and after taste (2.7) was recorded in the wines produced using 1:1 or 1:2 fruit: water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified by pectinase. But the highest mean score for aroma (5.6), taste/texture (5.4), after taste (2.7) and overall impression (2.0) was observed in the wine produced with 1:1 fruit: water ratio, 1:1 fruit: Sugar ratio, without nitrogen source and clarified by pectinase. The mean total sensory score of jamun wines varied from 11 to 18.5. The wine produced using 1:1 fruit: water ratio, 1:1 fruit: sugar ratio, without nitrogen source and clarified by pectinase had the highest mean total score (18.5), hence considered extra ordinary. None of the wines were deficient or poor and objectionable. Mena *et al.* (2012) reported that the phenolic compounds greatly contribute to the sensory properties by affecting the colour, astringency and aroma. All wines produced with 1:1 and 1:2 fruit: water ratio, by maintaining 24° brix had high alcohol range of 10.55% to 14.06% and 13.18% to 15.82% respectively, irrespective of nitrogen source and clarification methods.

The common household technique of wine production involves usage of fruit: Water: Sugar in 1:1:1 ratio, clarification by settling with no addition of any nitrogen source. Wine produced by this practice had 89.2% yield, 4.39% alcohol content, low antioxidant activity (65.69%) with least appearance score (1.5) and total sensory score of 16. Anynew technology is to be compared with the traditional adopted technique before its recommendation. Replacement of settling with pectinase or addition of nitrogen source and use of pectinase or doubling the water content in addition to use of pectinase and nitrogen source to the household method had resulted in enhanced quality parameters. When clarification is replaced by pectinase , the resultant wine had 92.9% yield, 3.52% alcohol and 93.03% antioxidant activity with the highest total sensory score (18.5) and rated as extraordinary. Pectinase breaks down pectins which gives improved yield of juice when pressing, produces faster settling of juice, and may also release more aromatic constituents and increase the extraction of color components. These are the enzymes most useful to the winemaking process. Egwim *et al*. (2013) reported that addition of pectinase increased the organoleptic evaluation of banana and paw-paw wines. Sevda

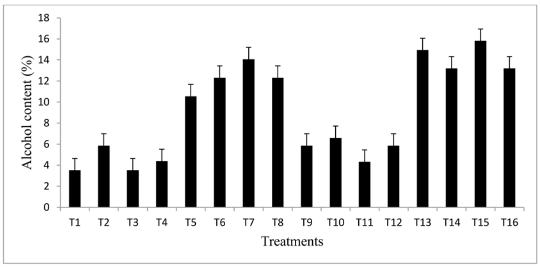
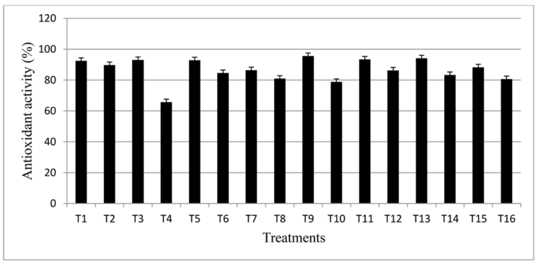


Fig. 6. Effect of process parameters on alcohol content of jamun wines.



Fig, 8. Effect of process parameters on antioxidant activity of jamun wines.

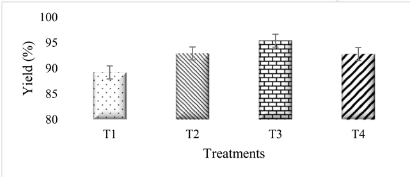


Fig. 9a

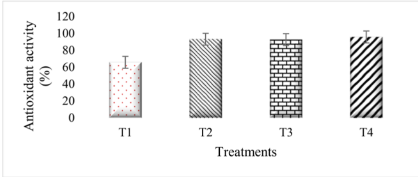


Fig. 9b

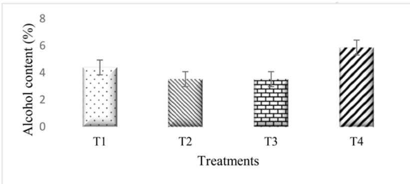


Fig. 9c

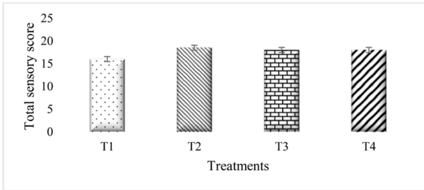


Fig. 9d

Fig. 9. (a-d) Comparison of superior jamun wines with wine prepared by common household method.

