AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2024; 24(9): 24656-24674 https://doi.org/10.18697/ajfand.134.24900

Date	Submitted	Accepted	Published
	30th April 2024	17th August 2024	4th October 2024

CONSUMER ACCEPTABILITY AND PHYSICOCHEMICAL PROPERTIES OF KENYAN CACTUS FRUIT WINE

Mwenda DM[1]*, Abong' GO[1], Kaindi DWM[1] and DG Omayio[1]

Denis Mutugi Mwenda

*Corresponding author email: denismutugi98@gmail.com

[1]Department of Food Science, Nutrition and Technology, University of Nairobi, P.O. Box 29053-00625, Nairobi, Kenya

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Cactus pear fruits are rich in phytochemical compounds. They are dominant in the Kenya's Arid and Semi-Arid [ASAL] areas due to their adaptation to prolonged drought. However, processing technologies to utilize these fruits in making consumer acceptable, therapeutic and quality products are almost non-existent in Kenya. This study sought to process the cactus fruits from Laikipia and Baringo to a high quality and acceptable red wine using *Saccharomyces cerevisiae* [Wine yeast BV818 and Baker's yeast] as fermentation factors. It incorporated a completely randomized study design to assess the wines' physicochemical parameters and a 7-point hedonic scale for sensory evaluation. Total soluble solids and pH were monitored over 24 days after which the wines were evaluated for sensory acceptability, color and phytochemical compositions. There were significant [$p<0.05$] differences in sensory parameters between the fruit wines, with Laikipia-made wines more accepted [5.28-5.46] and with higher scores in color [6.06-6.21], mouthfeel [5.39-5.42] and astringency [5.13-5.31] compared to Baringo-made wines that ranged between 5.33-6.04 for color, 4.64-5.29 for mouthfeel and 4.56-5.23 for astringency. Laikipia-made wines had a higher redness value [7.00-8.83] than Baringo ones [5.50-7.33]. Wine yeast [BV818], produced a higher alcohol content that ranged 14.08-14.17 % though not significantly [$p>0.05$] different to ones fermented by bakers' yeast [13.67-13.92. The pH, titratable acidity [T.A] and Total soluble solids [TSS] levels for the wines ranged at 4.1 -4.4, 0.8-1.4 g 100^{-1} L and 6.8-7.3^0 brix respectively. Vitamin C levels ranged [519.16-1078.91 mg 100^{-1} g], free phenolics [180.79-285.10 mg GAE 100^{-1} g] and flavonoids levels [179.26 – 242.46 mg CE 100^{-1} g]. The findings on high phytochemical compounds, average overall acceptability [5.17], and alcohol percentage within still table wines [6.5-16.5%] range maps cactus fruits as an alternative fruit for red wines in the local markets and indicate their potential in commercial utilization in the food industry.

Key words: Cactus, fermentation, phytochemicals, wine, alcohol levels, Laikipia, Baringo, acceptability

INTRODUCTION

Cactus pear fruits contain phytochemicals such as polyphenols and vitamin C [1] and well-adapted to survive and thrive in hot and harsh ecological conditions [2]. They possess a deep red color due to naturally coloring pigments-betalain that gives products an attractive red color [3]. Unfortunately, there exists very few processing technologies and value-addition practices for the fruits in Kenya, despite the dominance and prevalence of the fruits in the arid and semi-arid areas [4]. The fruits experience high post-harvest losses especially in seasons of glut with the fruits either being fed on by both wild and domestic animals while the rest end up rotting [5]. Whereas globally cactus plants have been commercially utilized to make several products, very little has been realized from the Kenyan cactus fruits [6]. Several studies across the globe have reported the possibility of cactus pear fermentation to make wines [7,8]. During fermentation, the health-promoting phytochemical and bioactive compounds from the fruits are translated to the fruit wines [9]. An acre of land is estimated to produce up to 50 tons of the cactus fruits annually, which requires processing to counter post-harvest losses [4]. With Kenya's wine industry slowly taking pace, utilizing the Kenyan cactus fruits to develop a red wine would provide an alternative to the red wines processed from grapes [10]. Value addition on cactus pear fruits and developing a processing technology will boost utilization and raise the socioeconomic status of the communities where the crop grows in Kenya. This study was designed to develop a fruit wine from the Kenyan cactus fruits, and evaluate their physicochemical properties and consumer acceptability.

METHODOLOGY

Study Area

Cactus fruit wine development was carried out at the Department of Food Science, Nutrition and Technology, University of Nairobi between the months of November 2022 to February 2023. Approximately 200 kgs of mature-firm ripe fruits were procured from each study area [Laikipia and Baringo counties], with the mature firm-ripe fruits harvested between 6 am to 10 am to counter losses due to field heat, collected under shade to prevent direct sunlight on the fruits, put in airtight food grade storage plastic containers and immediately transported via road to the Food processing hub at the University of Nairobi. On arrival, they were sorted to remove any bruised/ injured fruit before being stored in a cold room set at a temperature of 10 ± 2^{o} C and relative humidity RH 75% for further analysis. This aimed to control faster spoilage and deterioration on the fruits which are non-climacteric in nature.

Study design

A two-stage factorial design was incorporated in cactus fruit sourcing from Laikipia and Baringo and fermenting fruits using wine yeast [BV818] and baker's yeast.

https://doi.org/10.18697/ajfand.134.24900

Approximately, 100kg of cactus fruits from each study zone were purposively selected for pulp preparation using a locally fabricated crusher, presser, and pulper machine. The pulp was then homogenized by stirring before being split into duplicates of four equal batches of about 25 kgs each per region source for further amelioration and yeast inoculations.

