Gurukul International Multidisciplinary Research Journal (GIMRJ)*with* International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

PRODUCTION OF WINE FROM GRAIN GREEN OF SWEET SORGHUM AND ITS ANALYSIS

Author: -
1.Rajnikant S. Jadhao, Research Scholar **2. Dr J.P.Kaware, Principal, RSCOE, Buldhana**
3. Miss. Mitali Mate, Student **4. Miss. Snehal Patankar, Student**

Department of Chemical Engineering,
College of Engineering & Technology, Babhulgaon (Jh), Akola,Dist. Akola, MS (444301)
Sant Gadge Baba Amravati University, Amravati, 444602.

1.INTRODUCTION

The production of wine from green grains of sweet sorghum presents an innovative approach to diversifying the wine industry and utilizing agricultural resources more efficiently. Sweet sorghum, a C4 grass species, is gaining attention for its potential as a bioenergy crop, but its applications extend beyond fuel production. This paper explores the feasibility and process of transforming green grains of sweet sorghum into wine, highlighting the biochemical composition of sweet sorghum, the fermentation process, and the potential challenges and opportunities associated with this novel approach to winemaking. Sweet sorghum, known scientifically as Sorghum bicolour (L.) Moench, is a versatile crop with high biomass and sugar content, making it an ideal candidate for biofuel production. However, the grains of sweet sorghum also contain fermentable sugars that can be utilized in winemaking. The biochemical composition of sweet sorghum grains includes starch, sucrose, glucose, fructose, and amino acids, providing ample substrates for yeast fermentation. The process of producing wine from green grains of sweet sorghum involves several key steps. Firstly, the grains are harvested at the green stage to capture their high sugar content before they mature and lose sweetness. The grains are then processed to extract the juice, which serves as the raw material for fermentation. Next, the juice undergoes clarification and may be supplemented with nutrients to support yeast growth and fermentation efficiency.

Fermentation is a crucial stage in winemaking, where yeast converts sugars into alcohol and other byproducts. Saccharomyces cerevisiae, commonly used in wine fermentation, can efficiently ferment the sugars present in sweet sorghum juice, yielding ethanol and carbon dioxide. The fermentation process typically takes several days to weeks, during which the wine develops its characteristic flavours and aromas. After fermentation, the wine undergoes clarification and aging to improve its clarity, stability, and flavour profile. Filtration and fining techniques may be employed to remove suspended particles and undesirable compounds, while aging in oak barrels or stainless-steel tanks allows the wine to mature and develop complexity. The production of wine from green grains of sweet sorghum offers several potential benefits and challenges. From an agricultural perspective, sweet sorghum can be grown on marginal lands and under diverse climatic conditions, providing farmers with additional income opportunities. Moreover, utilizing sweet sorghum grains for wine production adds value to the crop and contributes to agricultural diversification. On the other hand, challenges such as the variability in sugar content of sweet sorghum grains, the need for specialized equipment for processing, and the unfamiliarity of consumers with sorghum wine may hinder its widespread adoption. However, with research and development efforts focused on optimizing the production process and promoting sorghum wine as a unique and sustainable product, these challenges can be overcome. The production of wine from green grains of sweet sorghum represents a promising avenue for innovation in the wine industry and sustainable agriculture. By leveraging the abundant sugars present in sweet sorghum grains, this approach offers an alternative to traditional grape-based wines while promoting the cultivation of a versatile and resilient crop. Further research and experimentation are needed to refine the production process, enhance product quality, and expand market acceptance of sorghum wine.

2.LITERATURE REVIEW:

HISTORY OF WINE

The history of wine is as rich and diverse as the drink itself, spanning thousands of years and intertwining with the cultures, traditions, and advancements of civilizations throughout the ages. From its humble origins in ancient Mesopotamia to its global prominence today, the story of wine is a fascinating journey through time. Origins in Ancient Mesopotamia: The earliest evidence of winemaking dates back to around 6000 BCE in what is now modern-day Iran, Georgia, and Armenia, regions located in the ancient cradle of civilization known as Mesopotamia. The inhabitants of these regions, particularly the Sumerians and later the Babylonians, cultivated wild grapevines and developed rudimentary techniques for fermenting grape juice into wine.

Spread to Ancient Egypt and the Mediterranean: The knowledge of winemaking gradually spread across ancient civilizations, including Egypt and the Mediterranean region. Ancient Egyptian hieroglyphs depict scenes of winemaking and consumption, indicating the importance of wine in religious ceremonies, social gatherings, and everyday life. The Egyptians also traded wine with neighbouring cultures, facilitating its dissemination throughout the Mediterranean basin. Wine in Ancient Greece and Rome: Wine held a central role in the cultures of ancient Greece and Rome, where it was associated with gods and goddesses, symposia (drinking parties), and philosophical discourse. The Greeks revered Dionysus, the god of wine, fertility, and ecstasy, while the Romans worshipped Bacchus, their equivalent deity. Greek philosophers such as Plato and Aristotle extolled the virtues of moderation in wine consumption, while poets like Homer and Sappho immortalized the pleasures of wine in their works. In Rome, wine became a symbol of luxury and social status, with vineyards sprawling across the Italian countryside and beyond. Influence of Christianity: With the spread of Christianity across the Roman Empire, wine took on religious significance as the symbol of the blood of Christ in the Christian sacrament of communion. Monasteries played a crucial role in preserving and advancing winemaking knowledge during the Middle Ages, with monks cultivating vineyards and refining techniques for viticulture and winemaking. European Expansion and Global Trade: During the Age of Exploration in the 15th and 16th centuries, European explorers ventured to distant lands, introducing grapevines to new territories and establishing vineyards in the Americas, Africa, Australia, and beyond. Wine became a commodity of global trade, with European powers vying for control over lucrative wine-producing regions. Modernization and Industrialization: The Industrial Revolution brought significant advancements to winemaking, with innovations such as the cork press, glass bottles, and temperature-controlled fermentation enabling the production of higher-quality wines on a larger scale. Viticultural practices also evolved, with the identification of grape varieties suited to specific terroirs and the adoption of scientific methods for soil analysis and grape cultivation. Contemporary Wine Culture: In the modern era, wine has become a global phenomenon, with diverse styles, regions, and varietals catering to a broad spectrum of tastes and preferences. Wine tourism has surged in popularity, with enthusiasts flocking to renowned wine regions to explore vineyards, wineries, and tasting rooms. The history of wine is a testament to the ingenuity, creativity, and cultural significance of humanity throughout the ages. From its humble beginnings in ancient Mesopotamia to its global prominence today, wine continues to captivate our senses, inspire our passions, and enrich our lives. Whether enjoyed as a sacrament, a social lubricant, or a culinary delight, wine remains a timeless symbol of civilization's enduring pursuit of pleasure, conviviality, and celebration.

WORLDWIDE PRODUCTION OF WINE

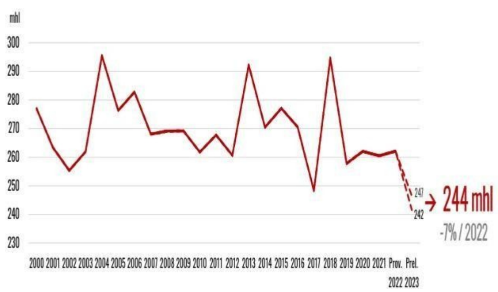
Worldwide wine production is a significant agricultural activity with a rich history and

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

cultural significance. Grapes, the primary raw material for wine production, are cultivated in numerous countries across the globe, with vineyards spanning diverse climates and terroirs. Major wine producing regions include France, Italy, Spain, the United States, Argentina, Chile, Australia, and South Africa, among others. Global wine production fluctuates from year to year due to factors such as weather conditions, vineyard management practices, and market demand. However, it generally amounts to several billion liters annually. Wine production encompasses a wide range of styles, from still and sparkling wines to fortified and dessert wines, each reflecting the unique characteristics of the grape varieties, growing regions, and winemaking techniques employed.

