UNIVERSITY OF CAPE COAST

PRODUCTION AND CONSUMER ACCEPTABILITY OF JACKAL BERRY WINE

AUGUSTINA LOGE

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BY

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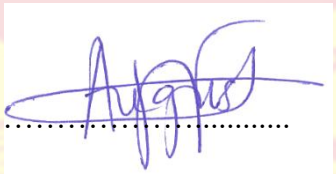
Thesis submitted to the Department of Vocational and Technical Education of the Faculty of Science and Technology Education, College of Education Studies, University of Cape Coast, in partial fulfilment of the requirements for award of Master of Philosophy Degree in Home Economics

2024

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.



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Supervisors' Declaration

I hereby declare that the preparation and presentation of this thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature: ..... Date: .....

Name: Prof. (Mrs). Sarah Darkwa

ABSTRACT

The purpose of the study was to use wild edible jackal berry fruit to produce wine and test for its sensory acceptability using a panel. The study was guided by three research objectives and one hypothesis. Literature reviewed covered theoretical and empirical to give basis to the study. An experimental research design was used. A panel of 100 members selected from different religious and formal education backgrounds was used. The research findings on the objectives and hypothesis were analysed using a recipe chart, mean, standard deviation, One-way ANOVA and independent t-test. Results showed that the fruit fermented either without any inoculation of microbes (Sample A) or with inoculation of *Saccharomyces cerevisiae* yeast (sample B). These two wine formulations had good amounts of copper (Cu), zinc (Zn), phosphorus (P), iron (Fe), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) at different values for each of the formulations. Sample B was the most accepted formulation. The hypothesis showed that the value of the minerals present in the two formulations were significant. The study therefore suggest that different quantities of *Saccharomyces cerevisiae* should be added an inoculum for the for fermentation and the variations in the mineral value and product acceptability assessed.

ACKNOWLEDGEMENTS

Words cannot express my gratitude to my supervisor, Professor (Mrs.) Sarah Darkwa for her guidance, invaluable patience, feedback and patience. Additionally, I sincerely thank Mr. Steven Adu at the University of Cape Coast School of Agriculture laboratory for his guidance and Mr. Cosmos Kwaku Nutakor for helping me with the data analysis. My appreciation goes to all my participants who genuinely volunteered for the study.

Finally, my sincere thanks go to my husband, Lawyer Lwanga Sanyeh Bagonluri for his help and encouraging me to pursue further studies.

DEDICATION

To my husband, Lawyer Lwanga Sanyeh Bagonluri.

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CHAPTER ONE

INTRODUCTION

Background to the Study

Plants are living organisms that produce their own food through a process called photosynthesis. Plants, which include trees, grasses and shrubs, play a vital part in global ecosystems. They serve as a source of food and oxygen and complete the food chain and the food web; both animals and humans rely on plants for survival. Plants provide the world's medical sectors with raw materials for medicinal discovery. Plants contribute significantly as sources of shelter, clothes, firewood, medicine and food. Qin, Xu, An, Yang, Wang, Dou and Fu (2023) recognized the various uses of plants, ranging from pharmaceutical and physiological uses. As a result, there has been continual cultivation of cash crops such as cocoa.

Minor fruits are those that, although they are edible to humans, are comparatively less appetising than other popular fruits, have lower market demand, are not typically grown in organised plantations with inputs, and are only grown to a limited extent (De, 2021). These fruits are also referred to as less well-known, underutilised, less desirable, underexploited, prospective, stray, or wild fruits, among other words. Minor fruit species have the tolerance to endure in hard climates and serve as life support in vulnerable ecosystems and adverse climatic conditions. Minor food crops may contribute to food security, nutrition, health, income creation, and environmental services if they are used appropriately (Kahane et al 2013).

According to Mayes et al. (2012), minor crop species are frequently indigenous ancient crop species that are still utilised to some extent in local,

national, or even international societies. However, they have the potential to make a greater contribution to the availability of food sources than they now do. The majority of the smaller fruits form a part of the local diet and are tasty and nutritious. According to Narzary, Brahma and Basumatary (2013), minor fruits are a good source of vitamins, minerals, fibre, and polyphenols that have health advantages.

Eating wild fruits lowers the risk of a number of illnesses, including diabetes, cancer, heart disease, and neurological diseases (Rajurkar & Gaikwad, 2012). The majority of the population is aware of the therapeutic benefits of minor fruits that are cultivated nearby. Furthermore, these crops are essential to the livelihood and nourishment of the rural and tribal populations as well as to the creation of jobs and revenue. The majority of minor fruits have a high consumer appreciation rate and a special potential for value addition through product development and processing.

The world's largest alcoholic fermentation is used extensively by fruit farmers in tropical and subtropical nations (Saranraj & Ramesh, 2019). Since they are more than just nutritional components, fruits are one of the most widely prepared beverages in which ethanol is consumed. Since the beginning of time, fermented alcoholic beverages have been and continue to be essential for human upkeep. Both fresh and processed fruits fall into three general tax categories. The fruits enhance the quality of our diet and provide necessary production regulation, such as vitamins, minerals, and carbohydrates, as well as distilled beverages like whisky, rum, gin, vodka and antioxidants.

Africa is occupied by different plant species with large abundance and distribution. Most of the tree species and their roles are reasonably well

documented. Wilson and Maud (2008) indicated a variety of fruit tree species that provide edible fruits. Most importantly, the economical contribution and conversion of individual fruit types into consumable products has not been looked at properly, although it is well-known that wild fruits play a significant role in many peoples' daily diets (Bvenura & Sivakumar, 2017). Moreover, many indigenous plants have received little scientific interest from botanists, conservationists and environmentalists. Therefore, a lot of the indigenous and customary knowledge generated over the years has not been adequately employed in the processing of these plants' products into foods or wine (Sarkar, Dhumal, Panigrahi & Choudhary, 2015).