Cactus fruit wine fermentation

The wine yeast was directly imported from Angel Yeast Co., Ltd in Yichang City, 168 Chengdong Avenue, Yichang, Hubei 443003, China due to unavailability in the Kenyan market while the Angel instant dry yeast was purchased in a randomly selected local supermarket within Nairobi County, Kenya. Initial levels of total soluble solids [TSS], pH, and titratable acidity were determined in the fruit. TSS was regulated by the addition of 240g/L sugar to the must to adjust the brix of the must and acidity lowered by the addition of 0.2 % of calcium bicarbonate. Given the pulpy nature of the cactus pulp, 0.05 % pectinase enzyme was added to the must and held at 45-55 ^{o}C for 1-2 hours to allow the breakdown of the pulp fibers. Fermentation was carried out in 25-liter micro fermenter tanks purchased from Kariokor market, Nairobi, modified to have an air lock fitted at the top and the other end immersed in water to allow escape of excess CO_2 gas, maintain anaerobic conditions and had an air-tight tap was fitted at the bottom side of the fermenter tanks that allowed sample drawing for analysis during fermentation. Bakers and wine yeast were first activated by adding 1 % of yeast by weight of must to 2 % sugar solution at 30 ^{o}C, gently swirled, and left to stand for about 15 minutes for yeast rehydration after they were inoculated to the respective fermenter bottles. Fermentation was conducted at room temperature [25±5^{o}C] with monitoring of pH and Total soluble solids [TSS] done at an interval of two days until all activity of the yeast was done. After 10 days, they were transferred into a cold room [10±2^{o}C] for 20 days for aging after which wine was filtered using a high-pressure Filtrox – Werk AG machine [CH 9001, St Gallen, Switzerland] fitted with square [0.4m] Beco KD 5 filter sheets. The final wine was put in cherry green 750 ml wine bottles, tightly sealed, and pasteurized by immersing the bottles in hot water [85 ^{o}C] for 3-5 minutes. They were then transferred to a dark chamber at room temperature for storage until further analysis.

Sensory analysis

Sensory evaluation of the cactus fruit wines was carried out in well-lit and ventilated individual booths set aside in the sensory analysis room at room temperature [25°C]. Randomly selected untrained panelists [n=39] from the Faculty of Agriculture, the University of Nairobi comprising of adults of mixed gender [>18 years] with varying age categories were allowed to evaluate the sensory aspects of the fruit wines including color, flavor, smell, sourness/bitterness, sweetness, mouthfeel, and astringency. The evaluation scores were based on a 7-point hedonic scale following

https://doi.org/10.18697/ajfand.134.24900

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

procedures described by Granato *et al.* [11]. The panelists were presented with eight wine samples to include two samples made from Laikipia-sourced fruits fermented by either bakers or wine yeast and two samples made from Baringo-sourced fruits fermented either bakers or wine yeast and their duplicates. They were guided on the evaluation process of the 8 samples to rate on a scale of 1-7 [1=dislike very much, 2=slightly dislike, 3=moderately dislike, 4=neither like nor dislike, 5=slightly like, 6=moderately like, 7=like very much] and allowed to re-test to ensure the correct ranking in filling the sensory sheets. Fifty millilitres [50ml] of fruit wine samples were put in clear and coded wine glasses and presented to the panellists alongside a bottle of potable water for mouth rinsing in between from one sample to the other during evaluation.

Analytical methods for the wines

Proximate composition

The moisture content of the pulps was determined using the AOAC [2005], method number 930.5. The crude fat content was determined by solvent extraction method as specified in AOAC 2000 b, method number 960.39. The crude protein contents were determined using the Kjeldahl method as specified in AOAC [2006] method number 990.03, getting the Total Nitrogen which was multiplied by a protein conversion factor of 6.25 to obtain the protein content. The ash content was determined as per AOAC method protocol 942.05. Carbohydrate content was determined by the difference method, where CHO = 100 - [Protein% + Moisture% + Fiber + Fat% + Ash%] and energy was calculated based on Atwater factors for protein [4], carbohydrate [4], and fat [9] and expressed in kilojoules per 100 g. The results were determined in duplicates.

Chemical composition

The titratable acidity of the wine samples was determined titrimetically following AOAC, [2000a] protocol 942.15, as described by Balogun *et al.* [13]. Total soluble solids were determined using a hand-held refractometer [SK106R-SATO, Japan] by placing a drop of wine on the refractometer screen on one end and reading taken in degree Brix on the scale. The pH values were determined using a digital Five Easy pH meter, model F20 [Mettler, Toledo, USA], calibrated with 4.1, 7.0, and 9.1 pH water. Readings of the fresh samples were recorded in duplicates and tabulated as means and standard deviations

Phytochemical composition

Vitamin C was analyzed using the AOAC official method 967.21 [2, 6-dichloroindophenol] titrimetric method as described by Okumu *et al.* [14] where ten milliliters [10ml] of the samples were put in a 100ml conical flask and filled to the mark with 5% Trichloro Acetic Acid [TCA] and titrated against 2,6- dichlorophenol indophenol. The folin-Ciocalteu method was used to determine the Total phenolic

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

content according to the procedure outlined by Okumu *et al.* [14], with slight modifications using about 0.2 g of dried cactus wine put in a falcon tube added to 2ml petroleum ether and vortexed for 10 minutes at 3000g centrifugation for fat removal. The supernatant was discarded and the sample left to dry. To extract the phenolics, 2ml of 80% methanol, 2ml of 50% methanol and 2ml of 70% acetone acidified with 1% concentrated HCL was added and topped to 10 ml with distilled water. Three [3ml] of the extract was added to 1.5 ml of folin reagent, and centrifuged for 5 minutes after which, 1.2 ml of 7.5% aqueous sodium carbonate was added. The sample was left at room temperature for 30 minutes and absorbance was read at 765nm with the blank being distilled water using Hitachi 2900, UV/VIS spectrophotometer [Tokyo, Japan]. Phenolics were expressed in mg gallic acid equivalent [mg.GAE.g-1] per 100 g dry weight basis. Flavonoids were determined by the aluminium chloride colorimetric method as described by Atanassova *et al.* [15] with their milligrams of catechin [mgCE] per 100 g in dry weight basis and readings taken in duplicates. Reducing sugars were determined by the Luff-Schoorl method as Garro-Mellado *et al.* [16] described. The alcohol content was determined hydrometrically. All the results were recorded in duplicates on dry weight basis.

