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Process standardization, characterization and storage study of a sweet potato (*Ipomoea batatas* L.) wine

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Abstract

An investigation was undertaken to identify the best fermentation process parameters for the production of wine from reconstituted sweet potato (*Ipomoea batatas*) juice and study the effect of storage period and temperature on sensory and optical attributes of wine. The extracted sweet potato juice was first treated with crude amylase solution at 5% v/v to hydrolyze the starch into fermentable sugar. It was further reconstituted by adding distilled water, 60% sucrose syrup and 0.1M oxalic acid at different concentrations to attain samples of final total soluble solids concentration (TSS) and pH in the range of 18 - 30ºBrix and 4.0 - 5.5, respectively. All the samples were fermented at 20 - 35ºC with inoculums size of 8 - 14% (v/v) till TSS and ethanol percentage remained constant for three consecutive days. The reconstituted juice with initial TSS content of 22ºBrix and pH of 4.5, fermentation process temperature of 25ºC and inoculum size of 10% (v/v) for the fermentation period of 240 h produced wine with highest ethanol percentage of 9.6. The titratable acidity, total sugar, reducing sugar and TSS of the wine were 0.83 g/100 g, 1.84 g/100 g, 1.65 g/100 g and 3.15ºBrix, respectively. Color of the wine was observed to be yellowish white with little transparency. The pH of the wine was 3.73 and it was slightly higher than the generally acceptable limit. Sensory evaluation revealed that the wine had a very good taste and aroma with good body. The wine also had acceptably good after-taste and color. The changes in total color difference (ΔE) and browning index of the wine were prominent during storage. The longer storage period at lower temperature resulted in the stability of changes in ΔE and browning index of the wine.

Introduction

Wine is a popular alcoholic drink. It is prepared from various fruit juices by fermentation. Though grape juice is widely used in conventional process of wine making, juice of various other fruits have also been explored for wine making (Shukla *et al*., 1991; Sandhu and Joshi, 1995; Adsule and Kadam, 1995; Joshi *et al*., 1997; Gautam and Chundawat, 1998; Joshi *et al.*, 2005; Zeng *et al*., 2008). Further, recent advances in microbial technologies, like genetic engineering, have given rise to the use of new yeast strains for wine making as against the use of wild strains employed earlier. However, rate and extent of fermentation depends on process parameters like, total soluble solids (TSS), fermentation temperature, pH, inoculum concentration, fermentation duration, etc. The overall quality of wine as expressed by its sugar level, acid content, color and aroma, is affected by the process and storage parameters besides the type of fruit and yeast cultivars used for its preparation.

The sweet potato (*Ipomoea batatas* L.) is a dicotyledon plant that belongs to the family Convolvulaceae. Sweet potatoes are native to the tropical parts of South America and are now cultivated throughout tropical and warm temperate regions such as China, Uganda, New Zealand, India and most of the other Asian countries. Sweet potato has large, starchy and sweet tasting tuberous roots. The roots are rich in starch, sugars, vitamin C, provitamin A, iron and minerals. Some varieties contain colored pigments such as β-carotene and anthocyanin (Yamakawa, 1998; Hou *et al.*, 2001). These pigments have antioxidant properties possessing health promoting attributes such as ability to fight cancer, protect against night blindness, delay aging and prevent liver injury. The roots are consumed as fresh vegetable or processed by steaming or boiling, baking, frying, roasting, making chips, converting into flour, etc. Roots of some of the cultivars are used for the preparation of beverage, paste, powder, alcohol drink and natural color (Islam and Jalaluddin, 2004). Reports on the production of non-alcoholic beverage from sweet potato are available in the literature (Coggins *et al*.,

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2003; Wireko-Manu *et al.*, 2010). But, no significant scientific work has been reported on the production of alcoholic beverages from sweet potato. High starch content coupled with delicious taste and flavor seems to be promising for the production of alcoholic beverage from sweet potato. Therefore, an attempt is made in the present study to standardize the process parameters for the production of wine from reconstituted sweet potato juice and evaluate its quality attributes during storage. The present study consisted of the following: (i) Study on the effect of various process parameters on the fermentation of reconstituted sweet potato juice and identification of the best fermentation process parameters for the production of wine with highest ethanol content. (ii) Preparation of wine based on best identified process parameters and its characterization. (iii) Evaluation of quality and optical attributes of the wine during storage at various storage temperatures.