However, the little rise in the scientific documentation of these species as part of the indigenous knowledge system and baseline data in conserving these foodstuffs such as wine is still very little (Rampedi & Olivier, 2013). As a result, vast natural vegetation in Africa remains largely unexplored for wine-making especially indigenous plants. Plant-based fruits are fruits or foods derived from plants (Rampedi, 2010). Fruits such as nuts, seeds, oils, whole grains, legumes, and beans have become essential resources for human survival and health improvement (Hu, Otis & McCarthy, 2019). Plant-based fruits support humans' immune systems through the essential nutrients that they offer. Several plant-based fruits are available, but individuals have to make choices over which fruits they consume.

In many countries, indigenous plant species and wine-based plants fruits have been commercialised with great success (Gupta & Abu-Ghannam, 2012). However, many of these wines are country specific. For example, Champagne as a sparkling wine is made exclusively in the Champagne region of France.

Barolo, a red wine is made from the Nebbiolo grape variety, which is produced in the Piedmont region of Italy. Moreover, Shiraz, a red wine grape variety is closely associated with Australia, although it is also grown in other countries. Port is a fortified wine produced under very specific conditions in the vineyards located along the Douro Valley in Portugal.

In Ghana, a number of indigenous plants that can be used for traditional breewing making have also received research attention. For example, pito, asana, sobolo, coconut breewings, cashew breewing and baobab breewing. These wines are produced for trade at the subsistence level, thus providing income for families involved. None of these has entered international markets successfully, and their methods of production have been examined in detail. For instance, pito is produced from maize or millet. However, jackal berry fruit has become an alternative fruit for producing wine (Nyanga, 2012). Jackal berry fruit is eaten raw by children and adults or may be dried and kept for later use. Jackal berry fruits are good sources of vitamins and minerals (Ilouno et al., 2018).

Beyond this, it is anticipated that the jackal berry fruit can be turned into wine for consumption. Research has revealed that the *Diospyros mespiliformis* leaves have medicinal use, as well as the stem, bark and roots (Adzu et al., 2015; Belemtougri et al., 2006; Sadiq et al., 2013). Consequently, the jackal berry fruit appears to be one of such fruits enjoyed by individuals across Africa. Abba et al. (2015) report that *Diospyros mespiliformis* commonly known as jackal berry or African ebony belongs to the family *Ebanaceae*, and it is a deciduous tree that can grow up to 25m in height. It grows wild in the northern part of Ghana and is found in clay and loamy soils. Fruits are round berries,

crowned with a persistent style, yellowish when ripe. The fruit pulp is soft and very sweet. Its leaves turn yellowish and orange when ripped.

People do collect the fruits during the cold season. Normally the seeds are consumed fresh, especially the sweetest ones. The remaining fruits are dried and consumed at a later time. They are either eaten raw with no special preparation or are pounded and the powder mixed with boiled water and millet meal to make a very sweet and delicious porridge (oshihenyandi) which is liked by many people, especially during the dry season. Furthermore, fruits are fermented for the famous hot liqueur - ombike. It has also been reported that the tree is characterized by dense foliage with leathery, dark green leaves, yet, the young leaves are reddish in colour (Abba et al, 2012). Chivandi and Erlwanger (2011) have also indicated that flowering of the tree occurs during the rainy season but fruit ripening takes place in the dry season. Significantly, most of these edible fruit trees are seasonal, therefore, take time to produce their fruits in their seasons. During this period, the fruits become food and many individuals survive on these enjoying the high nutritional values that these offers. The jackal berry fruit is largely known in the Dafiama Bussie Issa District of Ghana? as Gaa, proving its significance in the production of wine.

Statement of the Problem

There is a wide range of fruit wines produced in Africa from various sources such as, fruits, and starchy root crops (Misihairabgwi & Cheikhyoussef, 2017). In many countries, indigenous plant species and wines derived from these fruits have been commercialised with great success, often containing some percentage of alcohol. Among these, the jackal berry fruit stands out due to its significant mineral value and potential for alcohol-based products. According

to a National Research Council (2008) report, as a traditional food plant in Africa, the jackal berry fruit has the potential to improve nutrition, boost food security, foster rural development, and support sustainable land care.

Jackal berry fruit is edible and consumed by both humans and animals. In the Dafiama Bussie Issa District of Ghana, it has been observed over the years that most individuals consume the fruit in its raw state when it is ripe, often without knowledge of its mineral benefits. Despite the common knowledge of the jackal berry fruit and its traditional consumption methods, there is scepticism about its mineral value and potential for wine production among the local population. This scepticism highlights a gap in the utilisation of the jackal berry fruit's full potential. The potential of the jackal berry fruit for wine production has not been explored in the Dafiama Bussie Issa District. This lack of exploration raises several pertinent questions: What is the potential of jackal berry fruit for wine production? If wine production is feasible with jackal berry fruits, would consumers accept the wine? Additionally, how can the mineral value of jackal berry wine be leveraged to improve community health and economic development?

This study seeks to assess the production and consumer acceptability of alcoholic jackal berry wine in the Dafiama Bussie Issa District of Ghana. By exploring these aspects, the study aims to unlock the potential of jackal berry fruits for commercial wine production, thereby contributing to local economic development, enhancing nutritional awareness, and fostering sustainable agricultural practices in the region.

Purpose of the Study

The purpose of the study was to explore the production and consumer acceptability of alcoholic Jackal Berry wine in the Daffiama Bussie Issa District. This research aims to contribute to the development of locally produced wines by utilizing indigenous fruits, which may enhance economic opportunities for local farmers and entrepreneurs. Additionally, the study seeks to understand the potential health benefits and sensory preferences associated with Jackal Berry wine, which could pave the way for its acceptance and commercialization in broader markets.

Research Objectives

Specific objectives of the study were to:

1. formulate two types of wine from jackal berry fresh Fruits
2. evaluate the mineral value of the jackal berry wine formulations
3. evaluate the two wine formulations for consumer acceptability.

Research Hypothesis

1. H_0: There is no statistically significant difference in the mineral content of jackal berry wine produced from the natural and culture fermentation processes.