Color Analysis

The wine samples were subjected to color analysis for *l*, a*, b**, hue angles, and Chroma using a PCE colorimeter [PCE Instruments, London, UK]. Following the manufacturer's manual, the colorimeter was first black and white calibrated to ensure accuracy and precision in color determination. Three milliliters [3ml] of the wine samples were put in a clear 10 ml container and placed in the colorimeter for color determination. The color values of the samples were taken in duplicates and outputs including hue angle and chroma displayed through an interlinked colorimeter software.

Data Analysis

Data from both the laboratory and sensory evaluation data was filled in Microsoft excel for analysis. Sensory parameters were analyzed using sensory packages in XLSTAT to show the panelist scores on the different organoleptic parameters and display the most preferred. The physicochemical compositions of the cactus fruit wines were determined using one-way ANOVA and Tukey's HSD test to separate significantly [$p<0.05$] different means among the different fruit wines parameters using XLSTAT Microsoft Excel plugin software [17].

RESULTS AND DISCUSSION

Sensory evaluation of cactus fruits

The significant [$p<0.05$] differences in all the organoleptic scores by the panelists are an indication of the variations in the four wine formulations (Table 1). The aesthetic value of foods and consumer product acceptance is influenced by the sensory attributes of foods [18]. All wine samples scored > 5 in overall acceptability on the 7-point hedonic scale except the Baringo fermented by baker's yeast [4.56] (Table1). The lower score could have been influenced by the slight color deviation of the samples at the time of sensory analysis linked to probable exposure to uncontrolled oxygen during storage resulting in oxidative browning and off-flavor formation of the wine [19]. Color was the highest scored parameter compared to the rest of the parameters with a mean of 5.91. The wine samples from Laikipia-sourced fruits were higher at 6.06 and 6.21 for the bakers and wine yeast respectively compared to samples from Baringo for bakers [5.33] or wine yeast [6.04]. In addition, Laikipia-made wines had a deeper color [L*] [39.50-40.67] and higher redness index [a*] [7.00-8.83] compared to Baringo wines 41.50-42.83 for lightness and 5.50-7.33 redness (Table 2). Further, betalains [natural coloring pigments] in the cactus fruits [20], and viscous and thick mucilage in Laikipia fruits could have contributed to their higher color intensity [21]. There were significant [p<0.05] differences in flavor and smell parameters among wine samples. Whereas samples fermented by wine yeast had higher flavor scores [5.12 and 5.08] for Laikipia and Baringo respectively, those fermented by baker's yeast from Laikipia [5.52] had the highest overall score in smell. Differences in yeast metabolism during fermentation to release aroma-active esters and phenolics and influence pungency could have resulted in the variations [22]. Wine samples fermented with baker's yeast were more liked for bitterness/sourness [5.18], mouthfeel [5.39], and astringency [5.31] due to mellowness and velvet-like sensation caused by glycerol production during fermentation [23]. In addition, high phenolic quantities in the wines resulted in oral sensation of dryness, the puckering effect of astringency, and taste of bitterness [22]. Sweetness was the least scored parameter for all the wine samples by the panelist, which can be linked to little residual after action of yeasts [*Saccharomyces cerevisiae*] on the must-release alcohol [24]. This would necessitate back sweetening to balance the sourness and sweetness to obtain a better taste [25].

Chemical characterization of the cactus fruit wines

The significant [p<0.001] variations in proximate compositions of wines between the Baringo and Laikipia regions, could be due to morphological and genetic factors of fruits [1,26]. Further, high moisture content with a range of 98.40-99.27 gives the wines a quench-thirsting characteristic, suitable for beverages (Table 3) [26]. Fermentation process led to a decline in pH levels [Figure 1.1] in the most from 4.72-4.33 and 4.54-4.12 for Baringo and Laikipia fruits respectively (Table 4) which is critical in enabling yeast growth and ethanol formation during fermentation [27]. The minimal fluctuation in pH during fermentation of the must inoculated by both the bakers and wine yeast indicates minimal production of organic acids, which would have raised the pH to cause microbial spoilage of the wines [28]. Similar trends of a decrease in pH levels with an increase in fermentation time has been reported in probiotic drinks [29]. Acidity plays a vital role in determining wine quality by aiding the fermentation process and enhancing the overall characteristics and balance of the wine [26]. Lower levels of titratable acidity were noted in wine samples fermented by wine yeast for both Laikipia and Baringo regions [0.94 and 0.86g/L] when compared to those fermented by baker's yeast [1.22 and 1.17g/L] respectively (Table 1.4). Titratable acidity was lower than findings of 6.91g/L and 17g/L on fermented cactus pear juice reported in separate studies by Ayed *et al.* [30] and Panda *et al.* [31] respectively. Total Soluble Solids [TSS] steadily declined from day 0 to day 8 after which there was a slight decrease and remained constant until the end of the maturation period [day 24] [Figure 2] with the final TSS level of the fruit wines ranging 6.8-7.3º brix (Table 1.4). There were insignificant [p=0.322] differences in TSS in wines fermented by either the wine or baker's yeast. Yeasts utilized sugars as substrates during fermentation to produce ethanol thus a decline in TSS levels until when all the activity ended with results in line with findings by Roda *et al.* [28] and Gaharwar *et al.* [32] on the fermentation of pineapple wines decreasing from 12.93-5.42 º brix and 20-7.3º brix respectively. The reducing sugar levels were higher in wine samples from Baringo-sourced fruits at 54.47-71.51 g/100g compared to the ones fermented from Laikipia-sourced fruits at 40.32-69.90 g/100g for reducing sugars (Table 4) irrespective of the type of yeast used during fermentation. Variation in yeast's ability to utilize the sugars efficiently could have led to differences in residual sugars among the wines and an extent explain the higher activity of wine yeast [BV818] in utilizing more sugars between days 0 – 2, leading to a higher decline in TSS compared to baker's yeast [28]. Despite the variance, both the baker's yeast and wine yeast could achieve complete fermentation rates in regards to sugar utilization, and ethanol production and influence final wine characteristics i.e. aroma, taste, and flavor [33]. Cactus fruit wines fermented by wine yeast [BV 818] from both Laikipia and Baringo regions, had higher levels of alcohol content at 14.17% and 14.08% compared to those fermented by baker's yeast at 13.67% and 13.92% respectively. However, the differences were not significant [p>0.05] with a range of 13.00- 15.00 v/v which collated with the potential alcohol calculated and expected from the initial TSS must at 23 º brix and within the limits set by regulatory agencies in East Africa of 6.5-16.5 % for still table wines [34]. Notably, with rising consumer preference and acceptance of higher alcohol concentration and fruit flavor-rich profiles in wines, cactus fruits among other tropical fruits can be adopted for fermentation [35].