Materials and Methods

Good quality, fresh sweet potatoes were collected and washed with water. They were then peeled, cut and blended in a blender (Philips HL1632). The juice was obtained by squeezing the blended material through a muslin cloth. The TSS of the juice was determined using a refractometer (Erma, Japan) and it was found to be 3ºBrix. The extracted juice was treated with crude amylase enzyme before the preparation of wine. All the reagents used for the enzyme treatment of juice and preparation of wine were of Merck, Germany make.

Preparation of crude amylase solution

Fresh and clean paddy seeds of Ranjit variety with 100% viability were collected for the preparation of crude amylase solution. Paddy seeds (20 g) were washed using a solution of 1% sodium hypochlorite. They were rinsed well with water and then soaked in distilled water for 12 h. The seeds were allowed to germinate by keeping them covered at 25ºC for 120 h on a filter paper moistened with streptomycin (5 µg/ml). Use of streptomycin prevented the microbial growth. The vegetative portions were discarded and the endosperm tissues were homogenized by shaking in a buffer of 0.01M sodium acetate (pH 5.6) at a temperature below 4ºC. The extract was centrifuged at 5000 g for 15 min. The supernatant was collected and adjusted to pH 8.0 using 0.1N sodium hydroxide. Digital pH meter (Sartorius PB-11, Germany) was used for the determination of pH. This is the crude α and β amylase enzyme solution and it was stored at 4ºC (Shaw, 1982).

Assay of enzyme activity

Amylase activity of the extracted crude amylase enzyme of germinated paddy was determined by modified dinitrosalicylic acid method (Shaw, 1982; Park *et al.*, 1997). One milliliter of 1% starch solution and 1 ml of the enzyme solution were mixed in a test tube and incubated at 27ºC for 15 min. The reaction was terminated by adding 2 ml of dinitrosalicylic acid reagent. This mixture was heated in a boiling water bath for 5 min and immediately 1 ml of 40% potassium sodium tartarate solution was added. The hot solution was cooled by holding the test tube against the running tap water. The volume of the solution was made up to 100 ml by adding double distilled water. The absorbance was read at 540 nm in a UV-Vis spectrophotometer (Cecil Aquarius 7400). One unit of amylase activity was expressed as milligram of maltose produced in 5 min incubation with 1% starch taking 0 - 100 µg maltose as standard. It was found that the extracted crude amylase enzyme of germinated paddy produced 88 mg of maltose on 5 min incubation.

Enzyme treatment

Enzyme solution (5% v/v) was mixed with sweet potato juice and stirred well. The juice was kept in an incubator shaker (Sartorius Certomat IS) at 37ºC for 6 h to achieve maximum hydrolysis of the starch. Bentonite was introduced (10 g/l) to the must to ease the sedimentation of non-fermentable solids. The bentonite had been previously perched in water to a concentration of 10 g/l for facilitating its dispersion in the must (Whasley *et al.*, 2010). The enzyme treated material was then passed through a set of standard sieves of 100 µm pore size to remove fibre and other unfermentable materials and particles. The enzyme treatment raised the TSS of the sweet potato juice from 3ºBrix to 9ºBrix.

Yeast culture and inoculums preparation

The method described by Reddy and Reddy (2005), Ghosh *et al.* (2012) and Hong-Guang *et al.* (2012) was employed with slight modification for the preparation of inoculums. Pure culture of wine yeast viz., *S. cerevisiae* var. *ellipsoideus* strain was collected and maintained on MPYD (Malt extract 0.3%, Peptone 0.5%, Yeast extract 0.3%, Dextrose 2% and Agar 1.5%) slants at the storage temperature of 4°C. The slant culture was inoculated into 50 ml sterile MPYD broth in a 250 ml conical flask and allowed to grow in an incubator at a temperature of 37ºC and pH of 4.5 with slow rotary shaking for 48 h to prepare the inoculums. The prepared inoculum with cell concentration of 4 $\times 10^6$ CFU and optical

density of 1.35 was used for the experiments.

