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Potential and Processing Technology of Nutmeg Pulp for Wine Production: A Literature Review

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ABSTRACT

Nutmeg *(Myristica fragrans)* is a high-value spice commodity, yet the utilization of its fruit flesh remains limited and is often discarded. In fact, nutmeg flesh contains sugars, dietary fiber, and various bioactive compounds that can support the fermentation processes. This article reviews the potential of nutmeg fruit flesh as a raw material for wine production through a literature-based approach. Various studies indicate that fermentation using yeasts such as *Saccharomyces cerevisiae*, *Amylomyces rouxii*, and *Rhizopus oligosporus* has been shown to produce wine with desirable chemical and sensory characteristics. The review further highlights that processing nutmeg fruit flesh into wine may enhance the commodity's value, provide opportunities for product diversification, and support economic growth for farmers and local industries. Therefore, the development of nutmeg-based wine holds promising prospects from both technological and economic perspectives.

INTRODUCTION

Indonesia is widely recognized as an agrarian country rich in natural resources, including a diverse range of spices and fruit crops with high economic value. One of the agricultural commodities extensively utilized is nutmeg (*Myristica fragrans*), particularly its fruit flesh. To date, the utilization of nutmeg has primarily focused on the seed and mace for culinary and industrial purposes, while the fruit flesh is often treated as waste or processed only to a limited extent. In fact, nutmeg fruit flesh contains nutrients and bioactive compounds that hold significant potential for the development of various food products (Rohman, 2019). The production of nutmeg in Indonesia has remained stable for the last five years. In 2021, total production was 40,639 tons; in 2022, it was projected to decline slightly to 39,550 tons, but in 2023 it was expected to increase again to 44,597 tons (Pusdatin, 2022), indicating that nutmeg continues to be a strategically important agricultural commodity within Indonesia's agriculture (plantation) sector. Therefore, it is essential to maximize the utilization of all parts of the nutmeg fruit both the seed and the flesh to increase the economic value of the nutmeg fruit and strengthen efforts toward the product diversification of the entire nutmeg.

In the food processing industry, nutmeg is generally known for its seed as a spice; however, the fruit flesh, which is often overlooked, possesses substantial potential as a raw material for a wide range of food products. Nutmeg fruit flesh can be processed into candied

fruit, syrup, jam, jelly, chutney, dodol, and fermented beverages such as wine. This utilization is particularly important because the fruit flesh constitutes the largest portion of the nutmeg fruit (approximately 77.9%). When optimally utilized, it can enhance the economic value of the commodity and contribute to increased income for farmers and local industries, particularly with appropriate support from government stakeholders (Iznilillah & Jumiono, 2024).

The potential of nutmeg fruit flesh as a raw material for wine production has not been extensively discussed in the available literature. However, in general, nutmeg fruit components particularly the flesh exhibit characteristics suitable for fermentation due to their sugar content and aromatic profile, which can support the fermentation process. The use of nutmeg fruit flesh in wine production represents a promising innovation, as this part of the fruit contains constituents capable of imparting distinctive aromatic characteristics to the final product. Further research is needed to examine the sugar composition, enzymatic activity, and other fermentation-supporting compounds present in nutmeg fruit flesh (Iznilillah & Jumiono, 2024).

In addition, a study conducted by Marzuki et al. (2018). Demonstrated that nutmeg fruit flesh can be fermented into wine using various starter cultures, including *Saccharomyces cerevisiae*, *Amylomyces rouxii*, and *Rhizopus oligosporus*. Different yeast species and their concentrations influence sugar reduction, acidity levels, and pH changes during fermentation. The findings indicate that nutmeg fruit flesh contains essential components required to facilitate fermentation, making it a viable alternative raw material for producing value-added alcoholic beverages.