Significance of the Study

This study on the production and consumer acceptability of Jackal Berry wine holds significant importance on multiple fronts, encompassing economic, nutritional, and cultural dimensions. Economically, the successful formulation and acceptance of Jackal Berry wine can have profound implications for the Daffiama Bussie Issa District and similar regions. By tapping into the local abundance of Jackal Berry fruits, this research can lead to the creation of a new,

value-added product that can enhance the livelihoods of local farmers and entrepreneurs. The commercialization of Jackal Berry wine could generate employment opportunities, stimulate local economies, and reduce rural poverty. Moreover, promoting a locally produced wine can foster a sense of pride and ownership within the community, encouraging further investment in agricultural innovation and production.

From a nutritional perspective, evaluating the mineral content of Jackal Berry wine provides insights into its potential health benefits. As consumers become increasingly health-conscious, the nutritional profile of food and beverage products plays a crucial role in their market success. This study aims to highlight the presence of essential minerals such as potassium, calcium, magnesium, and iron in Jackal Berry wine, which can contribute to the dietary needs of consumers. Understanding these mineral benefits can enhance the wine's appeal to health-conscious consumers and differentiate it in a competitive market.

Culturally, the production of Jackal Berry wine can promote the use of indigenous fruits, preserving and celebrating local biodiversity and traditional knowledge. The Jackal Berry tree, native to many parts of Africa, has been used traditionally for various purposes, and incorporating its fruits into wine production aligns with sustainable practices and the valorisation of local resources. This can lead to increased awareness and appreciation of local biodiversity and traditional agricultural practices, fostering a deeper connection between consumers and their cultural heritage.

Additionally, the sensory evaluation of the wine formulations provides valuable insights into consumer preferences and acceptance. Understanding the

sensory attributes that influence consumer choices—such as taste, aroma, and colour—can guide producers in refining their products to meet market demands. This knowledge is crucial for developing a product that resonates with consumers and ensures its success in the marketplace.

Overall, this study contributes to the broader goals of sustainable development, economic empowerment, and cultural preservation. By exploring the potential of Jackal Berry wine, it lays the groundwork for innovative agricultural practices, enhances the value of local produce, and promotes a product that can benefit both producers and consumers alike.

Delimitations

The study was confined to the Dafiama Bussie Issa District of the Upper West Region of Ghana. This geographic focus was chosen because the district has a high concentration of Jackal Berry fruit trees, making it an ideal location for the study. Limiting the study to this district allowed for an in-depth investigation into the specific conditions and potential of Jackal Berry fruit within this context, ensuring a comprehensive understanding of the production and acceptability of Jackal Berry wine.

Focusing on a single district also provided the researchers with adequate time to delve deeply into the underlying issues related to Jackal Berry fruits and the opportunities available for wine production. This approach facilitated a thorough exploration of both the production process and consumer preferences, ensuring that the findings were robust and contextually relevant.

The study predominantly emphasized the production of Jackal Berry fruit wine and its consumer acceptability. By focusing on these aspects, the research aimed to uncover new opportunities for utilizing Jackal Berry fruits

beyond their traditional consumption in raw form. The intention was to demonstrate the potential of these fruits for value-added products, which could significantly enhance their economic value.

It is anticipated that the successful completion of this study will benefit the local community in the Dafiama Bussie Issa District by providing a new avenue for economic development. The introduction and potential mass production of Jackal Berry wine could improve the livelihoods of community members by creating employment opportunities and increasing the demand for locally cultivated Jackal Berry fruits. This, in turn, could stimulate local economies and enhance the financial transactions of traditional farming communities, fostering greater economic resilience and prosperity in the region.

Definition of Terms

Wine: is an alcoholic beverage made from fermented grapes or other fruits. The grapes or fruits are crushed, and the juice is then fermented with yeast to convert the sugar into alcohol. Wine can be made in various styles, including red, white, rose, and sparkling, and it can range from sweet to dry. Wine is typically consumed as a beverage during meals, as a way to celebrate special occasions, or as a social drink. It is also often used in cooking as a flavouring agent. The taste and quality of wine can vary depending on factors such as the type of grape or fruit used, the region where it is produced, and the aging process.

Production: This is the action of making or manufacturing from components or raw materials, or the process of being so manufactured. Production is the method of turning raw materials or inputs into finished goods or

products in a manufacturing process. In other words, it means the creation of something from basic inputs.

Consumer Acceptability: Determining the feasibility of whether a product or service will be acceptable to the consumer requires tests, surveys, pre-tests and even prototypes. Acceptability of a particular brand depends on price, taste, distribution, advertising effects, availability, performance and customer service.

Jackal Berry: *Diospyros mespiliformis* or jackal berry is a big dicotyledonous evergreen tree native to Africa's savannas. The name is derived from the fact that jackals enjoy the fruit. The bark of mature trees is dark grey and fissured. An adult tree grows to a height of 4 to 6 meters on average, with trees reaching 25 meters on rare occasions. The foliage is dense and dark green, with elliptical leaves that are frequently consumed by grazing animals like elephants and buffalo. During the rainy season, the tree blooms; the flowers are imperfect, with genders on distinct trees, and are cream-coloured.

Organization of the Study

The thesis is presented in five chapters. Chapter 1 provides the research background on indigenous plant wine and the importance of the study. A brief literature contextualisation, research motivation, aim and objectives as well as limitations of the study are also provided. Chapter 2 presents a review of the relevant literature pertaining to indigenous plants in South Africa and wine derived from these. Chapter 3 provides a description of study areas, research design as well as methodology of data collection, processing and analyses. Chapter 4 covers the first set of research findings and discussion of the study.

Chapter 5 comprises a summary of research findings, concluding remarks and recommendations which set research goals for further research.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature relevant to the study and could be related to the findings of the study. It also highlights the theoretical review, conceptual review and conceptual framework as well as the empirical review and summary of the chapter.