ajfand Since 2001
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

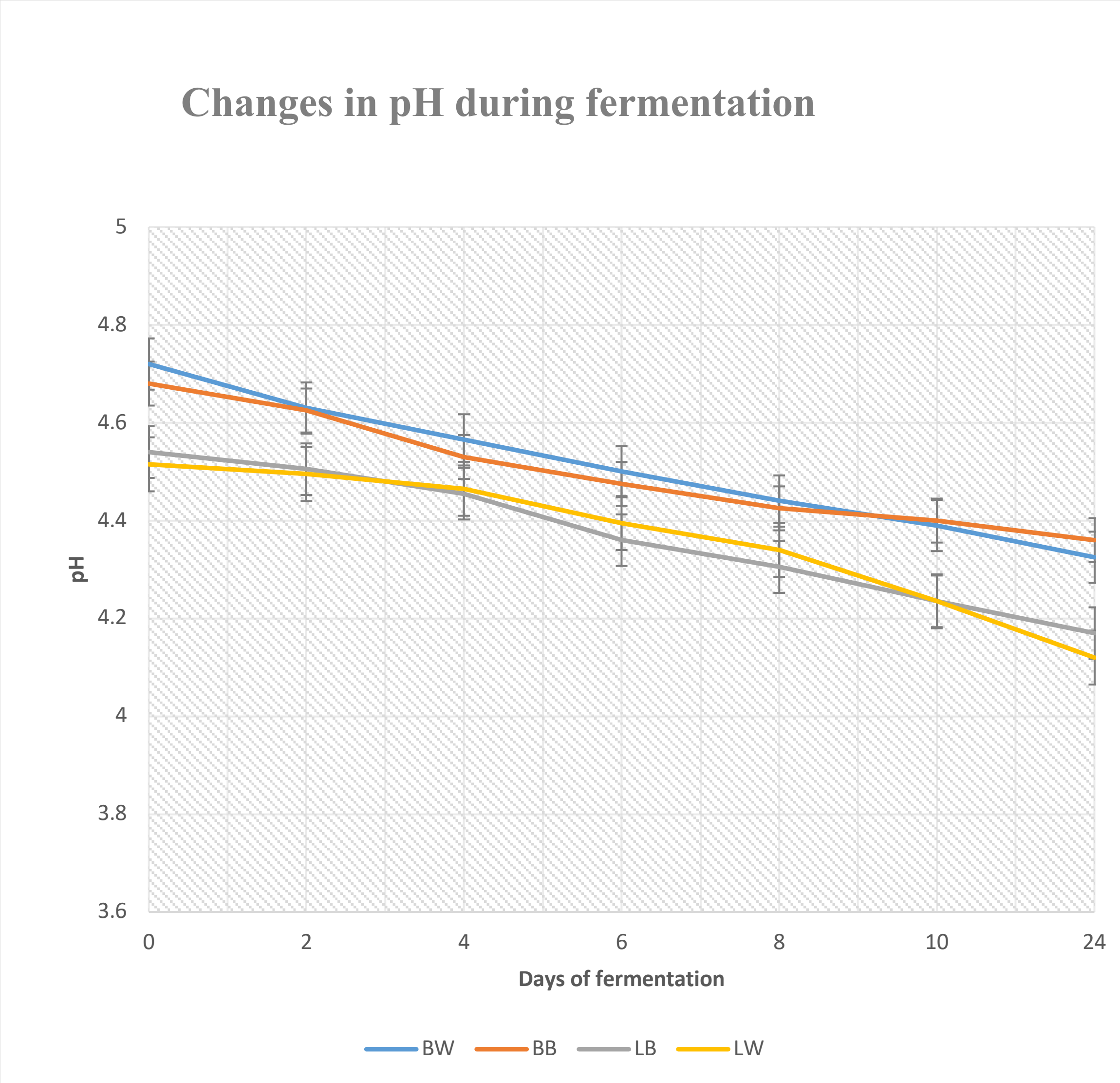

Figure 1: Changes in pH during wine fermentation and maturation

Since 2001
ajfand
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

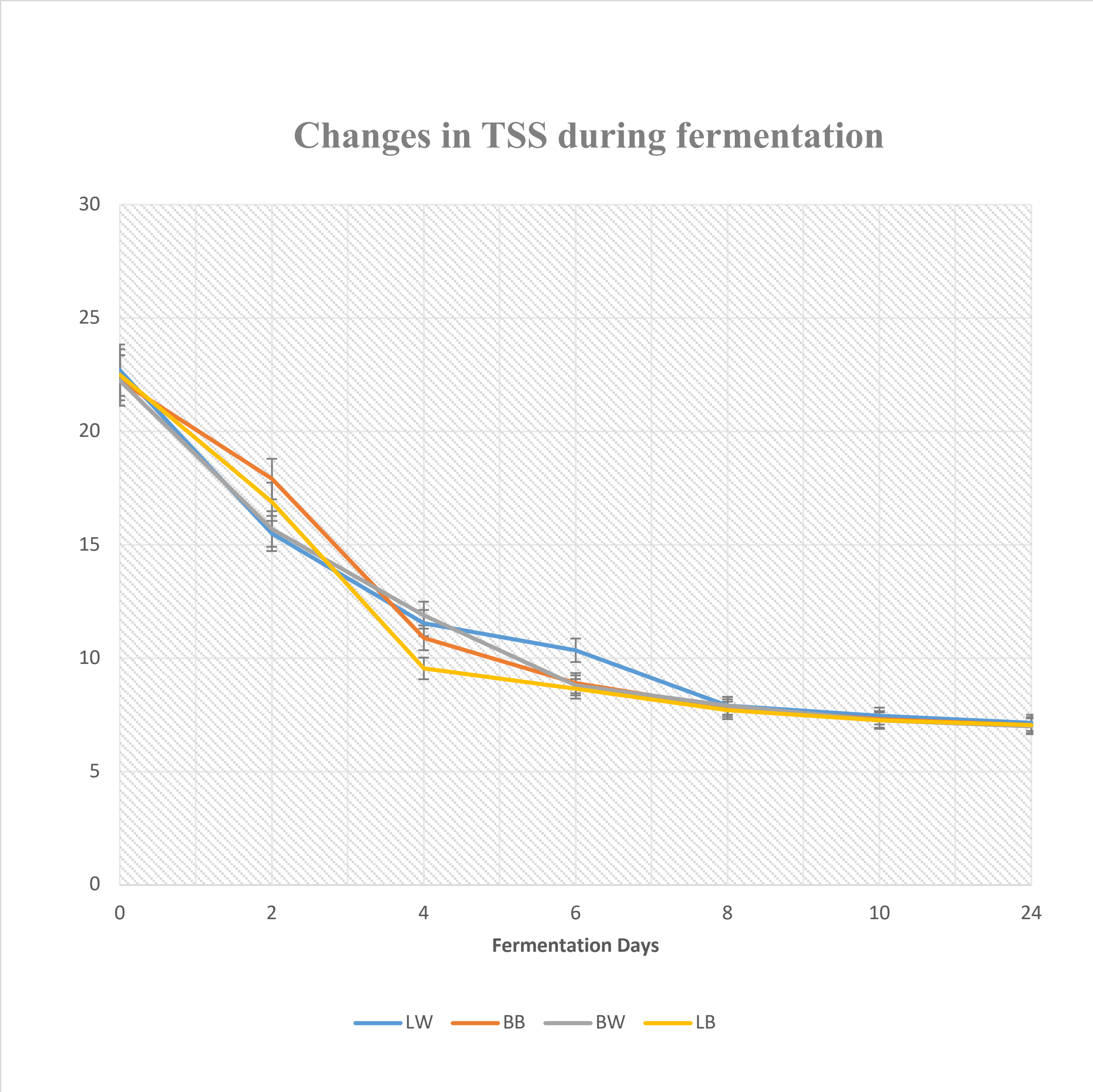

Figure 2: Changes in TSS during wine fermentation and maturation

The bars indicate the standard error of the means

BB - Baringo fruits fermented with Baker's yeast, BW – Baringo fruits fermented with Wine yeast, LB – Laikipia fruits fermented with Baker's yeast, LW – Laikipia fruits fermented with Wine yeast

Phytochemical composition

Total free phenolics [TFP] were significantly [P<0.001] different in all the cactus wines with those from Laikipia fermented by baker's yeast [LB] having the least quantities 185.35 mg GAE 100g^{-1} while those from Baringo fermented by baker's yeast [BB] had the highest quantities 275.49 mg GAE 100g^{-1} (Table 4). The quantities were lower than 580-980 mg GAE 100 $^{-1}$ ml reported by Karabagias *et al.*

[36] on a fermented cactus bio-functional beverage with variation due to differences in fermentation times, origin of fruits, and time of harvesting [current fruits were harvested during the dry season]. However, the free phenolic levels fairly compared with moderate grape wines from 8 grape varieties reported by Bin *et al.* [37] that ranged from 103.1 -257.0 mg GAE 100^{-1}g. Flavonoids, significantly [p<0.001] varied with wine samples from Laikipia fruits higher 232.83-242.46 mg CE/100g than those from Baringo sourced fruits [221.38-223.72 mg CE/100 g]. The levels were higher compared to cabernet sauvignon [notable grape wine] at 55.5mg CE 100^{-1} ml [38]] and above the range of 34.5-171.9 mg 100^{-1} g for various red wines categorized on the USDA data base [39]]. Vitamin C levels were significantly [p<0.001] different and lower in wines from Laikipia [601.01-665.96 mg $100g^{-1}$] than in Baringo [888.43-989.56 mg $100g^{-1}$] regardless of the type of yeast used to ferment the fruits (Table 4). Vitamin C quantities surpass the