Furthermore, research by Idris et al. (2021). Reported that ethanol extracts of nutmeg fruit flesh contain bioactive compounds such as flavonoids, alkaloids, and saponins, and exhibit significant antioxidant activity. The presence of these compounds may contribute to the flavor, aroma, and sensory attributes of fermented products. Therefore, utilizing nutmeg fruit flesh as a substrate for wine production not only offers economic advantages but also has the potential to generate products with unique characteristics distinct from those produced using other tropical fruit fermentation substrates.

RESEARCH METHODS

This article was compiled using a literature review method by collecting, examining, and analyzing scientific sources related to the utilization of nutmeg *(Myristica fragrans)* fruit flesh as a raw material for wine production. The literature was obtained from national and international journals, textbooks, and institutional publications discussing the chemical–physical characteristics of nutmeg fruit flesh, its potential applications in food processing, and fermentation techniques.

The review process involved several steps: searching for relevant literature, selecting credible sources, and synthesizing information related to nutmeg fruit characteristics and their relationship to fermentation performance. Literature searches were carried out using databases such as Google Scholar, ScienceDirect, and the Garuda Portal, with inclusion criteria focusing on relevance, data quality, and publication years between 2011 and 2024.

The overall process of gathering, reviewing, and writing literature citations required approximately 2 weeks, including verification of source credibility and comparison across studies. In total, 18 journal articles were used as primary references. This structured approach ensured that the discussion presented in this article provides a comprehensive and evidence-based overview of nutmeg fruit flesh potential for wine production without direct laboratory experimentation.

The method is described in detail, including the design, population, sample and sampling techniques, how the research works, the parameters observed, and technical analysis. The method is written in narrative form by conveying the importance of the way the research was carried out. Authors can include tables or graphs in the results and discussion.

RESULTS AND DISCUSSION

Chemical Characteristics of Nutmeg Fruit Flesh

The flesh of the nutmeg fruit (*Myristica fragrans*) typically has a pH range of 3 to 4, creating an acidic environment that supports the optimal growth of *Lactobacillus casei* during fermentation with starter concentrations between 2% and 6% and incubation durations of 16 to 20 h (Table 1).

Table 1. Comparison of the Chemical Composition of Nutmeg Fruit Flesh with Other Fruit

Parameter	Nutmeg Fruit Flesh	Grape Must	Pomegranate	Apple
°Brix (sugar)	10–15 (estimated)	22–28	14–18	12–14
pH	3–4	3–4	2.8–4	4.0–4.4
Total Acidity	1.44–1.85% lactic acid	6–11 g/L tartaric/malic	1.10% citric acid	0.76–0.87%
Fiber	High	Low	Low	Moderate
Protein	Moderate	Low	Low	Low
Aromatic Compounds	Myristicin, neolignans (erythrosurinamensi virolane), >17 volatiles	Phenolics	Organic acids	Minimal

This acidic environment facilitates high lactic acid production reaching up to 1.85% after 20 hours of fermentation and results in favorable organoleptic properties, including taste, aroma, and texture at a starter concentration of 4-6% with an 18 h incubation period (Zulkifli, 2022). This pH range closely matches that of grape must, which also exhibits a pH of 3 to 4 and a °Brix of 22 to 28, along with titratable acidity from 6 to 11 g/L tartaric and malic acids, conditions known to foster microbial stability and successful fermentation (Magalhães et al., 2011). Additionally, the high fiber and moderate protein content in the nutmeg fruit flesh, comparable to that of Passiflora species, provides nutritional support for yeast, enriching fermentative activity despite a moderate sugar concentration estimated to be 10-15 °Brix (Nguyen et al., 2023). Of particular note are the bioactive compounds identified in nutmeg fruit flesh, including neolignans such as erythrosurinamensin and virolane, along with volatile constituents such as myristicin and elemicin. More than seventeen distinct compounds have been identified, contributing to a uniquely aromatic profile and high phenolic antioxidant content. These features distinguish nutmeg fruit as a valuable substrate for non-grape wine fermentation, offering both functional and sensory benefits (Khalil et al., 2022).