Theoretical Review

This section of the chapter reviewed the theories underlying the study and the research objectives. The theories included Sensory Evaluation and Consumer Behaviour Theories, Nutrition and Health Behaviour Theories, and Diffusion of Innovation Theory. These theories were selected because they explain and provide a better understanding of how various factors influence consumer acceptability of Jackal Berry wine. The theories suggest that consumer acceptability is a multifaceted process influenced by sensory perceptions, nutritional considerations, and the wine's status as an innovative product. Therefore, understanding these factors was essential for a comprehensive analysis of consumer behaviour and acceptability in the context of the study.

Sensory Evaluation Theory

Sensory Evaluation Theory is a comprehensive framework that systematically assesses and interprets human responses to product properties as perceived through the senses of sight, smell, taste, touch, and hearing. This theory is fundamental in industries such as food and beverages, cosmetics, and textiles, where sensory attributes significantly influence consumer preferences and product quality. The primary objective of Sensory Evaluation Theory is to

provide a structured approach to understanding how sensory characteristics affect consumer perceptions and choices.

According to Meilgaard, Carr, and Civille (2007), sensory evaluation encompasses various components, including the use of trained sensory panels to objectively evaluate products and the application of standardized methods for sensory analysis. These methods range from discrimination tests, which determine whether detectable differences exist between products, to descriptive analysis, which profiles the specific sensory attributes of products. The theory employs tools such as the Hedonic Scale to assess consumer preferences, providing quantifiable data on sensory attributes and thereby reducing subjectivity in understanding consumer choices.

Components of Sensory Evaluation

Sensory evaluation comprises several key components designed to systematically assess and interpret sensory attributes:

1. **Sensory Panels:** These are groups of individuals selected and trained to evaluate products based on specific sensory characteristics. Panelists are screened for their sensory acuity and ability to discriminate between different stimuli. Training ensures consistency and reliability in evaluations, which is crucial for obtaining objective data (Stone & Sidel, 1985).
2. **Standardized Testing Methods:** Sensory evaluation employs various standardized methods to assess products, including:
    - **Discrimination Tests:** These tests determine whether there are detectable differences between products. Common types include

the triangle test, duo-trio test, and paired comparison test (Kemp, Hollowood, & Hort, 2018).

- **Descriptive Analysis:** This method involves detailed profiling of a product's sensory attributes, such as flavor, texture, and aroma. Techniques like Quantitative Descriptive Analysis (QDA) are used to quantify these attributes (Lawless & Heymann, 2010).
- **Affective Tests:** Also known as hedonic tests, these assess consumer preferences and acceptability. The 9-point Hedonic Scale is commonly used, where participants rate their liking or disliking of a product from "dislike extremely" to "like extremely" (MeiMeilgaard, Carr & Civille, 2007).

Application in Product Development

Incorporating Sensory Evaluation Theory into product development involves several critical steps:

1. **Product Formulation:** Sensory evaluation aids in formulating products that meet targeted sensory profiles, ensuring alignment with consumer preferences (Lawless & Heymann, 2010).
2. **Quality Control:** Regular sensory assessments help maintain consistency and quality in production, identifying deviations that may affect consumer satisfaction (Stone & Sidel, 1985).
3. **Consumer Testing:** By conducting affective tests, developers can gauge potential market acceptance and make necessary adjustments to enhance product appeal (Kemp et al., 2018).

Criticisms and Limitations

While Sensory Evaluation Theory offers a robust framework for assessing sensory attributes, it is not without limitations:

- **Resource Intensiveness:** Establishing and maintaining trained sensory panels and conducting comprehensive evaluations require significant time and financial investment (Meilgaard et al., 2007).
- **Focus on Sensory Factors:** The theory primarily emphasizes sensory attributes, potentially overlooking other factors influencing consumer choices, such as cultural preferences, brand loyalty, and psychological influences (Lawless & Heymann, 2010).

Relevance to the Study

In this study, Sensory Evaluation Theory was selected to facilitate the precise measurement and understanding of how consumers perceive and react to the sensory properties of Jackal Berry wine. Given that sensory attributes significantly influence a product's desirability, this theory is directly relevant to assessing consumer acceptability. It aids in product development, quality control, and optimization by providing systematic methods to evaluate and enhance the sensory characteristics of the product. Sensory evaluation often involves the use of trained sensory panels to provide objective assessments and standardized methods for sensory analysis, ensuring that the product meets both consumer expectations and industry standards (Meilgaard et al., 2007; Lawless & Heymann, 2010).

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Consumer Behaviour Theory

Consumer Behaviour Theory was developed and refined over the course of the 20th and 21st centuries by prominent theorists such as Albert Bandura, Leon Festinger, and Philip Kotler (Heymann & Lawless, 2013). It represents a broad spectrum of frameworks and models designed to understand why and how consumers make choices, including their attitudes, perceptions, and purchasing decisions. This theory is instrumental in deciphering the complex web of factors that influence consumer behaviour, helping businesses and researchers to predict and shape consumer preferences effectively.

The theory posits that consumers are driven by both physiological needs (such as hunger and thirst) and psychological wants (such as social status or personal satisfaction) (Hamilton & Lahne, 2020). Consumers perceive products and services in specific ways, and their attitudes toward these offerings are influenced by personal beliefs, social norms, and prior experiences. Positive perceptions and favourable attitudes are more likely to result in purchase decisions, thereby emphasising the importance of product image and brand communication (Hamilton et al., 2020).

According to Hamilton et al. (2020), Consumer Behaviour Theory encompasses a range of psychological, sociological, and economic factors that collectively shape consumer decision-making. Psychological components include motivations, perceptions, attitudes, and learning processes. Sociocultural factors acknowledge the roles of family, reference groups, culture, and social norms, all of which exert considerable influence over individual behaviour. Economic variables such as income levels and product pricing also play a pivotal role in shaping consumer decisions.