Based on the information collected on 29 countries, world wine production in 2023 is expected to be **244 mhl,** the smallest volume recorded in the last 60 years. This is due to the combination of extremely low harvest volumes in the Southern Hemisphere as well as in some major EU countries. Once again, extreme climatic conditions - such as early frost, heavy rainfalls and droughts - have significantly impacted the output of the world vineyard.

However, in a context where global consumption is declining and stocks are high in many regions of the world, the expected low production could bring equilibrium to the world market.



SOUTHERN HEMISPHERE

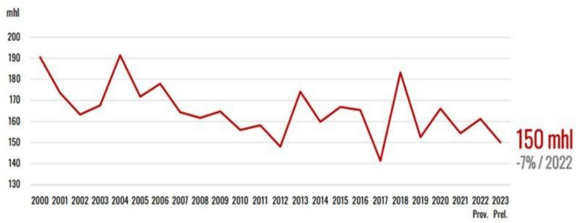
Vineyards in the Southern Hemisphere produced **45 mhl** of wine in 2023, the lowest volume recorded since 2003. This production level is 19% lower than in 2022. All major wine-producing countries have registered a significant fall in production with respect to 2022, with yoy declines ranging between - 10% and -30%. Overall, in 2023 the Southern Hemisphere wine production is expected to account for 19% of the world to total.

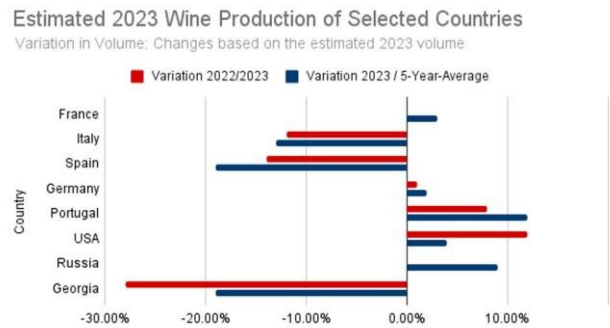
NORTHERN HEMISPHERE

In the European Union (EU), 2023 wine production is estimated at **150 mhl**, recording a decrease of 11 mhl (7%) compared to 2022.

Italy and Spain reported significant decreases with respect to 2022 due to unfavourable weather conditions that led to downy mildew and droughts.

France is expected to be the largest producer at the world level in 2023, with a volume slightly above its five-year average.





WINE PRODUCING STATES IN INDIA

India produced 1.4 crore litres of wine during 2022, of which Maharashtra accounted for 90 per cent. According to All India Wine Producers Association (AIWPA), the wineries crushed 20,000 metric tonnes (MT) of grapes last year and produced 1.4 crore litres of wine. Usually, the annual sale of wine is around 1.30 crore litres, but the sector is witnessing a 20% growth each year. The state has between 40 and 45 operational wineries. Of these, between 15 and 20 units directly market products, while the rest are only manufacturers. The wine industry has a turnover of around □1,000 crore in India, of which 65% is in Maharashtra. Most wineries are located in Nashik — which produces around 80% of India's wine, and is called the country's wine capital with 29 operational wineries — followed by Sangli, Pune, Solapur, Buldhana and Ahmednagar.

MUMBAI, 26 February 2024: India, a land of diverse landscapes and rich culture, is also emerging as a noteworthy player in the global wine map. While its journey may be relatively young compared to established wine regions, India boasts several states excelling in grape cultivation and wine production.

Let's embark on a virtual tour and explore the top 10 wine producing states in India

1.Maharashtra: Undisputedly the leader in Indian wine production, Maharashtra contributes over 80% of the country's wine grapes. The Nashik Valley, nestled in the Western Ghats, enjoys a Mediterranean climate ideal for viticulture. Renowned wineries like Sula Vineyards, Fratelli Vineyards, and Grover Zampa Vineyards call Maharashtra home, producing acclaimed red, white, and sparkling wines from popular grape varieties like Cabernet Sauvignon, Shiraz, Chenin Blanc, and Sauvignon Blanc.

2.Karnataka: Following closely behind Maharashtra, Karnataka has emerged as a significant wine producer. Regions like Bangalore and Hampi Hills offer suitable climatic conditions for grape cultivation. Known for its Cabernet Sauvignon, Merlot, Sauvignon Blanc, and Chenin Blanc wines, Karnataka boasts established wineries like Grover Zampa Vineyards and Bangalore Vineyard, contributing to the state's flourishing wine industry.

3.Tamil Nadu: This southern state, particularly the Cumbum Valley, has witnessed a recent surge in wine production. Warmer temperatures allow for double cropping in some regions, but maintaining grape quality remains a challenge. Despite this, wineries like Heritage Vineyards and TT Winery are producing interesting red and white wines from Shiraz, Cabernet Sauvignon, and Sauvignon Blanc grapes.

4.Andhra Pradesh: Similar to Tamil Nadu, Andhra Pradesh experiences warmer temperatures and focuses on red grape varieties like Sangiovese and Cabernet Sauvignon. Regions like Rangareddy and Medak are witnessing increasing interest in wine grape cultivation, with wineries like Valluvancheri Vineyards and Indage Winery making their mark on the Indian wine scene.

5.Madhya Pradesh: This central Indian state, particularly the Dindori region, boasts suitable soil and climatic conditions for viticulture. Known for its red and white varietals like Cabernet Sauvignon, Shiraz, Chardonnay, and Sauvignon Blanc, wineries like Reveilo Winery and Madhya Pradesh Winery are contributing to the state's emerging wine industry.

6.Gujarat: While not a major player yet, Gujarat has shown promising potential for wine production. Regions like Nasik and Kutch offer suitable conditions for grape cultivation, with wineries like Grover Zampa Vineyards and Fratelli Vineyards making initial inroads in the state.

7.Himachal Pradesh: Nestled in the Himalayas, Himachal Pradesh offers a unique climate for viticulture. The Kangra Valley, known for its scenic beauty, is witnessing the development of vineyards and wineries like Chateau Indage and Himalayan Winery, experimenting with grape varieties like Chardonnay, Riesling, and Pinot Noir.

8.Goa: This popular tourist destination is also exploring the potential of wine production. Warmer temperatures pose a challenge, but wineries like Goa Distillery & Winery are experimenting with grape varieties like Chenin Blanc and Sauvignon Blanc, aiming to produce unique and localized wines.

9.Rajasthan: This arid state is making surprising strides in wine production. Regions like Jodhpur and Jaisalmer, known for their desert landscapes, are witnessing the cultivation of grapes suitable for winemaking. Wineries like Madhulika Vineyards and Rajasthan Vintners are pioneering efforts in this challenging yet promising terrain.

10.Kerala: This southern state, known for its lush greenery and backwaters, is also venturing into the world of wine. Wineries like Kerala Wine Company are experimenting with grape varieties like Chenin Blanc and Sauvignon Blanc, aiming to tap into the potential of this scenic region for unique wine production.