recommended daily intake of 90mg for adult men and 75 mg for adult women by the National Institutes of Health [NIH], office of Dietary Supplements [ODS] [40] which suggests that 100 ml of the cactus fruit wine per day from either the Baringo or Laikipia regions would be overly adequate to meet the daily vitamin C requirement for a person.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The current study resulted in the successful development of red wine high in phytochemical properties from cactus fruits. Though fruit wines made from Laikipia-sourced fruits were more accepted by the panelist, those from Baringo-sourced fruits had a higher nutritional and phytochemical profile, generally accepted by the panelist and hence recommended for processing. From the findings, either the bakers or wine yeast can be used in fermentation to produce the high alcohol levels required for wines in Kenya. This study recommends further work to assess the changes in wine characteristics during storage and optimization of fermentation of the cactus fruit wine to achieve a higher standard and quality that can meet international standards and compete.

ACKNOWLEDGEMENTS
The first author acknowledges the Department of Food Science, Nutrition and Technology, University of Nairobi for financing the study.

COMPETING INTEREST STATEMENT
The authors declare no conflict of interest

ajfand Since 2001 AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Sensory scores of cactus fruit wine

Cactus fruit wines	Color	Flavor	Smell	Sourness/ bitterness	Sweetness	Mouthfeel	Astringency	Overall acceptability
LB	6.06±1.02[b]	5.03±1.49[b]	5.53±1.19[b]	5.18±1.41[b]	4.78±1.61[ab]	5.39±1.26[b]	5.31±1.37[b]	5.46±1.28[b]
LW	6.21±1.04[b]	5.12±1.69[b]	5.17±1.39[ab]	5.03±1.46[b]	4.97±1.79[b]	5.42±1.38[b]	5.13±1.51[ab]	5.28±1.39[b]
BB	5.33±1.63[a]	4.33±1.78[a]	4.74±1.68 [a]	4.41±1.44[a]	4.21±1.71[a]	4.64±1.60[a]	4.56± 1.62[a]	4.56±1.41[a]
BW	6.04±1.14[b]	5.08±1.54[b]	5.42±1.17[b]	4.91±1.45[ab]	4.86±1.70[ab]	5.29±1.36[b]	5.23± 1.45[b]	5.36±1.37[b]
P Value	<0.0001	0.008	0.002	0.007	0.028	0.001	0.009	<0.0001