The theory outlines several stages involved in the consumer decision-making process: problem recognition, information search, evaluation of alternatives, purchase, and post-purchase evaluation (Stankevich, 2017). It also considers the impact of external stimuli—including marketing strategies and advertising efforts—on consumer behaviour, making it a comprehensive model for understanding market dynamics.

One of the strengths of Consumer Behaviour Theory lies in its holistic approach to analysing consumer behaviour, offering a well-rounded view of why consumers choose specific products (Zhang & Benyoucef, 2016). Its broad applicability across different products and industries makes it a versatile analytical tool. However, the theory can be complex when advanced statistical techniques are required to apply its components, and its generalized models may not always account for individual differences in consumer preferences.

Nevertheless, Consumer Behaviour Theory was selected for this study because it incorporates both psychological and sociological factors that are highly relevant for assessing how nutritional information and sensory attributes influence consumer choices. This allowed for a comprehensive analysis that considered not only the sensory properties of Jackal Berry wine but also the wider decision-making processes influencing consumer acceptability. Through this integrated approach, the study obtained deeper insights into the motivational and behavioural factors driving consumer responses to unique and novel food products.

Diffusion of Innovation Theory

The Diffusion of Innovation Theory**,** formulated by Everett Rogers in the 1960s, provides a framework for understanding how new ideas, products, services, or technologies disseminate through a population or social system over time. This theory is instrumental in analysing the adoption patterns of innovations and has been applied across various fields, including marketing, public health, and technology adoption.

Core Components of the Theory

Rogers' theory delineates several key components that influence the diffusion process:

1. **Innovation Attributes:** The perceived characteristics of an innovation significantly affect its adoption rate. These attributes include:
    - **Relative Advantage:** The degree to which an innovation is perceived as better than the idea it supersedes.
    - **Compatibility:** How consistent the innovation is with the existing values, past experiences, and needs of potential adopters.
    - **Complexity:** The extent to which the innovation is perceived as difficult to understand and use.
    - **Trialability:** The opportunity to experiment with the innovation on a limited basis.
    - **Observability:** The extent to which the results of the innovation are visible to others.

    These attributes collectively influence an individual's decision to adopt or reject an innovation

2. **Adopter Categories:** Individuals within a social system adopt innovations at varying rates, leading to their classification into five categories:
    - **Innovators:** Venturesome individuals eager to try new ideas.
    - **Early Adopters:** Respected opinion leaders who adopt new ideas early but judiciously.
    - **Early Majority:** Deliberate individuals who adopt new ideas just before the average member of a social system.
    - **Late Majority:** Skeptical individuals who adopt innovations after the average member has done so.
    - **Laggards:** Traditionalists who are the last to adopt an innovation
3. **Communication Channels:** The means by which information about an innovation is transmitted to members of the social system. Effective communication channels are crucial for the spread of innovations
4. **Social System:** The network of individuals and institutions that collectively influence the adoption process. The structure and norms of the social system play a significant role in the diffusion of innovations

Application in Product Adoption

In the context of introducing a novel product such as Jackal berry wine, understanding the diffusion process is vital. The wine's trialability—allowing consumers to sample it—and observability—enabling potential adopters to witness its benefits—can significantly enhance its adoption rate. Furthermore, identifying and targeting early adopters within the market can create a ripple effect, influencing the early majority and subsequent groups to embrace the

product. The characteristics of the social system**,** including cultural preferences and societal norms, also play a crucial role in determining the product's acceptance and diffusion.

Criticisms and Limitations

While the Diffusion of Innovation Theory offers valuable insights, it is not without criticisms:

- **Oversimplification:** The theory may oversimplify complex human behaviours and the multifaceted nature of decision-making processes.
- **Post-Adoption Focus:** It primarily concentrates on the adoption process and may not comprehensively address post-adoption behaviours, such as continued use or discontinuance of the innovation.

Relevance to the Study

Applying the Diffusion of Innovation Theory to the study of Jackal berry wine adoption provides a structured approach to understanding how consumers might accept this new product. By analysing the innovation's attributes, identifying potential adopter categories, and considering the social system's characteristics, strategies can be developed to facilitate the wine's diffusion in the market.

Conceptual Review

Jackal berry Fruit and its Use in Wine making

The Jackal berry, scientifically known as *Diospyros mespiliformis,* is a deciduous tree native to many parts of sub-Saharan Africa, including West, East, and Southern Africa (Magaji, 2019). It thrives in savanna woodlands and along riverine forests, often reaching heights of up to 25 meters. The tree is a member of the Ebenaceae family and is widely regarded for its ecological,

medicinal, and nutritional importance. In many African societies, the fruit produced by this tree has been consumed for centuries due to its sweet, mealy pulp, which is not only palatable but also nutritionally rich, containing essential vitamins, minerals, and antioxidants (Magaji, 2019; Mahomoodally, 2013).

Traditionally, the Jackal berry fruit has served as a source of sustenance and refreshment, particularly in rural communities where food preservation and storage are limited. The fruit is eaten fresh or dried, and it often features in cultural rituals and traditional healing practices. The leaves, bark, and roots of the Jackal berry tree are also used in ethnomedicine to treat ailments such as fever, malaria, wounds, and gastrointestinal disorders (Mahomoodally, 2013).

Beyond its traditional applications, the Jackal berry has more recently drawn attention in food science and beverage production. Historically, communities in regions where the tree grows in abundance discovered the fruit's fermentable potential and began to process it into traditional alcoholic beverages, including beer and rudimentary wine. This indigenous knowledge laid the groundwork for contemporary explorations into its formal application in winemaking (Magaji, 2019).

The resurgence of interest in using Jackal berry in winemaking stems from both its nutritional profile and its unique flavour characteristics. The fruit contains a combination of natural sugars, organic acids, and phytochemicals, making it an excellent candidate for fermentation. Its flavour is described as a balance between tartness and sweetness, which provides a sensory profile distinct from the more conventional *Vitis vinifera* grape varieties typically used in wine production (Mahomoodally, 2013; Goold et al., 2017).