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

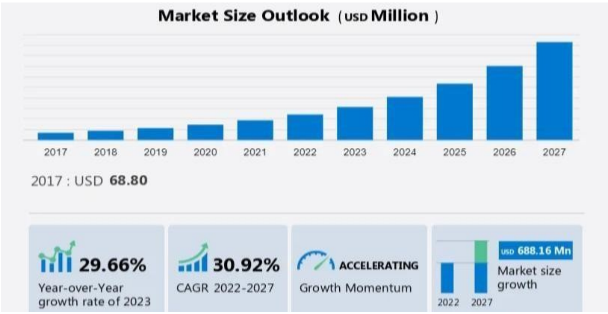


Figure: India - Wine Market Size, Share, Trends &
Forecast
2023- 2027

Beyond the Grapes- The rise of these wine-producing states signifies India's growing interest in quality wines and its potential to carve a niche in the global market. However, several challenges remain, including limited suitable land, high initial investment, and competition from established international brands. Looking Ahead Despite these challenges, the future of Indian wine production appears promising. Government initiatives promoting research and development, coupled with increasing consumer awareness and appreciation for domestic wines, can pave the way for further growth and diversification in the industry. As each state explores its unique terroir and grape varieties, India's wine map is sure to become even more captivating, offering exciting new flavors and experiences for wine enthusiasts worldwide.

WORLDWIDE CONSUMPTION OF WINE

World wine consumption likely dipped last year as higher prices contributed to people uncorking fewer bottles, a recent report has said, but which country drank the most?The US has continued to top the list of which countries drink the most wine overall, according to preliminary figures for 2022 released by the International Organisation of Vine & Wine (OIV).

Wine consumption in the US returned to pre-Covid pandemic levels last year, rising by around 3% versus 2021 to reach an estimated 34 million hectolitres (3.4bn litres), the recent OIV report said.

World wine consumption dipped by 1% in 2022, though, coming in at an estimated **232 million hectolitres (mhl).** <u>**Top 10 countries that drink the most wine:**</u>

Here is an updated list of the 10 countries that drink the most wine, according to OIV's preliminary figures for
2022. US: 34mhl, up 2.8% versus 2021
France: 25.3mhl, up 1.5%
Italy: 23mhl, down 5%
Germany: 19.4mhl, down 2.5%
UK: 12.8mhl, down 2.2%
Russia: 10.8mhl, up 3.3%
Spain: 10.3mhl, down 0.1%
China: 8.8mhl, down 16%
Argentina: 8.3mhl, down 1.3%
Portugal: 6mhl, up 14.3% In the chart above, the US accounts for 15% of the world's total wine consumption.

<u>**Which country drinks the most wine per person?**</u>

On a per capita basis, the leaderboard looks quite different. Portugal topped the charts in 2022, way ahead of France and Italy, with Switzerland taking fourth place, show preliminary OIV figures.

The US didn't make the cut, on 12.6 litres per capita, and the UK also missed out on the top 10, finishing 11th on 23.2 litres – just behind Argentina.

According to the OIV, the top 10 countries in terms of per capita wine consumption are:
Portugal: 67.5 litres per
capita
France: 47.4 litres
Italy: 44.4 litres
Switzerland: 35.5 litres
Austria: 30.8 litres
Germany: 27 litres
Australia: 26.1 litres
Czech Republic: 25.3 litres
Spain: 25.3 litres
Netherlands: 24.5 litres
Argentina: 23.8 litres

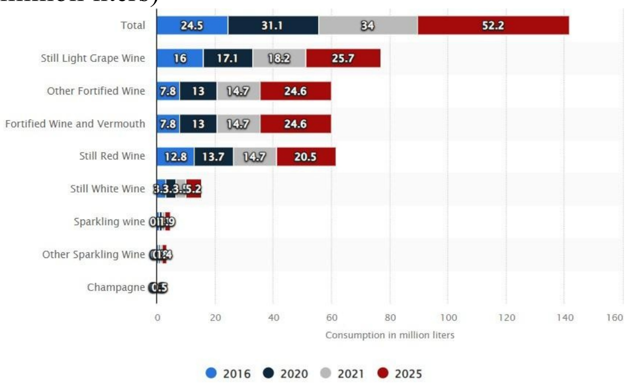
WINE CONSUMPTION IN INDIA

In 2021, about **34 million liters** of wine were consumed in India. Out of this, over 18 million liters of wine consumed were still light grape wine in the South Asian country. A compound annual growth rate of wine consumption of

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

over 11 percent was estimated from 2021 to 2025. Wine penetration in India is low, with an estimated 2-3 million consumers consuming 24 million liters. Wine-drinking remains largely urban.

Volume of wine consumption across India from 2016 to
2021, with an estimate for 2025, by type (in million liters)



SORGHUM

Sorghum is an important cereal crop of the world. Sorghum is the fifth most important cereal crop grown in the world after wheat, maize, rice and barley. Beside feed and fodder, sorghum is alternately used in bread making, pop, beer, alcoholic beverages, sorghum molasses, wax, starch, dextrose, sorghum syrup, edible oil, jaggery, gruel, malted beverages, etc.

Sorghum is a C4 herbaceous annual grass that is cultivated from the seed, and is known by various names like great millet and guinea corn in West Africa, kafir corn in South Africa, durra in Sudan, mtama in Eastern Africa, jowar in India, kaoliang in China and milo or milo-maize in the United States. It has wide flat leaves and a round or elliptical panicle with full of grain at maturity. The plant accumulates high concentrations of soluble sugars (10–15 %) in the plant stalk sap or juice.

SWEET SORGHUM

The name ''sweet sorghum'' is used to identify those varieties of sorghum, which has juicy and sweet stalks. It is considered to be a potential bioethanol feedstock, expected to meet food, feed, fodder, fuel and fibre demands. Some sweet sorghum lines attain juice yields of 78 % of total plant biomass, containing 15 to 23% soluble fermentable sugar. Most of the sugars are uniformly distributed in the stalk, with about 2% in the leaves and inflorescences making the crop particularly amenable to direct fermentable sugar extraction.

SORGHUM PRODUCTION WORLDWIDE AND IN INDIA

Sorghum is a staple food and provides carbohydrates to the people in North Karnataka, Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh and Rajasthan.

Sorghum is mainly concentrated in Peninsular and Central India. The crop is being grown in practically all the States, but the main areas of the production are those with a low rainfall, that is Maharashtra, Andhra Pradesh, Karnataka, Madhya Pradesh, Gujarat, Tamil Nadu, Rajasthan and Uttar Pradesh. The total area under sorghum in this country is 7.76 million ha with total production of about 7.93 million tonnes

World's average yield of sorghum is 1.37 t/ha. Average yields of sorghum are lower than important grain crops (maize, rice, barley and wheat). The lower average yield is primarily a result of the hot, dry conditions where sorghum is mostly grown, rather than sorghum plant capability. One of the reasons of low production of sorghum is the low per hectare grain yield due to traditional system of cultivation, slow spread of high yielding varieties and hybrids in the country

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

as well as the low and erratic distribution of monsoon rains, as maximum area under sorghum is concentrated in dry/rainfed zones of the country. It is observed that food habits of sorghum eating people are changing towards rice and wheat products. Perhaps this, and reduced market price for sorghum have resulted in the decline of area under sorghum culti-vation. Naturally, the poor farmers of rainfed areas who cannot grow crops other than sor-ghum are economically affected as they are not getting reasonable price of sorghum in the market. Worldwide sorghum production is significant, with sorghum being cultivated across diverse regions and climates. Sorghum is an important cereal grain crop valued for its versatility, adaptability, and nutritional benefits. While specific production figures vary from year to year due to factors such as weather conditions, agricultural practices, and market demand, sorghum is grown extensively in several continents, including Africa, Asia, the Americas, and Australia.

Africa is the largest producer of sorghum globally, with countries such as Nigeria, Sudan, Ethiopia, and Tanzania being major contributors to production. In many African nations, sorghum serves as a staple food crop and plays a crucial role in food security and livelihoods.