Fermentation and range of process parameters

The enzyme treated sweet potato juice was reconstituted by adding distilled water, 60% sucrose syrup and 0.1M oxalic acid at different concentrations to attain samples of final TSS in the range of 18 - 30ºBrix and pH in the range of 4.0 - 5.5. One hundred ppm of potassium metabisulphite was added prior to fermentation. The samples were then inoculated with different inoculums sizes (in the range of 8 - 14% v/v) and allowed to ferment at different temperatures ranging from 20 to 35ºC till maximum fermentation is achieved for individual samples. TSS and percent ethanol of the individual samples were determined at every 24 h interval after the first 72 h of fermentation. Fermentation process was decided to be completed when TSS and percent ethanol of the fermenting product was found to be constant for consecutive three days (Hong-Guang *et al*., 2012). The effect of all the four independent process parameters (TSS, pH, inoculum size and temperature) on fermentation of reconstituted sweet potato juice was studied. The dependent parameter was the ethanol production (%) and it was analyzed by the method proposed by Caputi *et al.* (1968). The range of the independent parameters was decided based on previous research (Cone, 1995; Reddy and Reddy, 2009; Kumoro *et al*., 2012; Ghosh *et al*., 2012; Hong-Guang *et al.*, 2012) on wine preparation from various fruits and other suitable sources and pre-experimental trials on reconstituted sweet potato juice.

Design of experiment and data analysis

The purpose of experiment is to determine the effects of various independent parameters (TSS, pH, inoculum size and temperature) on the dependent parameter (percent ethanol production) and identify the best combination of process (independent) parameters for maximum percent ethanol production. Hence, fermentation of reconstituted sweet potato juice with 4 levels of final TSS (18, 22, 26 and 30ºBrix) and 4 levels of pH (4.0, 4.5, 5.0, 5.5) was carried out by inoculating 4 levels of inoculums size (8, 10, 12 and 14% v/v) at 4 levels of temperature (20, 25, 30 and 35ºC) within the range of values selected above. Full factorial design of experiment with 3 replications for each combination of independent process parameters was conducted. The dependent parameter was the percent ethanol produced after the completion of the fermentation process. The data were subjected to analysis of variance to determine the significance of main and interaction effects. Data were plotted and significant differences between the means were evaluated using Duncan's multiple range test at $p \leq 0.05$ using statistical package for the social sciences SPSS 11.5 (SPSS Inc., Chicago, IL, USA).

Characterization of reconstituted juice and wine

The reconstituted juice was prepared and wine was produced by fermenting the juice using one of the combinations of the independent parameters that resulted in the highest ethanol formation after the completion of the fermentation process. TSS and pH of the wine were determined. The titratable acidity and ascorbic acid of the reconstituted juice and the wine were analyzed as per the method proposed by Ranganna (1986). Total sugar, reducing sugar and protein content was analyzed as per AOAC (2000). The total solids were determined by filtering 10 ml of the juice through a pre-weighed Whatmann filter paper No. 1. The filtrate was taken in a pre-weighed crucible. The crucible and filter paper were dried in a hot air oven at 100 ± 5ºC till a constant weight was obtained. Browning index (optical density at 420 nm) and daylight color parameters of the wine were measured using UV-VIS spectrophotometer (Cecil-7400, 7000 Series Aquarious) and Hunter Lab Color Quest (Model Ultrascan Vis-Model, USA), respectively. The results of color values were expressed in L, a, b system (Francis, 1998), where L indicates degree of lightness or darkness (L = 0 indicates perfect black and L = 100 indicates most perfect white), a indicates degree of redness (+) and greenness (-), and b indicates degree of yellowness (+) and blueness (-). C indicates chroma ($C = \sqrt{(a^2+b^2)}$) and H indicates hue angle ($H = \tan^{-1}(b/a)$).

Sensory evaluation of the wine

Sensory analysis of the wine was conducted by a panel of 50 semi-trained, non-smoking judges for various sensory parameters i.e., color, clarity, taste, aroma, after-taste, body and overall acceptability on a 9-point Hedonic scale (Dias et al., 2007). The lowest score in the scale 1 meant disliked-most, 5 meant neither liked nor disliked, and the highest score 9 meant liked-most. The judges were instructed to rinse their mouth after testing each parameter and were provided 20 ml of the prepared wine at chilled condition.