Values [means± standard deviation] with different superscripts along a column are statistically different [Tukey's test] LB - Fruit wine fermented with Baker's yeast from Laikipia sourced fruits; LW - Fruit wine fermented with Wine yeast from Laikipia sourced fruits; BB - Fruit wine fermented with Baker's yeast from Baringo sourced fruits; BW - Fruit wine fermented with Wine yeast from Baringo sourced fruits

Table 2: Color of cactus fruit wines fermented by wine and baker's yeasts

Cactus fruit wines	Color parameters				
	L*	a*	b*	Chroma	Hue Angle
LW	40.67±0.52[a]	7.00±0.00[b]	5.67±0.52[a]	9.00±0.00[ab]	38.00±1.79[b]
LB	39.50±1.38[a]	8.83±0.98[b]	6.00±0.00[a]	10.50±0.55[c]	33.83±2.32[a]
BB	42.83±0.98[b]	5.50±0.55[a]	6.83±0.41[b]	8.50±0.55[a]	52.67±1.75[d]
BW	41.5±1.87[ab]	7.33±1.75[b]	6.67±0.52[b]	9.83±0.98[bc]	48.17±1.83[c]
P value	0.001	<0.0001	<0.0001	0.001	<0.0001

Values [means± standard deviation] with different superscripts along a column are statistically different [Tukey's test, P≤0.05] LB - Fruit wine fermented with baker's yeast from Laikipia sourced fruits; LW - Fruit wine fermented with Wine yeast from Laikipia sourced fruits; BB - Fruit wine fermented with Baker's yeast from Baringo sourced fruit; BW - Fruit wine fermented with Wine yeast from Baringo sourced fruits

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Proximate composition of Cactus fruit wines

Cactus fruit wine samples	Proximate composition in g 100^{-1}g (wet weight basis) MC (%)	Crude fat (g)	Crude Protein (g)	Crude Ash (g)	Crude Fiber (g)	CHO (g)	Energy (Kcal)
LW	98.51±0.09^{a}	0.07±0.02^{b}	0.52±0.08^{b}	0.04±0.02^{a}	0.02±0.01^{a}	0.85±0.12^{b}	6.09±0.70^{b}
LB	98.93±0.02^{a}	0.04±0.02^{ab}	0.58±0.03^{b}	0.03±0.01^{a}	0.03±0.01^{a}	0.76±0.10^{ab}	5.75±0.23^{b}
BW	99.15±0.09^{b}	0.03±0.01^{a}	0.33±0.04^{a}	0.03±0.01^{a}	0.02±0.01^{a}	0.56±0.11^{a}	3.82±0.36^{a}
BB	99.00 ± 0.09^{b}	0.02±0.01^{a}	0.38±0.03^{a}	0.02±0.02^{a}	0.03±0.01^{a}	0.51±0.12^{a}	3.73±0.34^{a}
P Value	<0.001	0.011	<0.001	0.046	0.176	0.019	<0.001

Values [means± standard deviation] with different superscripts across the row are statistically different [Tukey's test, P<0.05]
LB - Fruit wine fermented with Baker's yeast from Laikipia sourced fruits; LW - Fruit wine fermented with Wine yeast from Laikipia sourced fruits; BB - Fruit wine fermented with Baker's yeast from Baringo sourced fruits; BW - Fruit wine fermented with Wine yeast from Baringo sourced fruits; MC - Moisture Content, DMC- Dry Matter Content, CHO – Carbohydrates

Since 2001 ajfand AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
SCHOLARLY, PEER REVIEWED
Volume 24 No. 9
September 2024
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 4: Phyto-chemical and chemical composition of cactus fruit wines

	Cactus fruit wines							
Chemical parameters	**LW**	**LB**	**BW**	**BB**	**GM**	**Range**	**C.V [%]**	**P value**
TSS [FW]	7.01±0.17[b]	7.1±0.13[b]	7.13±0.16[b]	6.98±0.15[a]	6.94	6.00-7.3	2.8	0.322
pH [FW]	4.12±0.03[a]	4.17±0.02[b]	4.33±0.01[c]	4.36±0.01[c]	4.24	4.08-4.37	0.5	<0.001
T.A [citric acid g/L FW]	0.94±0.03[a]	1.22±0.11[b]	0.86±0.02[a]	1.17±0.03[b]	1.05	0.83-1.35	5.5	<0.001
Reducing Sugars [g/100g DWB]	40.32±3.81	69.90±1.31	71.51±3.26	54.47±7.56	59.05	35.43-76.92	7.9	<0.001
TFP [mg GAE/100g DWB]	218.44±2.25[b]	185.35±3.00[a]	275.49±5.72[c]	221.19±0.88[b]	225.12	180.79-285.10	1.5	<0.001
Flavonoids [mg CE/100g DWB]	232.83±5.78[ab]	242.46±1.86[b]	223.72±12.57[a]	221.38±9.63[a]	230.10	206.94-245.27	9.0	<0.001
Vitamin C [mg/100g DWB]	601.01±64.89[a]	665.96±53.22[a]	989.56±59.31[b]	888.43±81.70[b]	786.24	519.16-1078.91	8.3	<0.001
Alcohol content [%]	14.17±0.26[a]	13.67±0.61[a]	14.08±0.38[a]	13.92±0.58[a]	13.92	13.00-15.00	4.2	0.384

Values [means± standard deviation] with different superscripts across the row are statistically different [Tukey's test, P<0.05]
LB - Fruit wine fermented with Baker's yeast from Laikipia sourced fruits; LW - Fruit wine fermented with Wine yeast from Laikipia sourced fruits; BB - Fruit wine fermented with Baker's yeast from Baringo sourced fruits; BW - Fruit wine fermented with Wine yeast from Baringo sourced fruits; TSS -Total Soluble Solids; F.W - Fruit weight; T.A – Titratable Acidity; C.V – Coefficient of Variation; DWB – Dry weight basis, TFP – Total free phenolics

REFERENCES

1. **Inglese P, Mondragon C, Nefzaoui A and C Saenz** Crop ecology, cultivation and uses of cactus pear. Crop Ecol Cultiv Uses Cactus Pear. Food and Agriculture Organization of the United Nations (FAO); 2017. https://www.cabdirect.org/cabdirect/abstract/20183168277 *Accessed December 2023*.