In Asia, sorghum production is prominent in countries like India, China, and Thailand. India, in particular, is a significant producer and consumer of sorghum, using it for food, animal feed, and industrial purposes.

World Sorghum Production 2022/2023 by December 2022

This month the United States Department of Agriculture (USDA) estimates that the World Sorghum Production 2022/2023 will be 60.06 million metric tons, around 0.08 million tons less than previous month's projection.

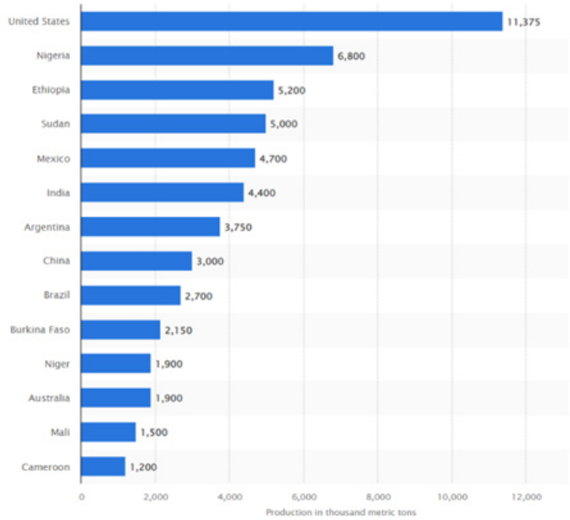
Sorghum Production last year was 62.20 million tons. This year's 60.06 estimated millions of tons could represent a decrease of 2.14 million tons or 3.43% in sorghum production around the globe.

Sorghum Production by Country (Values in Metric Tons)

Country	Production	Country	Production
Nigeria	7,000,000	United States	5,989,000
Sudan	5,000,000	Mexico	4,850,000
Ethiopia	4,500,000	India	4,400,000
Argentina	3,800,000	China	3,000,000
Brazil	2,940,000	Australia	2,900,000
Burkina Faso	1,900,000	Niger	1,900,000
Mali	1,500,000	Bolivia	1,400,000
Cameroon	1,200,000	Chad	950,000
Egypt	750,000	South Sudan	750,000
Tanzania	750,000	European Union	591,000
Ghana	350,000	Senegal	300,000
Togo	280,000	Uganda	225,000
Kenya	200,000	Yemen	185,000
Rwanda	170,000	Saudi Arabia	170,000
Mozambique	160,000	Benin	160,000
Zimbabwe	145,000	Eritrea	140,000
Pakistan	135,000	South Africa	130,000
Uruguay	120,000	Ukraine	100,000
Somalia	100,000	Paraguay	90,000
El Salvador	90,000	Haiti	75,000
Cote d'Ivoire	70,000	Mauritania	70,000
Nicaragua	65,000	Guinea	65,000
Sierra Leone	60,000	Thailand	50,000
Botswana	40,000	Guatemala	35,000
Central African Republic	30,000	Burundi	25,000
Iraq	25,000	Iran	21,000
Guinea-Bissau	20,000	Venezuela	15,000
Zambia	14,000	Ecuador	13,000
Lesotho	10,000	Colombia	9,000

Gurukul International Multidisciplinary
Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

Gambia, the	8,000	Congo (Kinshasa)	7,000
Honduras	5,000	Morocco	4,000
Taiwan	2,000	Peru	1,000
Eswatini	1,000		



VARIETIES OF SWEET SORGHUM

1] AKSSV – 22
(Sweet Sorghum Kharif Variety)

- Fresh green cane yield: 400 to 410 q/ha
- Juice yield from cane: 11000 to 12000 L/ha
- Alcohol production:
  From cane juice: 1450 to 1500 L/ha
  From grains: 1850 to 1870 L/ha
- Total sugar content in juice: 11.5 to 12.0%

2] CSV – 34
(National Released 2017 Kharif Variety)

- Potential Dual-Purpose Kharif Variety
- Grain yield 38 to 40 q/ha
- Fodder yield 135 to 138 q/ha
- Excellent grain and fodder quality
- Bold and lustrous grain
- The bread and taste quality are excellent.
- Tolerant to major pests and diseases.

3] PDKV HurdaKartiki (Wani 103)

- Early Variety (84 to 85 days) for green hurda.
- Green hurda yield 42 to 44 q/ha
- Easy threshability with more sweetness, excellent aroma and taste.
- Tolerant to major pest and diseases.

CONTENTS OF SWEET SORGHUM

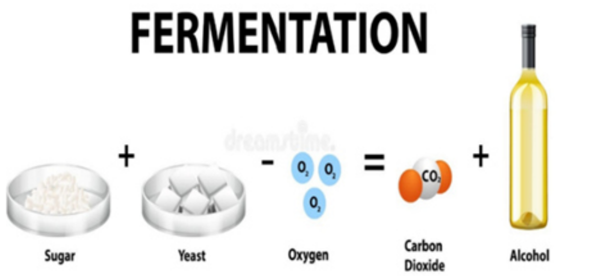
Sugar	16-23% BX
Protein	1.73%
Moisture	5.6%
Fibre	30.22%
Cellulose	35-50%
Lignin	15-25%
Energy	276.10 KCal

3. METHODOLOGY

FERMENTATION

Fermentation of biomass is a process where microbes use sugars as food and simultaneously produce alcohols as product of their metabolism. The fermentation process is usually anaerobic but can also be aerobic, depending on the microbes. In the fermentation process, microbes (fungi, yeast or bacteria) split organic matter, producing alcohols (usually ethanol) as a final product.
First-generation biofuels made from agricultural crops are produced commercially on a large scale and the industry is growing throughout the world. Second-generation biofuels made from wood and by-products (i.e., lignocellulosic material) are more promising in the long term since they do not use material suitable for food. Various companies and research groups work intensively to produce second-generation biofuels commercially. The alcohol production process consists mainly of pre-treatment or hydrolysis, fermentation, separation and purification. Milling and, when using lignocellulosic feedstock, acid or enzyme pre-treatment is the first step of the process. The sugars produced are then fermented and solid residues are separated. Ethanol is toxic to fermenting organisms at concentrations above 15 %, so that ethanol is continuously siphoned off at about 6 % and purified to fuel-grade (over 99 %). Alcohol fermentation is a multi-stage process requiring carefully balanced production logistics.

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII



Chemical Reaction:

$C_6H_{12}O_6$ + Yeast → $2C_2H_5OH + 2CO_2$
(Sugar) (Bakers Yeast) (Ethanol)

ANAEROBIC FERMENTATION:
Anaerobic fermentation occurs in the fermentation vessel once the oxygen is discharged and replaced with N_2, CO_2, or another by-product of the fermentation process. Anaerobic fermentation is usually a slower process. In the mid-1850s, the French chemist Louis Pasteur produced anaerobiosis by boiling the medium to drive out oxygen and then introducing inert gas for cultivation. He showed that a microorganism, probably Clostridium bothrium, was responsible for butyric acid fermentation. In the 1960s and 1970s, anaerobic chambers were invented that allowed the cultivation of numerous anaerobic cultures for certain strictly anaerobic organisms, including C. botulinum. During World War I, industrial anaerobic fermentation was further demonstrated by Perkins and Weizmann, who worked on acetone butanol-ethanol (ABE) fermentation with C. acetobutylicum.
Anaerobes may grow under the unfavourable conditions used to minimize contamination during fermentations because they have unusual enzymes and catabolic pathways. Most anaerobic fermentations require little energy to keep cells in suspension. Because less biomass is produced in anaerobic fermentations, more carbon can be converted to the end product, and a higher product yield is attained. Anaerobes can utilize a wide range of substrates, including agricultural waste streams. This reduces the overall cost of the fermentation process. Anaerobic fermentation has been applied to many important industrial fermentations, such as ethanol production by yeasts, lactic acid preservation of foods, anaerobic digestion of organic matters in ruminant cultivation and waste treatment. The most important industrial fermentation is the anaerobic production of ethanol by S. cerevisiae and other yeasts. However, mixed-culture processes in anaerobic fermentation are also difficult to study and model. The microbial communities are usually unstable, varying with environmental changes and the availability of nutrients. Obligate anaerobes need specialized media and apparatus. They are deactivated by exposure to oxygen. Hence, special skills and meticulous methods are required for the cultivation and manipulation of strictly anaerobic microorganisms. Compared to aerobic organisms, there is little known about methods for genetic manipulation and to express desired genes or biosynthetic pathways.