Evaluation of sensory and optical attributes of wine during storage

The wine was sealed in 250 ml amber glass bottles and stored at 4ºC, 15ºC and 25ºC temperatures up to 90 days. The changes in sensory attributes, browning indices and total color differences were analyzed once every 15 days. Total color difference (ΔE) was

calculated as the root mean square of the differences in individual L, a and b values (Maftoonazad and Ramaswamy, 2005) as follows:

$$\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{0.5}$$

where, ΔL, Δa and Δb indicates the differences in L, a and b values of stored wine on every fifteenth day and corresponding values on day 0. This represents the time related changes of color parameters.

Results and Discussion

Effect of process parameters on fermentation of reconstituted sweet potato juice

The percent ethanol produced after the completion of the fermentation of the reconstituted sweet potato juice at various combinations of the independent parameters in the selected range varied from 6.9 to 9.8. Figure 1 shows the variations in the percent ethanol produced at various combinations of TSS, pH of the reconstituted sweet potato juice, inoculums size and fermentation temperature. The fermentation temperature of 25ºC and pH of 4.5 was found to be favorable for the fermentation of sweet potato juice. Singh and Kaur (2009) reported the highest ethanol formation at the fermentation temperature in the rage of 25 to 30ºC for litchi juice, whereas Hong-Guang *et al*. (2012) reported 22.65°C as the optimum for the preparation of blue berry wine. Joshi *et al.* (1997) reported pH of 4.5 as optimal for the fermentation of kinnow juice. The increase in temperature above 25ºC and pH above 4.5 decreased the percent ethanol produced. This may be due to the susceptibility of cells and their enzymes to the variation in favorable temperature and pH. The extrinsic temperature and pH control the cell viability, growth rate, exponential phase, enzyme activity and membrane function (Narendranath *et al*., 2001; Torija *et al.*, 2003; Ghosh *et al*., 2012). The percent ethanol produced was higher when the TSS of the juice was in the range of 18 to 22ºBrix and further increase in TSS decreased the ethanol formation. Similar results were reported for litchi, strawberry and kinnow wine (Singh *et al.*, 1998; Joshi *et al.*, 2005; Singh and Kaur, 2009). The inoculum size of 10% (v/v) produced the highest percent ethanol at all combinations of pH and fermentation temperatures and it was closely followed by inoculums size of 12% (v/v). Singh *et al.* (1998) and Singh and Kaur (2009) reported the similar trend for kinnow and litchi wine, respectively. Higher inoculum size produces more toxic metabolites and creates a nutritional deficit in the fermentation media leading to the disturbances in the favorable growing conditions of the yeast.

Best fermentation process parameters for the preparation of wine

The analysis of variance of percent ethanol produced is presented in Table 1. The main and interaction effect of all the independent parameters had the significant effect (1% level) on percent alcohol produced. Means of all possible combination of independent parameters were compared (Duncan's multiple range test at $p \leq 0.05$) and the best 8 combinations of independent parameters are listed in Table 2. Reconstituted sweet potato juice with TSS of 22ºBrix, pH of 4.5, inoculums size of 10 - 12% (v/v) and fermentation temperature of 25ºC was found to be the best combination of parameters for wine preparation. Decreasing TSS to 18ºBrix with inoculums size of 10% (v/v) also favored highest ethanol formation. Increasing the fermentation temperature to 30ºC or decreasing the inoculums size to 8% (v/v) with other parameters at the best identified levels significantly reduced the alcohol formation.

The wine was produced by preparing 500 ml of reconstituted juice and fermenting it at one of the best identified combinations of parameters for alcohol production, i.e., TSS = 22ºBrix, pH = 4.5, inoculums size = 10% (v/v) and fermentation temperature = 25ºC. In a conical flask of 1 litre capacity, 500 ml of reconstituted juice (22ºBrix TSS and 4.5 pH) was treated with 100 ppm potassium metabisulphite. The juice was inoculated with inoculum size of 10% (v/v) and allowed for fermentation at 25ºC temperature. TSS and percent ethanol of the fermenting product was found to remain constant after 168 h of fermentation period. The process was continued till next three days for further evaluation and fermentation was terminated at 240 h of fermentation. The fermented juice was subjected to racking and filtration. The wine was filled in clean glass bottles up to the brim and preserved with 50 ppm of sulfur dioxide in the form of potassium metabisulphite for 15 days. The matured wine was pasteurized for 20 min at 64 ± 2ºC temperature.