One of the standout features of Jackal berry fruit is its high tannin content. Tannins are naturally occurring polyphenols that contribute to the astringency, colour, and mouthfeel of wine. In the case of Jackal berry, this elevated tannin concentration not only adds complexity to the wine's taste but also acts as a natural preservative. According to studies, the tannin content in *Diospyros mespiliformis* can reach levels as high as 15.94 g per 100g of dry sample, particularly when extracted using aqueous methanol solutions (Anumah, 2021). This astringency, however, presents a dual challenge—it enhances the antioxidant capacity of the fruit but may also complicate the fermentation process, especially if not properly managed.

Furthermore, the acidity of Jackal berry fruit plays a crucial role in fermentation. Its relatively high acidity supports microbial stability and aids in maintaining the wine's freshness, but excessive acidity can hinder yeast activity and affect palatability. Modern winemakers are therefore experimenting with controlled fermentation processes and the use of additives such as pectinase enzymes to enhance clarity, reduce viscosity, and optimise sugar conversion during winemaking (Zhang et al., 2023).

Despite these challenges, the Jackal berry's potential in winemaking is promising. Several experimental studies and pilot projects have demonstrated that, with the right balance of fermentation techniques, temperature control, and possible blending with other fruits or grape musts, Jackal berry can produce wines with desirable physicochemical properties and good consumer acceptability (Goold et al., 2017). These wines not only possess a unique flavour profile but also retain the health benefits associated with the bioactive compounds found in the fruit.

Importantly, the application of Jackal berry in wine production aligns with broader efforts to promote indigenous African fruits and value addition within local agricultural systems. The use of such underutilised fruits not only supports biodiversity and sustainability but also provides opportunities for local economic empowerment through the development of niche markets and small-scale wineries.

In conclusion, the Jackal berry fruit offers significant potential as a raw material for winemaking due to its rich nutritional content, distinctive flavour, and cultural relevance. While the high tannin and acid content present certain technical challenges, ongoing research and innovation in fermentation techniques continue to unlock new possibilities. This study contributes to the growing body of knowledge by examining the sensory qualities, nutritional profile, and consumer acceptability of wine made from this indigenous African fruit.

Evolution of Jackal berry wine production techniques

The techniques and methods for producing Jackal berry wine have evolved over time. While the traditional natural fermentation process remains prevalent in some communities, modern winemaking has introduced new approaches. The evolution of winemaking techniques has been influenced by factors such as globalization, changing consumer preferences, and technological advancements (Ofoedu, Ofoedu, Chacha, Owuamanam & Awuchi, 2022). In contemporary winemaking, there is a growing interest in improving the quality and consistency of Jackal berry wine. Some producers have adopted controlled fermentation processes that involve the introduction of specific yeast strains to manage and enhance the fermentation. This evolution in techniques aims to

produce wines with unique flavour profiles, improved stability, and extended shelf life (Ofoedu et al., 2022).

Furthermore, the demand for healthier beverage options has spurred the development of techniques that preserve the mineral content of the fruit during the winemaking process (Ofoedu et al., 2022). This aligns with a global trend towards producing nutritious and functional beverages. As such, modern production techniques for Jackal berry wine incorporate practices to retain essential nutrients and antioxidants, which are valued for their potential health benefits.

The globalization of food and beverage trends has played a substantial role in shaping the evolution of Jackal berry wine production techniques (Vushe, 2021). As the world becomes more interconnected, consumers are increasingly curious and open to trying new and unique flavours. This has created an environment in which lesser-known fruits like Jackal berry gain global recognition and the interest of winemakers seeking to create distinctive products. In the African context, where the Jackal berry tree is native, traditional techniques for producing Jackal berry wine have been passed down through generations (Vushe 2021). These methods often involve natural fermentation, making use of wild yeast strains. However, the recognition of the fruit's potential for winemaking has led to a blending of tradition and innovation.

Local producers in African countries, such as Ghana, have started to experiment with modern winemaking approaches to improve the quality and consistency of their products (Vushe, 2021). These techniques include controlled fermentation processes that involve the introduction of specific yeast strains. These strains can manage and enhance the fermentation, resulting in

wines with unique flavour profiles and improved stability (Urama & Ozor, 2010).

In addition to flavour and quality improvements, there has been a growing emphasis on preserving the nutritional content of the fruit during the winemaking process (Omayio, Abong, Okoth, Gachuiri & Mwang'ombe, 2019). This reflects a global trend toward producing beverages that are not only flavourful but also nutritious and health-conscious. Modern production techniques for Jackal berry wine now incorporate practices aimed at retaining essential nutrients and antioxidants. These components are highly valued for their potential health benefits, aligning with the growing consumer demand for healthier beverage options (Omayio et al, 2019).

The evolution of Jackal berry wine production techniques demonstrates the dynamic nature of the wine industry, where tradition and innovation coexist. While traditional practices remain part of the heritage and culture of winemaking, the integration of modern techniques has broadened the possibilities for producing Jackal berry wines with broader appeal and improved characteristics. This evolving landscape offers opportunities for local producers to meet global demands for unique, nutritious, and high-quality beverages, contributing to the expansion of the Jackal berry wine market both in Africa and beyond Omayio et al, 2019).

Botanical and Nutritional Aspects

Characteristics of the Jackal berry tree *(Diospyros mespiliformis)*

The Jackal berry tree, scientifically known as *Diospyros mespiliformis*, is a striking and significant species native to various regions of Africa (Grant & Thomas, 2006). This tree belongs to the *Ebenaceae* family and is characterized

by its distinctive features. Jackal berry trees can grow to considerable heights, often reaching 25 meters or more. They have a unique appearance, with dense, dark green foliage and a crown that provides ample shade. The tree is known for its durable and dense wood, which has been traditionally used for crafting various items, including furniture and carvings. The bark is dark and rough, contributing to the tree's distinct visual appeal (Grant et al., 2006).