Fermentation by-products:
Wine is produced by yeast fermentation. Although yeast mainly produces ethanol, it also produces by-products. These by-products need to be removed to obtain pure ethanol. There are mainly two kinds of by-product sources, starch and lignin. Starch derived by-products include esters, organic acids, and higher alcohols. Lignin derived by-products include cyclic and heterocyclic compounds.

SACCHAROMYCES CEREVISIAE YEAST
Saccharomyces cerevisiae is a species of yeast commonly used in various fermentation processes, including winemaking, brewing, and baking. Here's an overview of Saccharomyces cerevisiae yeast and its role in winemaking:
Species Identification: Saccharomyces cerevisiae is a single-celled fungus belonging to the Saccharomycetaceae family. It is known by various common names, including baker's yeast, brewer's yeast, and wine yeast.
Fermentation in Winemaking: Saccharomyces cerevisiae plays a crucial role in winemaking as it is responsible for alcoholic fermentation. During fermentation, Saccharomyces cerevisiae metabolizes sugars present in grape juice, converting them into ethanol (alcohol) and carbon dioxide. This process not only produces alcohol but also contributes to the development of wine's aroma, flavor, and mouthfeel.
Yeast Strains: Within the species Saccharomyces cerevisiae, there are numerous strains that exhibit

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

different characteristics and fermentation behaviors. Winemakers often select specific Saccharomyces cerevisiae strains based on factors such as desired fermentation temperature, alcohol tolerance, aroma production, and the style of wine being produced.

Fermentation Conditions: Saccharomyces cerevisiae yeast performs optimally under specific fermentation conditions. These conditions include temperature, pH, nutrient availability, and oxygen levels. Winemakers carefully control these factors to ensure that Saccharomyces cerevisiae yeast can thrive and complete fermentation efficiently.

Aromatic Profile: Saccharomyces cerevisiae yeast contributes to the aromatic profile of wine through the production of various volatile compounds during fermentation. These compounds include esters, higher alcohols, and sulfur-containing compounds, which contribute to the fruity, floral, and spicy aromas characteristic of wine.

Nutrient Requirements: Saccharomyces cerevisiae yeast requires various nutrients for healthy fermentation, including nitrogen, vitamins, and minerals. Winemakers may supplement grape juice with yeast nutrients to ensure that Saccharomyces cerevisiae yeast has access to the necessary nutrients for optimal fermentation performance.

Quality Control: Commercial strains of Saccharomyces cerevisiae yeast used in winemaking undergo rigorous quality control measures to ensure purity, viability, and performance consistency. These strains are carefully selected and propagated under controlled conditions to maintain their fermentation characteristics and reliability.

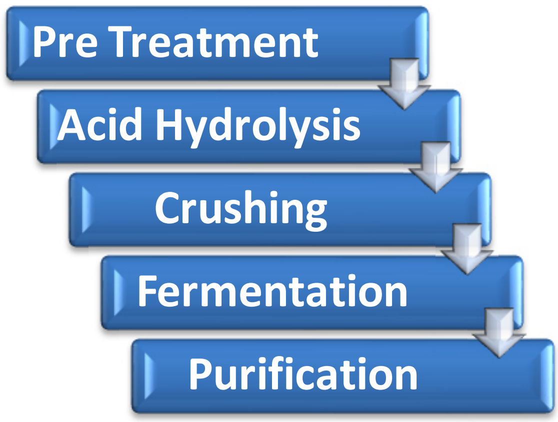
Overall, Saccharomyces cerevisiae yeast is a versatile and essential organism in winemaking, contributing to the transformation of grape juice into wine through alcoholic fermentation. Its ability to produce alcohol and a wide range of aroma compounds makes it a valuable tool for winemakers seeking to craft wines with specific sensory characteristics and flavor profiles.

LALVIN EC 1118 YEAST

Lalvin EC 1118 yeast is a specific strain of Saccharomyces cerevisiae known for its robust fermentation performance and versatility in winemaking. It exhibits rapid fermentation kinetics, high alcohol tolerance (up to 18% ABV), and efficient sugar metabolism, resulting in clean fermentation with low residual sugar levels. While considered a neutral strain, it can enhance fruity and floral aromas in wines. This yeast is widely used in various wine styles, including sparkling, still, white, red, and dessert wines, as well as in cider and beer brewing. Lalvin EC 1118 undergoes rigorous quality control to ensure consistency, and technical support is available from the manufacturer, Lallemand. Overall, it's valued for its reliability and efficiency in producing high-quality wines across diverse fermentation conditions.

PROCESS OF MAKING WINE

The process of making wine from green grains of sorghum involves several steps, from cultivation and harvesting to fermentation and aging.



1. Cultivation and Harvesting:
   - Select sweet sorghum varieties with high sugar content and suitable agronomic traits for winemaking.
   - Prepare the soil and plant sweet sorghum seeds at the appropriate spacing and depth.

- Provide adequate irrigation, fertilization, and pest control throughout the growing season.
- Monitor the development of sorghum grains, aiming to harvest them at the green stage when sugar content is optimal.

2. Grain Preparation:
- Harvest sweet sorghum grains when they reach the desired maturity, typically at the green stage before full ripening.
- Clean and remove any impurities from the harvested grains.
- Crush or mill the green sorghum grains to release the sugars from the cellular structure.
- Extract the juice from the crushed grains using methods such as pressing, squeezing, or soaking in water.

3. Inoculation and Fermentation:
- Inoculate the clarified sorghum juice with wine yeast strains suited for fermenting sorghum sugars.
- Monitor fermentation temperature, typically maintaining it between 40°C to 45°C, to ensure optimal yeast activity.
- Allow fermentation to proceed until the yeast converts the sugars into alcohol and carbon dioxide, typically for 7 to 14 days.
- Monitor fermentation progress by measuring sugar levels and monitoring CO2 production.

4. Pressing and Racking:
- Once fermentation is complete, separate the fermented wine from the solids by pressing or racking.
- Press the solids to extract any remaining wine, then discard or reuse the spent grains.
- Transfer the clarified wine into clean containers, leaving behind any sediment or lees at the bottom.

5. Aging and Maturation:
- Age the sorghum wine in suitable containers such as stainless-steel tanks, oak barrels, or other aging vessels.
- Allow the wine to undergo maturation and development of desired flavors and aromas over time, typically for several months to years.
- Monitor the aging process, periodically tasting and assessing the wine's sensory characteristics.
- Optionally, blend different batches of sorghum wine to achieve the desired flavor profile and consistency.

6. Bottling and Packaging:
- Once the wine has reached the desired level of maturity, prepare it for bottling.
- Filter the wine to remove any remaining solids or impurities.
- Fill clean, sanitized bottles with the wine, cork or seal them securely, and label them appropriately.
- Store the bottled wine in a cool, dark place to preserve its quality and prevent spoilage.