Physicochemical and optical attributes of reconstituted juice and wine

The physicochemical and optical quality parameters of the crude enzyme treated juice and the wine prepared from it (240 h of fermentation) are given in Table 3. The high content of sugar (total sugars 19.5 ± 0.65%; reducing sugars 16.25 ± 0.23%) in the crude enzyme treated sweet potato juice allowed for fermentation to take place and yield 9.6 ± 0.28% alcohol. Ethanol content in wine

Table 1. Analysis of variance of percent ethanol produced with TSS and pH of the reconstituted sweet potato juice, inoculums size (IS) and fermentation temperature (Temp)

Source	df	MSS	F
TSS	3	19.281	7712.38**
pH	3	48.216	19286.25**
IS	3	3.894	1557.50**
Temp	3	22.229	8891.63**
TSS × pH	9	0.738	295.29**
TSS × IS	9	0.223	89.04**
pH × IS	9	0.0623	24.92**
TSS × pH × IS	27	0.0320	12.79**
TSS × Temp	9	0.514	205.67**
pH × Temp	9	0.846	338.21**
TSS × pH × Temp	27	0.488	195.25**
IS × Temp	9	0.0462	18.46**
TSS × IS × Temp	27	0.0206	8.22**
pH × IS × Temp	27	0.0236	9.43**
TSS × pH × IS × Temp	81	0.0257	10.27**
Error	512	0.0025	

** Significant at 1% level of significance

Table 2. Best combination of independent parameters for the wine production from reconstituted sweet potato juice

TSS (ºB)	pH	Inoculums size (%, v/v)	Temperature (ºC)	Percent alcohol produced
22	4.5	8	25	9.5[d]
22	4.5	10	25	9.8[a]
22	4.5	12	25	9.8[a]
22	4.5	14	25	9.7[b]
22	4.5	10	30	9.6[c]
22	4.5	12	30	9.5[d]
18	4.5	10	25	9.8[a]
18	4.5	12	25	9.5[d]

Data are mean of 3 replications. Different letter above the values of the dependent parameter indicate significant differences at $p \leq 0.05$ (Duncan's multiple range test)

Table 3. Physicochemical parameters of enzyme treated sweet potato juice and wine prepared from it. Values are mean ± standard deviation (n = 3)

Parameter	Enzyme treated sweet potato Juice	Sweet potato wine
pH	4.15 ± 0.09	3.73 ± 0.07
TA (oxalic acid)	2.3 ± 0.15 g/100 g	0.83 ± 0.11 g/100 g
Total sugar	19.5 ± 0.65 g/100 g	1.84 ± 0.23 g/100 g
Reducing sugar	16.25 ± 0.23 g/100 g	1.65 ± 0.16 g/100 g
TSS	8.9 ± 0.1ºBrix	3.15 ± 0.06ºBrix
Ascorbic acid	20 ± 0.46 mg/100 g	-
Protein	0.58 ± 0.08 g/100 g	-
Ethanol production	-	9.6 ± 0.28 mL/100 mL
OD	-	0.22 ± 0.01
Color parameters		
L	-	58.65 ± 0.15
a	-	0.64 ± 0.09
b	-	11.6 ± 0.16
H	-	86.84 ± 0.48
C	-	11.61 ± 0.15