The Jackal berry tree produces round or oval fruit, about the size of a small apple (Mphephu, 2017). The fruit's skin is typically yellow or orange when ripe, and it encases a sweet and nutritious pulp. These characteristics have made the fruit not only a vital food source for various wildlife but also an essential component of human diets in regions where the tree is prevalent. Jackal berry trees often play a role in the ecosystem by providing sustenance to animals and serving as a valuable shade tree in arid environments (Mphephu et al., 2017).

Nutritional content of Jackalberry fruit

Jackal berry fruit, sometimes referred to as African ebony or monkey fruit, is celebrated for its exceptional nutritional richness (Francis, Kingsford & Brandis, 2022). This remarkable fruit boasts a nutritional profile that encompasses a wide array of essential nutrients, making it not only a delicious treat but also a source of significant health benefits. One of the distinguishing features of the Jackal berry fruit is its sweet and sour taste, which proves its remarkable vitamin content. In particular, this fruit is a notable source of vitamin C, a powerful antioxidant vitamin. Vitamin C contributes both to the fruit's characteristic flavour and its nutritional value. This essential vitamin not

only enhances the sour-sweet taste but also plays a vital role in supporting the body's immune system and overall health.

Jackal berry fruit is not just about taste; it is also a source of dietary fibre. The significant levels of dietary fibre in the fruit's pulp have been recognized for their potential in promoting digestive health. Fibre aids in maintaining regular bowel movements, preventing constipation, and supporting a healthy gastrointestinal system. Thus, beyond its flavour, the fruit contributes to overall well-being by promoting digestive comfort (Francis et al., 2022). The pulp of the Jackal berry fruit is rich in natural sugars, providing a satisfying and energy-providing snack. These natural sugars offer a quick energy boost, making the fruit not only a delightful treat but also a source of vitality. It is particularly appealing in regions where it grows, where it serves as a natural and nutritious energy source that can be enjoyed as a snack or included in various culinary preparations.

According the study conducted on jackberry fruit, the result showed that for every 100 g of fresh fruit sample, the pulp's crude protein, carbohydrate, and fibre contents were 1.05±0.06, 17.40±0.36, and 0.46±0.15 g, respectively. Accordingly, the jackfruit pulps had K, Ca, and P levels of 422.36±9.60, 69.91±1.66, and 61.17±0.01 mg/100 g of fresh fruit sample, respectively. The pulps had respective contents of TPC, TFC, and βcarotenes of 65.9302±0.0163 mg GAE/100 g, 5.7620±0.0291 mg QE/100 g, and 2.43±0.06 mg/100 g (Afotey, Yuorkuu, Akinie, Eshun & Sufyan, 2024).

Triterpenoids, trinylated flavonoids, triterpenoids, and steroids are abundant in jackfruit bark. Several of these substances have demonstrated intriguing biological properties, including cytotoxicity, antioxidative, anti-

inflammatory, and antimalarial properties, as well as the inhibition of 5α-reductase, tyrosinase, and melanin production (Wang, Xia, Tao, Shu & Xiao, (2017). Swami, Thakor, Haldankar and Kalse (2012) claim that extracts from roots or barks and rags—the inedible part of mature fruits—can aid in the treatment of dysentery.

The jack fruit pulp's crude fibre content (0.46 percent wet basis) was much lower than the range of 1.0 to 1.5% wet basis that Khan, Israt, Ruman, Shofiul, Anayat, Sana, and Muhammad (2021) stated in their review paper. Additionally, the fibre composition of the pulps and leaves differed significantly from Amadi and Ihemeje's (2018) findings. When ingested, fibre promotes smooth bowel motions and better food digestion. By eliminating carcinogenic substances from the large intestine, crude fibre also protects the mucosal membrane of the colon, avoiding colon cancer.

Compared to the bark and leaves, the pulp of jackfruit has the most water or moisture. Additionally, the jackfruit pulps' moisture content fell within the range that several researchers and review publications have documented (Khan, Israt, Ruman, Shofiul, Anayat, Sana & Muhammad, 2021; Swami, Thakor, Haldankar & Kalse, 2012). However, the leaves' moisture content (66.37±0.29%) was much lower than the 85.33±0.45% figure that Amadi and Ihemeje (2018) reported. There are various advantages to eating fruits that are higher in moisture or water content.

The nutritional content of the Jackal berry fruit extends beyond vitamins and dietary fibre. It includes valuable minerals such as potassium, magnesium, and calcium. These minerals play pivotal roles in maintaining various bodily functions. Potassium, for instance, is essential for muscle contractions and

regulating blood pressure. Magnesium supports nerve transmission and muscle function, while calcium contributes to bone health and numerous other physiological processes.

Health Benefits Associated with Jackal berry Consumption

Consuming Jackal berry fruit can have several health benefits. The fruit's high vitamin C content is advantageous for the immune system, contributing to better protection against illnesses (Magaji, 2019). Additionally, the dietary fibre in the fruit aids in digestion and can assist in regulating blood sugar levels. The natural sugars present in Jackal berry fruit can provide a quick energy boost, making it a suitable option for individuals looking for a natural and healthy source of vitality. Moreover, the minerals found in the fruit, such as potassium and magnesium, contribute to overall well-being by supporting essential bodily functions.

The health benefits of Jackal berry fruit extend beyond its nutritional content (Magaji, 2019). Traditional medicine systems in some African communities have recognized its potential medicinal properties. It has been used to address various health concerns, from alleviating symptoms of diarrhoea to supporting wound healing. Consuming Jackal berry fruit offers a plethora of health benefits, making it not only a delightful addition to diets but also a source of wellness. From its immune-boosting vitamin C content to its natural sugars for energy, the fruit provides a range of advantages for those who partake in its consumption (Magaji, 2019).

One of the primary health benefits associated with Jackal berry fruit consumption is its contribution to the immune system. The fruit's high vitamin C content, a potent antioxidant, bolsters the body's natural defense mechanisms.