Physical Characteristics of Nutmeg Fruit Flesh

The physical characteristics of nutmeg fruit flesh vary greatly based on several factors including nutmeg cultivar (genotype), growing region, and local climate conditions. Variations in fruit flesh affect both the juice recovery process and yeast fermentation. Morphological studies from the Sangihe Islands indicate that two dominant shapes of nutmeg fruit exist round and elongated. The weight of fresh fruit can reach up to 59.41 g. According to Legoh et al. (2020), when fresh nutmeg fruit is cut open, an increase in white fleshy tissue is observed. In addition, characterization of nutmeg populations on the island of Siau (Gaghana et al. 2024), has found large differences in the weights of whole fruits, weights of seeds, and masses of mace among three distinct clusters. This suggests that the amount of fruit flesh available to be processed will vary considerably for each of the genotypes studied.

The amount of pulp that can be recovered from nutmeg fruit and the amount of fermentable sugar available during fermentation also depends on the physical characteristics of nutmeg fruit, such as the thickness of the pericarp and the size of the fruit flesh mass.

Chemical structural characterizations of nutmeg fruit flesh conducted by Tang et al. (2020) have identified key components within the cell wall of nutmeg fruit that can influence the texture and pressing efficiency of the pulp, as well as the amount of soluble sugar released during the maceration of nutmeg fruit.

The above-mentioned factors indicate that additional pre-treatment techniques, such as enzymatic hydrolysis and maceration techniques that extend time periods, may be required to increase juice recovery and enhance fermentation kinetics. Therefore, understanding the morphological and physical variability of nutmeg fruit flesh is essential for selecting suitable raw materials, optimizing extraction, and ensuring consistent fermentation yield and final wine quality.

Nutmeg Processing Technology

Nutmeg fruit is suitable for various food products, such as candied nutmeg, nutmeg syrup, nutmeg paste, sliced nutmeg paste, nutmeg hard candy, nutmeg jelly, and finally, nutmeg dodol. Then again, nutmeg also contains essential oils and oleoresins which have potential uses in the seasoning formulations, cosmetics, perfumery, and pharmaceutical industries. Thus, these examples not only show the multiple uses of nutmeg but also highlight the need for specific technological processes necessary to convert nutmeg fruit flesh into a suitable wine substrate. Pulp particle size, pre-treatment methods (blanching, enzymatic maceration, or salt soaking), sugar adjustment, and fermentation temperature control are all parameters that have a huge influence on juice extraction efficiency, microbial activity, and the chemical makeup of the final wine product. For instance, finer pulp particle size and proper maceration result in higher soluble solids release, which in turn increases fermentable sugar availability and aroma extraction. Moreover, temperature control during fermentation plays a crucial role in yeast metabolism and alcohol yield (tropical fruit wines are usually fermented at 25-30°C).

Practically, nutmeg fruit pulp is associated with several technological impediments, the major ones being its fibrous nature, moderate lignocellulose content, and initial sugar levels that are low compared with fruits used in the conventional winemaking process, all of these factors may limit fermentation performance unless proper measures like sugar supplementation, nitrogen sources, or enzyme-assisted clarification are taken. Yet, paradoxically these challenges also open opportunities for further development, such as pre-processing treatments, yeast strain selection for high-fiber substrates, and co-fermentation, which may further enhance flavor complexity. Hence, the consideration of nutmeg-specific processing parameters and the overcoming of technological limitations are the main steps in the refinement of nutmeg wine production and the enhancement of product quality, simultaneously making the relevance of this part to the study's overall goals stronger (Iznilillah & Jumiono, 2024).

Nutmeg Fruit Flesh Wine

When producing wine from nutmeg, fermentation must be controlled using appropriate technical parameters that are important for product quality. Manginsela et al. (2018) showed that the use of 4 g of *Rhizopus oligosporus* starter yeast and 14 days of fermentation at room temperature produced the most stable wine characteristics, with a total sugar content of 1.15%, total acidity of 0.19%, and a pH of 3.28. These findings highlight the need for precise control over yeast type, inoculum size, initial pH, and fermentation time in the process of making wine from tropical fruits.