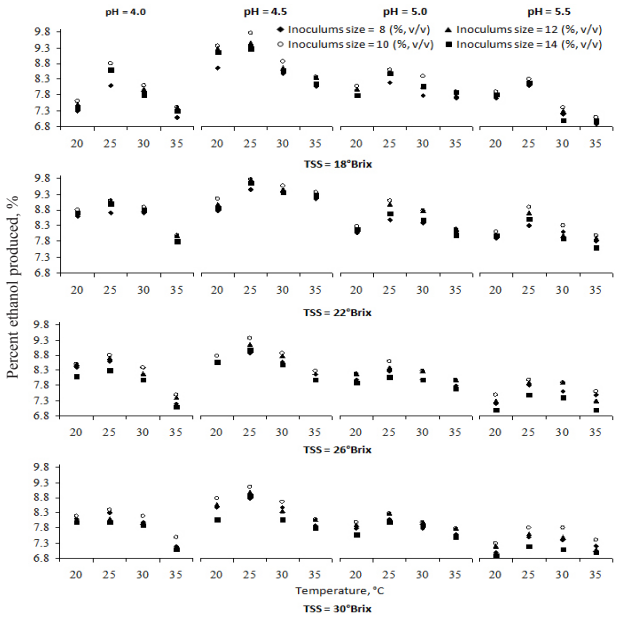

Figure 1. Variations in percent ethanol produced after the completion of fermentation process of the reconstituted sweet potato juice with variation in temperature and inoculums size at different combinations of pH and TSS of the juice.

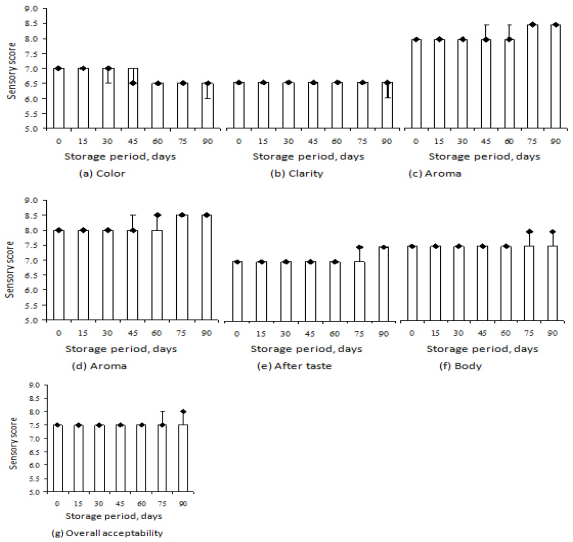

Figure 2. Changes in sensory attributes of sweet potato wine with storage period and temperature. Bars indicate the scores of sensory attribute when stored at a temperature of 4 ºC. The symbol ♦ indicates the scores of sensory attribute when stored at a temperature of 15ºC. Error bars indicate the difference in scores of sensory attribute when stored at a temperature of 25ºC in comparison to that at 4ºC.

is a key parameter for the characterization of wine into various categories. Table wine usually contains 11 - 14 g/100 g of alcohol and it may be as low as 7 g/100 g (Joshi, 1998). Thus, the wine prepared using the sweet potato juice in the present study can be considered as a light table wine. Total sugars and total acids are generally considered as the two main factors for the production of wines from any juice while ethanol content is the most important parameter for evaluating wine quality. The ethanol content in wine is influenced by the type of yeast used, method of wine preparation and initial TSS before fermentation (Joshi *et al*., 1991). The low content of residual sugar and low level of TSS in the prepared wine indicates that almost all the sugars present in the reconstituted juice were used during fermentation. Titratable acidity is an important characteristics for the better taste and aroma of wine (Joshi, 1998). The acidity of wine depends on a number of factors like, type of raw material used, method of preparation and type of yeast used. The wine prepared in the present study had the titratable acidity within acceptable limits (0.5 - 1.0%). However, the pH of the wine (3.73 ± 0.07)

Table 4. Effect of temperature and storage period on optical properties of sweet potato wine

Storage temperature (ºC)	Optical parameters	Storage period (Days)					
		15	30	45	60	75	90
4	ΔE	0.57	1.34	2.01	2.75	2.87	2.91
	Browning index	0.22	0.24	0.27	0.32	0.33	0.33
15	ΔE	1.23	2.17	3.35	4.20	4.34	4.33
	Browning index	0.23	0.26	0.30	0.34	0.35	0.35
25	ΔE	1.63	2.87	4.25	5.16	5.40	5.52
	Browning index	0.25	0.29	0.34	0.36	0.36	0.37

was found to be slightly higher than the generally considered maximum level of 3.5. Reddy and Reddy (2005) reported pH, titratable acidity and ethanol percentage in the range of 3.6 - 4.0, 0.6 - 0.82 and 6.5 - 8.0 for the wine samples prepared using 6 different varieties of mango. Optical density (OD) of the sweet potato wine was found to be 0.22 ± 0.01 and the values of L = 58.65 ± 0.15, a = 0.64 ± 0.09 and b = 11.6 ± 0.16. The hue angle, H = 86.84 ± 0.48 and chroma, C = 11.61 ± 0.15. Thus, visual color of the wine was yellowish white with little transparency.