T_1: 1:1 fruit: Water ratio, 1:1 fruit: Sugar ratio, without nitrogen source, clarified by settling
T_2: 1:1 fruit: Water ratio, 1:1 fruit: Sugar ratio, without nitrogen source, clarified by pectinase
T_3: 1:1 fruit: Water ratio, 1:1 fruit: Sugar ratio, with nitrogen source, clarified by pectinase
T4: 1:2 fruit: Water ratio, 1:1 fruit: Sugar ratio, with nitrogen source, clarified by pectinase

et al. (2011) reported that pectinase treated banana produced better quality wine as compared to wine prepared without enzyme treatment. Wine produced using 1:1 fruit: Water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified by pectinase had 3.52% alcohol, highest (95.4%) yield and high antioxidant activity (92.5%). Nitrogen is the most important yeast nutrient, essential for yeast growth and yeast metabolism, influencing both fermentation kinetics and wine quality. It represents an important nutritional factor for yeasts during alcoholic fermentation due to its function in protein synthesis and sugar transport. Joshi *et al.* (2012) showed that jamun wine with 1:1 dilution was considered best as table wine due to good appearance, color, total acidity, sweetness, body and overall impression. The highest antioxidant activity (95.64%) was obtained for the wine produced using 1:2 fruit: Water ratio, 1:1 fruit: Sugar ratio, with nitrogen source and clarified by pectinase. This wine had 92.8% yield and 5.86% alcohol. Das (2019) reported that fruit wines prepared with 1:2 fruit: Water ratio had highest antioxidant activity. Kerala State Government had approved commercial production and sale of low alcoholic beverages with not more than 7% alcohol. Hence the parameters viz., high yield, superior antioxidant activity, high total sensory score and alcohol content within the approved range of low alcoholic beverages were considered for selecting the three superior wines. Wine produced using 1:1 fruit: water ratio, 1:1 fruit: sugar ratio, without nitrogen source and clarified by pectinase, wine prepared with 1:1 fruit: water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified by pectinase and wine prepared with 1:2 fruit: water ratio, 1:1 fruit: sugar ratio, with nitrogen source and clarified by pectinase were selected for storage study. Comparison of the wines prepared by house hold method and by the selected treatments is shown in Fig. 9.

Storage stability of selected wines: When the selected wines were stored in amber colored glass bottles under ambient condition for a period of two months for analysing the storage stability, it was seen that the polyphenol content of all wines decreased during maturation (Fig.10), which is in agreement with the findings of Chaudhary *et al.* (2015). Decreased phenol concentration is due to the susceptibility of phenolic constituents to degradation, condensation and polymerization, and subsequent precipitation (Zoecklein *et al.* 1995). The acceptability of wine increased on prolonged storage due to reduction of phenolic compounds and yeast odour on storage (Sharma and

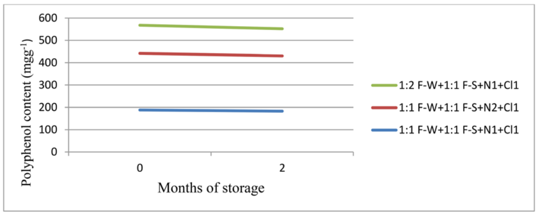


Fig. 10. Polyphenol content of selected jamun wines during storage.

Joshi 2003 and Chaudhary *et al.* 2017). The alcohol content of all wines decreased during ageing (Fig. 11) as stated by Joshi *et al*. (2012). Zoecklein *et al.* (1995) reported that decreased ethanol content during ageing is apparently the results of interaction between alcohols and acids to form esters.

CONCLUSION

Production of wine from jamun fruit was tried with varying process parameters viz., fruit water ratio, fruit sugar ratio, nitrogen source and clarification methods. Wine produced using 1:1 fruit: water ratio, 1:1 fruit: Sugar ratio, without nitrogen source and clarified by settling (common household practice) had 89.2% yield with 65.69% antioxidant activity, 4.39% alcohol content, but had least appearance score (1.5). Use of pectinase for clarification resulted in "extraordinary wine" with total sensory score of 18.5 with a comparatively high yield (92.9%) and antioxidant activity (93.03%). Addition of a nitrogen source and clarification by pectinase could produce wine with highest yield (95.4%) and the highest antioxidant activity (95.64%) was obtained when dilution was

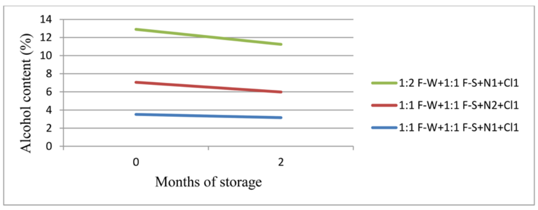


Fig. 11. Alcohol content of selected jamun wines during storage. F-W: Fruit: Water ratio, F-S: Fruit: Sugar ratio, N_1: With nitrogen source, N_2: Without nitrogen source, Cl_1: Clarified by pectinase. Cl_2: Clarified by settling.

increased to 1:2 along with usage of nitrogen source and pectinase. The polyphenol and alcohol content were decreased by two months of storage under ambient condition.

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