7. Quality Control and Testing:
- Conduct quality control tests on the finished wine, including analysis of alcohol content, acidity, pH, and sensory evaluation.
- Ensure that the wine meets quality standards and regulatory requirements for safety and labelling.
- If necessary, adjust the wine's characteristics through blending, fining, or other corrective measures.

PROCESS OF EXPERIMENT

STEP 1:

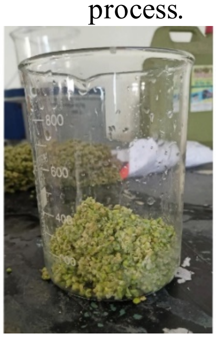
[PRE-TREATMENT]
- Wash the sweet sorghum grains thoroughly with hot water.
- It is being done so that the dust gets washed away and if there are any insects then they will float on top and we can remove it.

STEP 2:

https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

[ACID HYDROLYSIS]

- Take 1 litre of distilled water in a packed glass jar.
- Add 10ml of acetic acid.
- Further pour all the 200gms of clean washed sorghum in the jar.
- Stir it for 5 minutes and then let it settle for 10 more minutes.
- Here acetic acid is used to catalyse the cleavage of a chemical bond via a nucleophilic substitution reaction, with the addition of the elements of water (H2O). Acid hydrolysis is done kill the impurities and breakdown the unwanted reactions.
- Then wash the acid hydrolysed sorghum grains with distilled water.
- Crush these grains until it forms a paste like texture. Crushing of grains is done to facilitates the extraction of juice and compounds from grains, promotes maceration, increases surface area for extraction, ensures uniformity, and enables control over the fermentation process.



STEP 3:

[PREPARATION OF MUST]

- Take a clean, sterilized 1500 ml of air tight glass jar.
- Take 700ml of warm distilled water of temperature around 45°C into it.
- Add 100 grams of powdered sugar into the jar.
- Stir continuously till the sugar gets dissolved.
- As the sugar gets dissolved, add 200grams of crushed grains into the glass jar.
- Mix the must properly and air tight the container.

STEP 4:

[YEAST ADDITION]

- Let the temperature of the must solution reduces to around 35 to 40°C.
- Then add 1.25 grams of Lalvin EC 1118 yeast to the must solution.
- Stir well the must solution and pack the glass jar tightly.

STEP 5:

[FERMENTATION]

- Keep the must solution in an anaerobic condition.
- For which seal the opening of the glass jar with a rubber cork. And attach a long tube to the glass jar through rubber cork.

[Put the tube inside a beaker full of water, so that no air can pass through the tube]

- Maintain a temperature of around 40°C for the glass jar containing the must solution.

STEP 5:

Frequently stir the sample to exploit the fermentation process inside the glass jar under a temperature of 40°C.

[The tube attached to the glass jar also helps to identify the fermentation process by observing some bubbles of CO2 in beaker full of water]

STEP 6:

[SIPHONING]

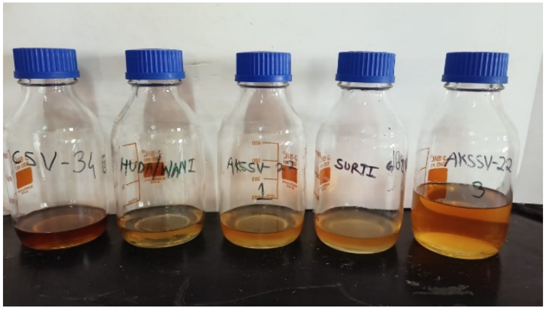
After approximately 30 to 35 days, a glass clear layer of solution appears which is then separated by a method known as siphoning.

[Siphon is the easiest way to rack or transfer your clear wine must or from one container to another]

STEP 7:

[PURIFICATION]

Purify the clear wine and store it in an air tight container under a constant temperature around 35 to 40°C.



4. RESULTS AND DISCUSSION

Ethanol & methanol analysis:

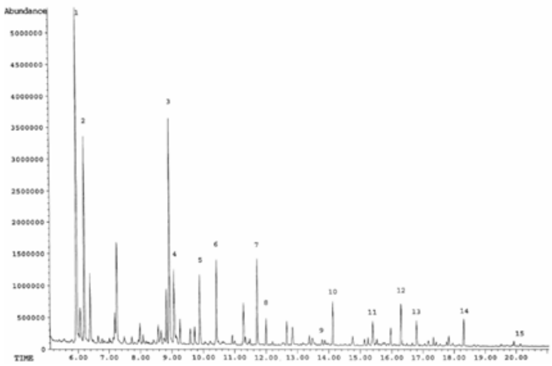
Gas chromatography:

Gas chromatography (GC) is an analytical technique for volatile and semi-volatile compounds. Many ethanol analyses have done with GC since impurities in ethanol are basically volatile as well as ethanol itself.

A sample is vaporized at an injection port by heat. The sample vapor is sent to column packed with adsorbent or absorbent. Inside column, each component in sample is separated depending on its physical and chemical property. The end of column the concentration of each compound is measured by a detector. There are many kinds of coatings for column. A coating should be chosen depending on the target compounds. Also, there are many kinds of detectors. Each detector has advantages and disadvantages. Thus, a detector should also be chosen carefully to detect target compounds.

Gas chromatography-mass spectrometry (GC-MS) is an integrated system of two analytical equipment's. Gas chromatography separates analytes and mass spectrometry identifies them.

Gas chromatography and Mass spectrometry accelerates ethanol analysis with its simultaneous separation and identification capacities. A typical GC chromatogram of alcoholic beverage is shown in fig below.



Ethanol contains (%):

Ethanol content of wine was estimated by using specific gravity. This method provides an approximation of the alcohol content only. The method assumes that the difference in specific gravity before and after fermentation is due solely to the conversion of sugars before fermentation into alcohol after fermentation. The method relies on all the wines measured, starting with the same sugar levels all the sugars being fermented, with the wine finishing dry the unfermentable sugars being the same for all wines.

Total soluble sugar (°B):

The total soluble sugar was determined with the help of digital refractometer and was expressed in degree brix. A drop of juice/wine was placed on clean prism of refractometer and the lid was closed. Reading was taken directly from the scale

Gurukul International Multidisciplinary Research Journal (GIMRJ)*with*
International Impact Factor 8.357
Peer Reviewed Journal
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

at 20°C temperature and recorded as total soluble solids in °Brix.

PH:

The pH of wine was measured by using pH meter at 30°C temperature.

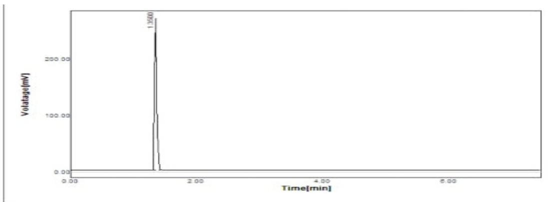
Total dissolved solids(ppm):

Total dissolved solids (TDS) is the total amount of solids dissolved in the water, including soluble hydrogen carbonate ions, chloride salts, sulphates, calcium, magnesium, sodium, potassium, volatile solids and non-volatile solids. Its concentration will affect the taste. It is measured by TDS meter in parts per millions.