On the other hand, research on fruit wine production from other tropical fruits, such as that conducted by Lestari et al. (2019) on wine from red dragon fruit, shows that the initial sugar level (up to 25° Brix) and fermentation time (up to 15 d) strongly influence the pH (≈3.5), alcohol content (8–9% v/v), and quality. The same principle can be applied to nutmeg fermentation, due to the similar characteristics of tropical fruits, which typically contain low initial sugar and acid levels that must be adjusted to support yeast activity.

Additionally, the technological challenges in tropical fruit fermentation are highlighted by Osho et al. (2019), who emphasize low natural sugar content, the need for pH adjustment, and the potential for microbial contamination during fermentation. This makes sanitation control and microbial stability critical aspects in the production process of nutmeg wine.

In addition, the potential for utilizing nutmeg pulp is enormous. According to Sahusilawane et al. (2023), nutmeg pulp accounts for approximately 77.8% of the total fruit weight, yet it has not been optimally utilized to date. Therefore, the development of nutmeg wine and other fermented products (such as nutmeg vinegar or low-alcohol fermented beverages) has the potential to enhance the value of nutmeg as a commodity and expand the diversification of processed nutmeg products.

Processing Stages in Nutmeg Wine Production

The production of nutmeg wine involves a series of sequential processes designed to obtain a high-quality fermented product. Following the procedures described by Wijayanti et al. (2013) in Figure 1. The process begins with preparing the nutmeg fruit flesh by peeling the fruit, splitting it, and separating the seed and mace. The flesh is then soaked in a 2% saline solution for 24 hours and thoroughly rinsed to reduce the salt content. The extracted flesh is subsequently mixed with water at a 1:1 (w/v) ratio, blended, and filtered to obtain nutmeg juice. In parallel, mung bean sprout extract is prepared by washing 200 g of sprouts, blanching them briefly for approximately one minute, and crushing and filtering the mixture to produce the extract. The nutmeg juice is then combined with the sprout extract, followed by the addition of 350 g of cane sugar, after which the mixture is pasteurized at 75–80 °C for 30 minutes using a boiling-water heating method.