2. **El-Mostafa K, El Kharrassi Y, Badreddine A, Andreoletti P, Vamecq J and MS El Kebbaj** Nopal Cactus [Opuntia ficus-indica] as a Source of Bioactive Compounds for Nutrition, Health and Disease. Molecules. *Multidisciplinary Digital Publishing Institute.* 2014; **19(9)**:14879–901 https://doi.org/10.3390/molecules190914879

3. **Cheok CY, Mohd Adzahan N, Abdul Rahman R, Zainal Abedin NH, Hussain N and R Sulaiman** Current trends of tropical fruit waste utilization. Crit Rev Food Sci Nutr. *Taylor & Francis.* 2018; **58(3)**: 335–61. https://doi.org/10.1080/10408398.2016.1176009

4. **Kunyanga CN, Vellingiri V and KJ Imungi** Nutritional quality, phytochemical composition and health protective effects of an under-utilized prickly cactus fruit [Opuntia stricta Haw.] collected from Kenya. *Afr J Food Agric Nutr Dev.* 2014; **14(7)**: 9561–77. https://doi.org/10.4314/ajfand. v14i7

5. **FAO**. Agro-industrial utilization of cactus pear. FAO; 2013. https://repositorio.uchile.cl/handle/2250/186304 *Accessed 28th November 2022.*

6. **Nation news (Kenya)**. 2017. From wine to yogurt, wild cactus offers a lot. https://nation.africa/kenya/business/seeds-of-gold/from-wine-to-yoghurt-wild-cactus-offers-a-lot-450960 *Accessed 23rd September 2023.*

7. **Navarrete-Bolaños J I, Fato-Aldeco E, Gutiérrez-Moreno K, Botello-Álvarez J e., Jiménez-Islas H and R Rico-Martínez** A Strategy to Design Efficient Fermentation Processes for Traditional Beverages Production: Prickly Pear Wine. *J Food Sci.* 2013; **78(10)**: M1560–8. https://doi.org/10.1111/1750-3841.12237

8. **Tsegay ZT, Sathyanarayana CB and SM Lemma** Optimization of Cactus Pear Fruit Fermentation Process for Wine Production. *Foods*. Multidisciplinary Digital Publishing Institute. 2018; **7(8)**: 121. https://doi.org/10.3390/foods7080121

9. **Saranraj P, Sivasakthivelan P and M Naveen** Fermentation of fruit wine and its quality analysis: A review. 2017; 13. https://aujst.com/vol-1-2/07_AJST.pdf *Accessed 28th August 2023.*

10. **Mugo SN** Innovations and performance of Kenya's wine industry. 2015; https://erepository.uonbi.ac.ke/bitstream/handle/11295/93838/Mugo_Innovations%20and%20performance%20of%20Kenya%e2%80%99s%20wine%20industry.pdf?sequence=1&isAllowed=y *Accessed 15th December 2023.*

11. **Granato D, Masson ML and JCB Ribeiro** Sensory acceptability and physical stability evaluation of a prebiotic soy-based dessert developed with passion fruit juice. *Food Sci Technol.* 2012; **32(1)**: 119–26. https://doi.org/10.1590/S0101-20612012005000004

12. **AOAC.** 2000. AOAC METHOD 942.15. http://www.aoacofficialmethod.org/ *Accessed 2nd June 2023.*

13. **Balogun MA, Abiodun OA, Kolawole FL, Kayode RMO and OE Olushola** Physicochemical and sensory properties of blends of pineapple-carrot wine. *J Microbiol Biotechnol Food Sci.* Faculty of Biotechnology and Food Sciences in Nitra, Slovakia. 2021; **10**: 306–11. https://doi.org/10.15414/jmbfs.2017/18.7.3.306-311

14. **Okumu M, Mbaria J, Kanja L Laetitia, Gakuya D, Kiama S and F Okumu** Phytochemical profile and antioxidant capacity of leaves of Moringa oleifera [Lam] extracted using different solvent systems. *J Pharmacogn Phytochem.* 2016; **302**: 302–8.

15. **Atanassova M, Georgieva S and K Ivancheva** Total Phenolic and Total Flavonoid Contents, Antioxidant Capacity and Biological Contaminants In Medicinal Herbs. *J Univ Chem Technol Metall.* 2011; **46:** 81–8.

16. **Garro-Mellado L, Guerra-Hernández E and B García-Villanova** Sugar Content and Sources in Commercial Infant Cereals in Spain. *Children.* Multidisciplinary Digital Publishing Institute. 2022; **9(1)**: 115.https://doi.org/10.3390/children9010115

17. **Lumivero A. XLSTAT**. Your data analysis solution. 2021. XLSTAT | Statistical Software for Excel. https://www.xlstat.com/en/ *Accessed 3rd June 2023.*

18. **Sen T, Barrow CJ and SK Deshmukh** Microbial Pigments in the Food Industry—Challenges and the Way Forward. *Front Nutr*. 2019;6. https://www.frontiersin.org/articles/10.3389/fnut.2019.00007 *Accessed 3rd June 2023.*

19. **Benucci I, Cerruti M and M Esti** Dosing oxygen from the early stages of white winemaking: Effect on oxidation-reduction potential, browning stability, volatile composition, and sensory properties. *Food Chem.* 2023; 432:137243. https://doi.org/10.1016/j.foodchem.2023.137243

20. **Sigwela V, De Wit M, du Toit A, Osthoff G and A Hugo** Bioactive Betalain Extracts from Cactus Pear Fruit Pulp, Beetroot Tubers, and Amaranth Leaves. Molecules. Multidisciplinary Digital Publishing Institute. 2021; **26(16)**: 5012. https://doi.org/10.3390/molecules26165012