RESULTS OBSERVED

Ethanol contains (%):

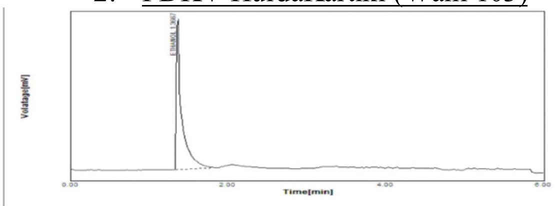
1. Standard Ethanol



Result

No.	Name	RT[min]	Area[mV*s]	Area%	Height[mV]
1		1.3500	662.5237	100.00	269.1166
Sum			662.5237		269.1166

2. PDKV HurdaKartiki (Wani 103)



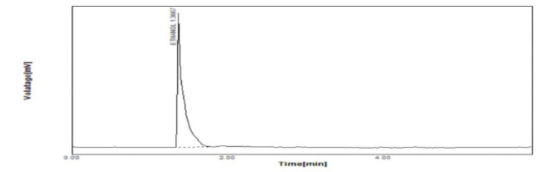
Result

No.	Name	RT[min]	Area[mV*s]	Area%	Height[mV]
1	ETHANOL	1.3667	72.4877	100.00	15.0485
Sum			72.4877		15.0485

ETHANOL % = SAMPLE AREA / STD AREA X 100 =

72.48/ 662.52 X 100 = 10.94 %

3. AKSSV – 22 (1)



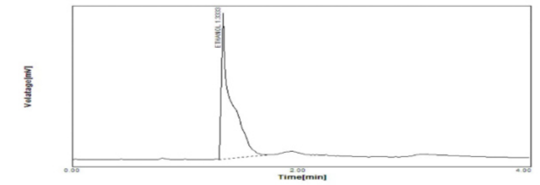
Result

No.	Name	RT[min]	Area[mV*s]	Area%	Height[mV]
1	ETHANOL	1.3667	85.0465	100.00	17.3302
Sum			85.0465		17.3302

ETHANOL % = SAMPLE AREA / STD AREA X 100 =

85.04/ 662.52 X 100 = 12.83 %

4. AKSSV-22(2)



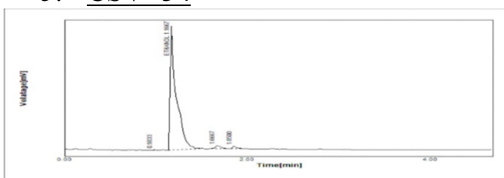
Result

No.	Name	RT[min]	Area[mV*s]	Area%	Height[mV]
1	ETHANOL	1.3333	67.8779	100.00	11.3861
Sum			67.8779		11.3861

ETHANOL % = SAMPLE AREA / STD AREA X 100 =

67.87/ 662.52 X 100 = 10.24 %

5. CSV- 34



Result

No.	Name	RT[min]	Area[mV*s]	Area%	Height[mV]
1		0.9833	0.0691	0.13	0.0691
2	ETHANOL	1.1667	49.7628	96.70	10.4267
3		1.6667	0.9167	1.78	0.2270
4		1.8500	0.7105	1.38	0.2302
Sum			51.4592		10.9531

ETHANOL % = SAMPLE AREA / STD AREA X 100 =

49.76/ 662.52 X 100 = 7.51 %

Total Soluble Sugar:

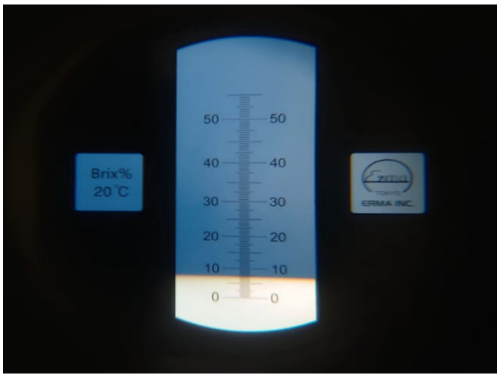
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065

e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

1. PDKV HurdaKartiki (Wani 103) = 3◦ Brix

2. AKSSV – 22 (1) = 7◦ Brix

3. AKSSV- 22 (2) = 7.5◦ Brix



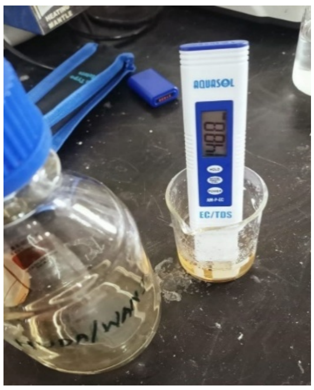
CSV – 34 = 5◦ Brix

PH:

Sr. No.	Sample	pH
1	PDKV HurdaKartiki (Wani 103)	3.26
2	AKSSV-22 (1)	3.66
3	AKSSV-22(2)	3.90
4	CSV-34	3.87

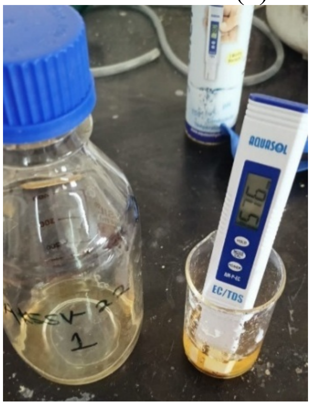
Total Dissolved Solids (ppm):

1. PDKV HurdaKartiki (Wani 103) = 1488



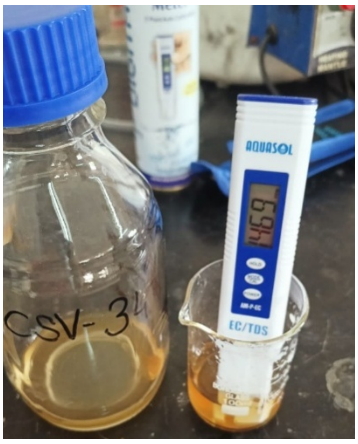
https://doi.org/10.69758/GIMRJ/2505I5VXIIIP0065
e-ISSN No. 2394-8426
Monthly Issue
MAY-2025
Issue–V, Volume–XIII

2. AKSSV-22(1) = 1576



3. AKSSV-22(2) = 1614

4. CSV-34 = 1469



COMPARATIVE ANALYSIS

Sorghum	**Grapes**
• Sorghum can thrive in a variety of climates, including arid or semi-arid regions. • Sorghum is relatively drought-tolerant and requires less water. • It is adaptable to both acidic and alkaline soils. • Sorghum requires short period of time to grow. • Sorghum can be cultivated twice a year.	• Grapes thrive in temperate climates with well-defined seasons. • Grapes require regular and well-distributed water, especially during the growing season. • Grapes prefer well-drained soils with good aeration. • Grapes requires longer period of time to grow. • Grapes can be cultivated only once in a year.

Analysis of properties of Grapes and Sorghum Wine:

Sample	**Alcohol(%)**	**pH**	**TSS (◦ Brix)**	**TDS (ppm)**
Grapes Wine	5 – 15	2.9 – 4.2	18 – 26	1000 – 3000
Hurda/Wani Wine	10.94	3.26	3	1488
AKSSV-22(1) Wine	12.83	3.66	7	1576
AKSSV-22(2) Wine	10.24	3.90	7.5	1614
CSV-34 Wine	7.51	3.87	5	1469

COST EFFECTIVENESS

- Average selling price of a bottle (750ml) of wine is Rs. 850 to Rs. 1000.
- Minimum average selling price of a bottle (750ml) of wine is Rs.800 to 950.
- Yield of sorghum is 12 Quintals/ Acre.
- Average cost of sorghum is Rs. 42600 (Rs. 3550 x 12).

- Cost required to cultivate sweet sorghum is Rs. 11,605 per acre.
- Net profit to farmers = Rs. 42600 – Rs. 11,605 = Rs. 30995/-
- Cost of sweet sorghum is Rs 10000/ Quintals (Rs 100/kg X 10 Qt)
- Average cost of sweet sorghum is Rs. 100000 (Rs. 10000 x 10).
- Thus, cost of green grain of sweet sorghum is Rs 1,00,000/ Acre
- Thus, farmers profit on selling green grain of sweet sorghum is Rs 89400/ Acre.