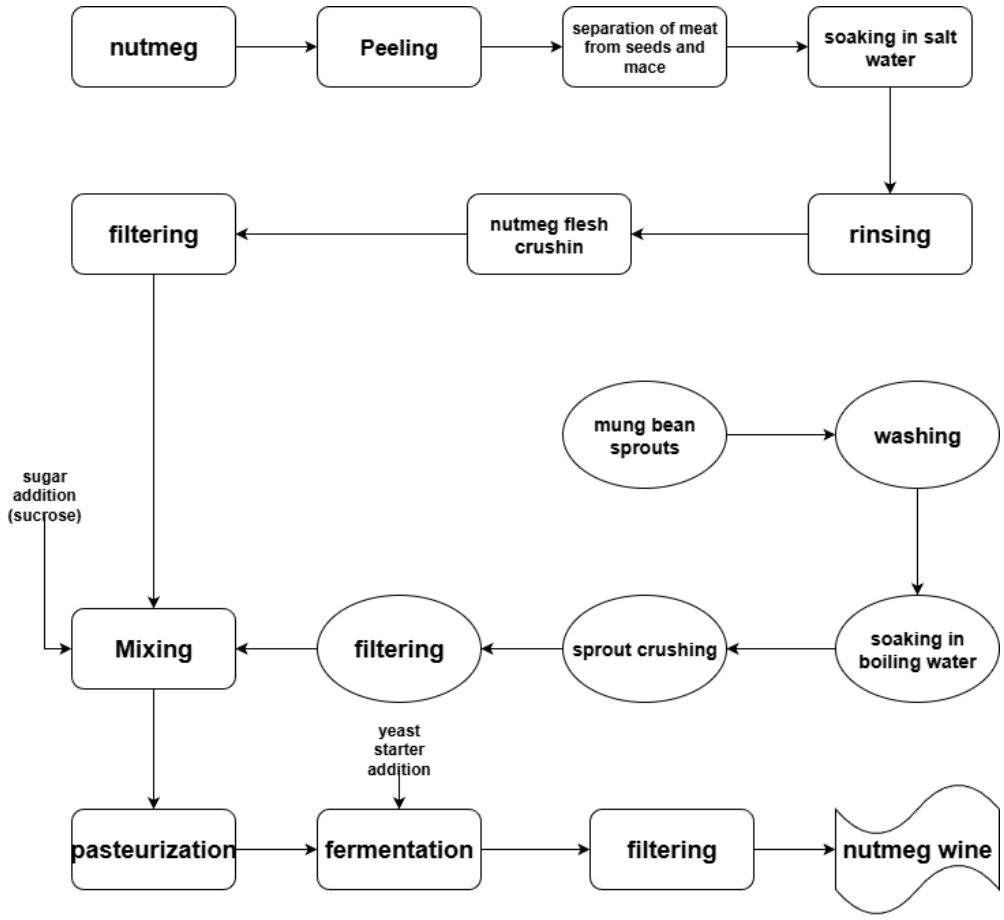

Figure 1. Process flow and fermentation outcomes of nutmeg wine production

After cooling, yeast starters such as *Saccharomyces cerevisiae*, *Amylomyces rouxii*, or *Rhizopus oligosporus* are added at concentrations of 4 g, 6 g, or 8 g, and the mixture is incubated at room temperature for 14 days to allow fermentation. Once the fermentation phase is complete, the product is filtered to obtain the final nutmeg wine. In this formulation, sucrose acts as the primary carbon source, while mung bean sprout extract provides essential nitrogen required to support microbial growth throughout the fermentation process. The following flow diagram illustrates the standardized processing steps in producing nutmeg flesh wine, including raw material preparation, juice extraction, fermentation, and post-fermentation handling.

CONCLUSION

Nutmeg fruit flesh *(Myristica fragrans),* which has been underutilized to date, possesses considerable potential as a raw material for value-added food products, including fermented beverages such as wine. The chemical composition of nutmeg fruit flesh, particularly its sugars, dietary fiber, and bioactive compounds such as flavonoids, alkaloids, and saponins support the fermentation process while also contributing distinctive sensory attributes to the final product. Numerous studies have demonstrated that the selection of yeast species and starter concentrations, including *Saccharomyces cerevisiae, Amylomyces rouxii,* and *Rhizopus oligosporus,* has a significant influence on the residual sugar content, acidity, pH, and overall flavor profile of the resulting wine.

The processing of nutmeg fruit flesh into wine not only enhances the economic value of nutmeg but also creates opportunities for the diversification of tropical spice-based products that are unique and competitive. With further research focusing on fermentation optimization, quality standardization, and market development strategies, nutmeg wine has the potential to emerge as a high-value product that could increase farmers' income, strengthen local food-processing industries, and expand the diversity of fermented beverages in Indonesia.

REFERENCES

Al-Qahtani, W. H., Dinakarkumar, Y., Arokiyaraj, S., Saravanakumar, V., Rajabathar, J. R., Arjun, K., Gayathri, P. K., & Appaturi, J. N. (2022). Phyto-chemical and biological activity of *Myristica fragrans*, an ayurvedic medicinal plant in Southern India and its ingredient analysis. *Saudi Journal of Biological Sciences*, 29(5), 3815–3821. https://doi.org/10.1016/j.sjbs.2022.02.043