21. **Messina CM, Arena R, Morghese M, Santulli A, Liguori G and P Inglese** Seasonal characterization of nutritional and antioxidant properties of *Opuntia ficus-indica* [[L.] Mill.] mucilage. *Food Hydrocoll*. 2021; **111**: 106398. https://doi.org/10.1016/j.foodhyd.2020.106398

22. **Ofoedu CE, Ofoedu EO, Chacha JS, Owuamanam CI, Efekalam IS and CG Awuchi** Comparative Evaluation of Physicochemical, Antioxidant, and Sensory Properties of Red Wine as Markers of Its Quality and Authenticity, 2022. https://doi.org/10.1155/2022/8368992

23. **Laguna L, Álvarez MD, Simone E, Moreno-Arribas MV and B Bartolomé** Oral Wine Texture Perception and Its Correlation with Instrumental Texture Features of Wine-Saliva Mixtures. Foods. Multidisciplinary Digital Publishing Institute. 2019; **8(6)**: 190. https://doi.org/10.3390/foods8060190

24. **Yang H, Sun J, Tian T, Gu H, Li X and G Cai** Physicochemical characterization and quality of Dangshan pear wines fermented with different Saccharomyces cerevisiae. *J Food Biochem.* 2019; **43(8)**: e12891. https://doi.org/10.1111/jfbc.12891

25. **Nazarova NE, Zaletova TV, Zubova EV and KA Kulagina** Quality and biological value of wine from gooseberries, raspberries and black currants using vegetable sweetener. *Proc Voronezh State Univ Eng Technol*. 2019; **81(4)**: 131–7. https://doi.org/10.20914/2310-1202-2019-4-131-137

26. **Mo E, Ji E and O Ca** Proximate, Chemical Compositions and Sensory Properties of Wine Produced from Beetroot [*Beta vulgaris*]. 2020;

27. **Kocher G and P Nikhanj** Status of wine production from guava (*Psidium guajava* L.): A traditional fruit of India. *Afr J Food Sci.* 2011; 5. https://doi.org/10.5897/AJFSX11.008

28. **Roda A, De Faveri DM, Dordoni R, Cases EV, Jáuregui NN, Carbonell and AA Barrachina** Pineapple Wines Obtained from Saccharification of Its Waste with Three Strains of Saccharomyces cerevisiae. *J Food Process Preserv.* 2017; **41(5)**: e13111. https://doi.org/10.1111/jfpp.13111

29. **Worku KF, Kurabachew H and Y Hassen** Probiotication of Fruit Juices by Supplemented Culture of *lactobacillus acidophilus*. *Int J Food Sci Nutr Eng.* Scientific & Academic Publishing. 2019; **9(2)**: 45–8.

30. **Ayed and M Hamdi** Manufacture a beverage from cactus pear juice using "tea fungus" fermentation. *Ann Microbiol.* BioMed Central; 2015; **65(4)**: 2293–9: https://doi.org/10.1007/s13213-015-1071-8

31. **Panda SK, Behera SK, Witness Qaku X, Sekar S, Ndinteh DT and HM Nanjundaswamy** Quality enhancement of prickly pears [*Opuntia sp.*] juice through probiotic fermentation using Lactobacillus fermentum - ATCC 9338. LWT. 2017; **75:** 453–9. https://doi.org/10.1016/j.lwt.2016.09.026

32. **Gaharwar A, Shinde RM, Wasule DL, Bharsakhale RD, Yelme MP and K Vaibhavi** Studies on Isolation of Yeast and its Comparative Performance for Quality Wine Production from Pineapple and Sapota. *Int J Curr Microbiol Appl Sci.* 2020; **9(1):** 1306–13. https://doi.org/10.20546/ijcmas.2020.901.144

33. **Alonso-del-Real J, Lairón-Peris M, Barrio E and A Querol** Effect of Temperature on the Prevalence of Saccharomyces Noncerevisiae Species against anan S. cerevisiae Wine Strain in Wine Fermentation: Competition, Physiological Fitness, and Influence in Final Wine Composition. *Front Microbiol*. 2017; **8**. https://www.frontiersin.org/articles/10.3389/fmicb.2017.00150 *Accessed 3rd June 2023.*

34. **EAC**. still table wine — Specification. 2013.

35. **Ramoba L, Monyama MC and K Moganedi** Storage Potential of the Cactus Pear [Opuntia ficus-indica] Fruit Juice and Its Biological and Chemical Evaluation during Fermentation into Cactus Pear Wine. *Beverages*. Multidisciplinary Digital Publishing Institute. 2022; **8(4)**: 67. https://doi.org/10.3390/beverages8040067

36. **Karabagias VK, Karabagias IK, Prodromiti M, Gatzias I and A Badeka** Bio-functional alcoholic beverage preparation using prickly pear juice and its pulp in combination with sugar and blossom honey. *Food Biosci.* 2020; 35:100591. https://doi.org/10.1016/j.fbio.2020.100591

37. **Bin Du** Phenolic content and antioxidant activity of wine grapes and table grapes. *J Med Plants Res.* 2012; **6(17)**. https://doi.org/10.5897/JMPR12.238

38. **Munoz-Bernal ÓA, Coria-Oliveros AJ, Vazquez-Flores AA, de la Rosa LA, Núnez-Gastélum JA and J Rodrigo-Garcia** Evolution of Phenolic Content, Antioxidant Capacity, and Phenolic Profile during Cold Pre-fermentative Maceration and Subsequent Fermentation of Cabernet Sauvignon Red Wine. *South African Journal of Enology and Viticulture* [SAJEV]. 2020; **41(1)**: 72–82. https://doi.org/10.21548/41-1-3778

39. **USDA**. 2018. Ag Data Commons | Providing Central Access to USDA's Open Research Data. https://data.nal.usda.gov/dataset/usda-database-flavonoid-content-selected-foods-release-33-march-2018/resource/32589c52-e993-4cfc-918e-b6c5382957b5 *Accessed 3rd June 2023.*

40. **NIH (USA)**. 2021. Office of Dietary Supplements - Vitamin C. https://ods.od.nih.gov/factsheets/VitaminC-HealthProfessional/ *Accessed 3rd June 2023.*