Cost of Sweet Sorghum Wine:

- Green grains of sweet sorghum required – 200gm (Price = Rs 35 approx.)
- Distilled water required – 700ml (Prize = Rs 50 approx.)
- Cost of yeast required – Rs 100
- Approximate cost of process (Labor cost, operation cost, GST, tax, others) – Rs 200
- Thus, maximum total cost of a bottle (750ml) of sweet sorghum wine at initial stage is Rs 400 to Rs 450
- Cost of 1litres of sweet sorghum wine is Rs 530 to Rs 600 approximately.
- Production of sweet sorghum wine from 1 kg of sweet sorghum is approximately 3 liters.
- Thus, production of sweet sorghum wine is approximately 3000 liters/ acre.
- Cost of sweet sorghum wine per acre is Rs 18,00,000 approx.
- Wine market price reduces to approximately Rs 300 to Rs 450 per bottle (750ml).

5. CONCLUSION

In conclusion, the production of wine from green grains of sweet sorghum offers a promising avenue for innovation in the winemaking industry. Sweet sorghum, with its high sugar content and agronomic resilience, presents a viable alternative to traditional grape-based winemaking, particularly in regions where grape cultivation may be challenging or limited.Through meticulous cultivation practices and optimization of fermentation techniques, winemakers can harness the potential of sweet sorghum grains to produce wines with unique sensory characteristics and flavor profiles. The fermentation of sweet sorghum sugars by selected yeast strains yields wines that exhibit a spectrum of aromas, flavors, and textures, enriching the diversity of available wine styles.Moreover, the production of wine from sweet sorghum grains aligns with sustainability objectives, as sorghum cultivation requires fewer inputs such as water and pesticides compared to grape cultivation. This environmentally friendly approach, coupled with the versatility and adaptability of sweet sorghum as a crop, positions sorghum-based wine as a compelling option for environmentally conscious consumers and producers alike.However, further research and development are needed to optimize cultivation practices, fermentation techniques, and sensory characteristics of sorghum-based wines. Collaboration between researchers, winemakers, and agricultural experts can drive innovation and refinement in this emerging field, unlocking the full potential of sweet sorghum as a valuable raw material for wine production.

In summary, the production of wine from green grains of sweet sorghum represents an exciting frontier in winemaking, offering opportunities for sustainability, innovation, and diversification in the global wine industry. With continued exploration and investment, sorghum-based wines have the potential to carve out a niche market and contribute to the rich tapestry of wines available to consumers worldwide.

6. REFERENCES

1. Sweet Sorghum Research and Development in India: Status and Prospects K. S. Vinutha • LaavanyaRayaprolu • K. Yadagiri • A. V. Umakanth • J. V. Patil • P. Srinivasa Rao (Received: 4 January 2014 / Accepted: 22 January 2014 / Published online: 4 February 2014)
2. A New Model of Alcoholic Fermentation under a By-product Inhibitory Effect (2021) Hamid Zentou, * Zurina Zainal Abidin, * RobiahYunus, Dayang R. Awang Biak, Mohammed Abdullah Issa, and Musa Yahaya Pudza
3. The Role of Yeasts in Fermentation Processes (Received: 17 July 2020; Accepted: 25 July 2020; Published: 28 July 2020) by SergiMaicas Recent Advances in Sorghum

Improvement Research at ICRISAT (2010) Belum V.S. Reddy*, A. Ashok Kumar and P. Sanjana Reddy
4. Global Sorghum Production Scenario (2004) UK Deb1, MCS Bantilan2, AD Roy3 and P Parthasarathy Rao
5. The Chemical Process Industries by R. NORRIES SHREVE Fermentation Industries (Page no. 664-672)
6. Journal of wine research, Volume 34, Issue 4(2023)
7. Wine studies journal, Volume 2 (2023): Regular Issue, Published: 05-09-2023
8. A review: potential of wine production from different fruits, (Feb, 2023), Ashutosh S Dalal& Sandeep Kumar
9. Quality Characteristics of Korean Traditional Wines with Puffed Sorghum, August 2015Journal of the Korean Society of Food Science and Nutrition 44(8):1219 1225DOI:10.3746/jkfn.2015.44.8.1219
10. Wine research and its relationship with wine production: a scientometric analysis of global trends, H.R. Jamali, C.C. Steel, E. Mohammadi, First published: 12 February 2020
11. 2018 Jul; 23(7): 1684. Published online 2018 Jul 11. Contribution of Red Wine Consumption to Human Health Protection
12. Fruit Wine Production: A Review, (July 2014) Authors:ShrikantBaslingappa Swami, Dr.Balasaheb Sawant Konkan Krishi Vidypeeth, DapoliDistRatnagiriNayansinghThakor
13. Production of Wine from Fermentation of Grape (Vitis vinifera) and Sweet Orange (Citrus seninsis) Juice using Saccharomyces cerevisiae Isolated from Palm Wine(January 2017) International Journal of Current Microbiology and Applied Sciences
14. De Menezee, I. J. B. 1978. Alcohol Production from Cassava. Pp. 41—45 in: Cassava Harvesting and Processing. International Development Research Center, Ottawa, Canada.
15. Purseglove, J. W. 1985. Tropical Crops. In: Monocotyledons. England: Longman.
16. Kuboye, A. O., A. B. Oniwinde, and I. A. Akinrele. 1978. Production of Alcoholic Beverages from Ripe Pineapples, Plantain, and Bananas, Vol. 2, Pp.78-80. Nigerian Institute of Food Science and Technology. Lagos, Nigeria
17. Hong, J.H., Jung, J.Y., Kim, Y.S., Kim, S.M., Seo, Y.G., & Lee, S.Y. (2015). Optimization of ethanol production from green sweet sorghum juice using response surface methodology. Bioresource Technology, 186, 261-267.
18. Ren, W., Zhao, X., & Jiang, L. (2017). Green process for bioethanol production from sweet sorghum stalk. Bioresource Technology, 224, 537-542.
19. Balat, M. (2011). Production of bioethanol from lignocellulosic materials via the biochemical pathway: A review. Energy Conversion and Management, 52(2), 858-875.
20. Li, Q., Yang, Y., Li, H., Ren, J., & Zhao, X. (2018). Evaluation of sweet sorghum as a potential ethanol crop in China. Industrial Crops and Products, 111, 83-90.
21. Wu, Y., Jin, Y., Wu, Y., Zhang, M., Wang, J., & Wang, Y. (2018). Comparative analysis of ethanol production from sugarcane bagasse and sweet sorghum bagasse. Bioresource Technology, 250, 860-865.
22. Kim, J., Kim, S., & Kim, S. (2013). Comparison of bioethanol production from corn cob and sweet sorghum bagasse. Bioresource Technology, 149, 391-394.
23. Kumar, S., & Gupta, R. (2017). Production of bioethanol from sweet sorghum: A review. Sugar Tech, 19(6), 577-586.
24. Wang, Y., Zhao, L., Wang, J., &Jin, Y. (2019). Comparative study on bioethanol production from sweet sorghum bagasse pretreated with liquid hot water and dilute acid. Bioresource Technology, 282, 125-130.
25. Wang, X., Lu, X., Yang, G., Luo, F., & Wang, Y. (2019). Comparative study of ethanol production from sweet sorghum juice at different temperatures. Bioresource Technology Reports, 5, 31-36.
26. Singh, A., Kumar, A., &Adholeya, A. (2019). Bioethanol production from sweet sorghum: Current trends and future perspectives. Renewable and Sustainable Energy Reviews, 105, 386-399.
27. Liu, H., Liu, J., & Ma, Y. (2013). Research progress on sweet sorghum for bioethanol production. In Advanced Materials Research (Vol. 662, pp. 392-395). Trans Tech Publications Ltd.