Alegu, H. A., Ugo, V. O., Nzekwe, C. B., Okeke, C. N., Christaugunus, M. C., & Vincent, I. C. (2025). Biotechnological studies on the fermentation and physicochemical characterization of Palm Fruit, Tiger Nut, and Watermelon Juices for Wine Production. *International Journal of Research and Innovation in Applied Science, 10*(6), 1023-1033. https://doi.org/10.51584/IJRIAS.2025.10060076

Anjelina, F., Rahmiati, R., & Sigit, B. (2024). Variation in longan fruit extract (*Dimocarpus longan*) concentrations and fermentation duration on the characteristics of fruit wine. *Jurnal Teknologi Pangan dan Hasil Pertanian, 19*(2), 1–10. https://doi.org/10.26623/jtphp.v19i2.9006

Arief, R. W., Firdausil, A. B., & Asnawi, R. (2015). Potential of nutmeg fruit processing being various products with high value economic. *Bul. Littro, 26(2),* 165–174. https://doi.org/10.21082/bullittro.v26n2.2015.165-174

Dareda, C.T., Suryanto, E., & Momuat, L. I. (2020). Characterization and antioxidant activity of dietary fiber from nutmeg flesh (*Myristica fragrans* Houtt). *Chem. Prog., 13*(1), 48–55. https://doi.org/10.35799/cp.13.1.2020.29661

Iznilillah, W., & Jumiono, A. (2024). Various processed food products from nutmeg (*Myristica fragrans* Houtt) with economic value and multifunctional benefits. *Jurnal Ilmiah Pangan Halal, 6*(2), 144–153. https://doi.org/10.30997/jiph.v6i2.15813

Legoh, W. L., Runtunuwu, S., & Wanget, S. (2020). Characterization of nutmeg (*Myristica fragrans* L.) in the Sangihe Islands Regency based on fruit and leaf morphology. *Agri-SosioEkonomi Unsrat, 16*(2), 279–290. https://doi.org/10.35791/agrsosek.16.2.2020.29532

Nguyen, A. T., & Tran, D.K. (2025). Determination of chemicophysical properties of wild maracuja (*Passiflora foetida* L.) fruits cultivated in Vietnam. *Food Research, 9*(3): 392-398. https://doi.org/10.26656/fr.2017.9(3).177

Pusat Data dan Sistem Informasi Pertanian. (2022). *Outlook Pala 2022*. Kementerian Pertanian Republik Indonesia. https://satudata.pertanian.go.id/assets/docs/publikasi/Outlook_Pala_2022.pdf

Runtunuwu, S. D., Mamarimbing, R., Pamandungan, Y., & Horonis, S. (2022). Pengelompokan Pala Siau (Myristica fragrans Houtt) Berdasarkan Karakter Buah, Biji, dan Fuli. *AGRI-SOSIOEKONOMI*, *18*(2), 515–520. https://doi.org/10.35791/agrsosek.v18i2.55221

Saiful, A., Kurniaty, R., Muhammad, Y., Zulyani, R., Mahmudi, M., Mustika, R. W., & Farida, M. (2024). Phytochemical screening and antioxidant activity of ethanolic extract of nutmeg flesh (*Myristica fragrans*) from Southern Aceh Province, Indonesia. *Journal of Pharmaceutical Sciences and Research,* 537–543. https://doi.org/10.36490/journal-jps.com.v7i4.421

Suwarrizki, G. B., Gunam, I. B. W., & Wijaya, I. M. M. (2019). Pengaruh penambahan konsentrasi gula dan lama fermentasi pada proses pembuatan sweet dessert wine buah naga super red. *Agrotechno, 4(1),* 44–53. https://doi.org/10.24843/JITPA.2019.v04.i01.p06

Wijayanti, F. W., Ijong, F. G., & Mandey, L. C. (2013). Wine-making process of nutmeg flesh using different types and concentrations of yeast starters. *Jurnal Ilmu dan Teknologi Pangan, 1*(1), 16–22. https://ejournal.unsrat.ac.id/index.php/itp/article/view/19400