Sensory analysis of the wine

The mean scores of the sensory attributes by the 10 semi-trained panel members are presented in Figure 2 along with their variation with storage period and storage temperatures. On the day when wine was ready (0 day), it had a very good taste and aroma with good body. The wine also had an acceptable good after-taste and color. However, the clarity of the wine was assigned quite low scores by the panelists. This may be due to lack of aging and presence of polysaccharide molecules that might have resulted in insufficient malolactic fermentation including other physicochemical improvement. However, the clarity and slightly high pH of the wine suggests that there is scope for further improvement of the wine quality in terms of color and acid strength. Probable alternatives can be enzyme treatment of the prepared wine to simplify the polysaccharide molecules, addition of natural pigments and acidulants or blending with other fruit juices/wines at a suitable ratio.

Sensory and optical attributes of wine during storage

Temperature and storage period produced some alterations in both sensory and optical parameters (Figure 2 and Table 4). Both sensory and optical attributes were more stable at lower temperatures than at higher temperature. It might be due to lower rate of biochemical reaction at lower storage temperatures. Almost all sensory parameters were stable at shorter storage period with almost no change in organoleptic sensation. However, at longer storage period, the wine developed recognizable alteration in quality. It can be observed in Figure 2 (c - f) that taste, aroma, after-taste and body characteristics got improved with time and temperature during storage making its overall acceptability high.

Changes in colorimetric parameters of the sweet potato wine with storage period and storage temperatures are presented in Table 4. Browning index of the wine in terms of optical density was found to increase with increase in storage period, but the rate of increment was quite slow at 4ºC (0.22 on 0 day and 0.33 on 90 days storage period). Storage of wine at higher temperature increased the browning index at a higher rate as OD of the wine at 25ºC got raised to 0.37 in 90 days of storage period. This can be attributed to different browning reactions and formation of the brown polyphenolic compounds at a higher rate at elevated temperature. It was also observed that the browning index increased upto a certain storage period but after that no significant difference in browning index was observed. It may be due to the exhaustion of the substrate or/and inter-conversion or molecular rearrangement of the brown pigments. Due to this fact, visual clarity of the wine got decreased at longer storage period with higher temperature. Similar trend in visual clarity has also been reported for mango wine (Reddy and Reddy, 2009).

Hunter Color Lab results revealed that degree of lightness (i.e., L value) decreased with increase of storage period. Rate of decrease of lightness of wine is almost same at all temperatures, but increase in storage temperature slightly raised the decreasing rate of lightness of the wine. It was found that a and b value of the wine tends towards positivity, thus reducing its greenness and intensifying the yellowness with increase in storage period. It was observed that ΔE value raises at a higher rate at 25ºC than at lower storage temperatures. After 90 days of storage period ΔE of the wine were 2.91, 4.33 and 5.52, respectively at 4ºC, 15ºC and 25ºC, which indicates increase in temperature fasten the reaction rate of color transformation with significant deviation in overall color change (ΔE) value. It also revealed that upto a certain storage period, the rate of change of ΔE value is rapid which gradually declines at the later stage indicating higher color stability (Selli *et al.*, 2002).

Conclusion

The study revealed that the sweet potato has a tremendous potential to be used as a raw material for wine production with very good physicochemical, optical and sensory attributes. Further work to improve its clarity and pH would certainly lead to

a newer dimension in the use of sweet potato as a potential source for quality wine production. Probable alternatives for quality improvement of the wine can be enzyme treatment, addition of natural pigments and acidulants or blending with other fruit juices/ wines at a suitable ratio. This study establishes the scope for further research in the area of alcoholic fermentation of this root vegetable.

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