By consuming foods rich in vitamin C, individuals can enhance their immune response, which is essential for better protection against a variety of illnesses. In regions where Jackal berry fruit is indigenous, this attribute is particularly valuable as it can contribute to overall health and resilience (Ilouno, Omaji & Anthony, 2018).

The dietary fibre found in Jackal berry fruit is not only beneficial for digestion but can also assist in regulating blood sugar levels. Dietary fibre supports gastrointestinal health by promoting regular bowel movements, preventing constipation, and sustaining a healthy digestive system. Furthermore, its potential in blood sugar regulation can be particularly significant in areas where issues related to blood sugar levels are a health concern (Ilouno et al., 2018).

The natural sugars present in Jackal berry fruit provide an immediate and natural energy boost. This aspect makes it an attractive option for individuals seeking a quick source of vitality, especially in regions where the fruit is available (Ilouno et al., 2018). As an energizing and nutritious snack, Jackal berry fruit can offer an alternative to processed snacks or sugary drinks. Jackal berry fruit's nutritional richness extends to its mineral content, including potassium and magnesium. These minerals play crucial roles in supporting essential bodily functions. Potassium, for instance, is vital for regulating blood pressure and ensuring proper muscle contractions. Magnesium supports nerve transmission, muscle function, and overall well-being. Such mineral content enhances the nutritional value of the fruit, making it more than just a flavourful treat (Ilouno et al., 2018).

Beyond its nutritional content, the Jackalberry fruit holds a place in traditional medicine systems in some African communities. Recognized for its potential medicinal properties, the fruit has been employed to address various health concerns (Ilouno et al., 2018). From alleviating symptoms of diarrhoea to promoting wound healing, the fruit's traditional medicinal applications reflect its significance in local health practices and its role in supporting community well-being. However, incorporating Jackal berry fruit into diets not only introduces a unique and delicious flavour but also provides an array of health benefits (Anthony, Joseph, Anthony & Joseph, 2014).

From immune system support to digestive health and energy provision, this fruit embodies the harmonious blend of traditional knowledge and modern understanding of nutrition. It is a testament to the rich tapestry of African heritage and the adaptability of this fruit in meeting the nutritional and health needs of individuals both in Africa and globally (Ilouno et al., 2018).

Wine Production Process

The production of Jackal berry wine involves a series of carefully orchestrated steps, each of which plays a vital role in shaping the final product (Misihairabgwi & Cheikhyoussef, 2017). It begins with the harvest of ripe Jackal berries, a critical stage that impacts the wine's flavour and quality. After harvesting, the berries are prepared by cleaning and removing any impurities to ensure that only the best fruit is used. Following preparation, the fruit is mashed or crushed to extract the juice, a process that can be executed manually or with the aid of machinery (Misihairabgwi et al., 2017).

Once the juice is extracted, it is placed in fermentation vessels, where yeast is introduced. Yeast is a key player in the winemaking process, as it

converts the natural sugars in the fruit into alcohol and carbon dioxide during fermentation. This fermentation period, which can span several weeks, has a significant influence on the wine's character (Misihairabgwi et al., 2017).

After fermentation, the wine is pressed to separate the liquid from the solid remnants of the fruit. It is then transferred for aging in suitable containers, which can include stainless steel tanks or wooden barrels (Misihairabgwi et al., 2017). The aging process allows the wine's flavours to mature and develop complexity. Once the desired flavour profile is achieved, the wine is finally bottled and sealed, ready for distribution and consumption. The role of fermentation, yeast, and other factors is pivotal in determining the wine's qualities.

Fermentation is central to the process, transforming the fruit's sugars into alcohol while significantly influencing the wine's flavour and aroma. The choice of yeast strains is essential, as it can impart distinct characteristics to the wine. Additionally, temperature control during fermentation ensures that the process proceeds as intended while minimizing oxygen exposure is vital to prevent spoilage and oxidation (Misihairabgwi et al., 2017).

Steps Involved in Making Jackal Berry Wine

1. **Harvesting:** The journey of Jackal berry wine begins with the careful selective harvesting of ripe Jackal berries. This is a pivotal phase, as the ripeness of the fruit plays a substantial role in determining the wine's eventual flavour and quality. Only perfectly ripe Jackal berries are chosen for the winemaking process.
2. **Preparation:** Once harvested, the Jackal berries undergo a thorough cleaning process. This step involves the removal of any debris,

impurities, or imperfect fruits. By ensuring that only the finest fruit is used, this preparation phase sets the stage for the production of a high-quality wine.

3. **Mashing:** After meticulous preparation, the selected Jackal berries are subjected to mashing or crushing to extract the juice. The method of mashing can vary, with some producers opting for manual techniques, while others employ machines, depending on the scale of production. The goal is to efficiently release the juice from the fruit.
4. **Fermentation:** The extracted juice is transferred to fermentation vessels, typically with the addition of yeast. Fermentation is a central process in winemaking, as it is during this phase that yeast converts the natural sugars in the Jackal berry fruit into alcohol and carbon dioxide. The fermentation period can extend over several weeks, and the selection of yeast strains plays a critical role in shaping the wine's character.
5. **Pressing:** Following the completion of fermentation, the wine is subjected to pressing. This step is essential for separating the liquid wine from the solid remains of the fruit, ensuring that only the liquid component is retained for further processing.
6. **Aging:** The wine then embarks on an aging journey, often taking place in appropriate containers such as stainless-steel tanks or wooden barrels. The aging process allows the wine's flavours to mature, develop complexity, and attain the desired flavour profile.
7. **Bottling:** Once the wine reaches its desired level of maturity and flavour, it is carefully bottled and sealed for distribution and

consumption. This marks the culmination of the winemaking process, as the wine is prepared for its journey to the consumer.

Role of Fermentation, Yeast and Other Factors in Winemaking

Fermentation serves as the linchpin of the winemaking process. During fermentation, the natural sugars inherent in Jackal berries are converted into alcohol by yeast (Uushona, 2013). This enzymatic conversion not only contributes to the alcohol content of the wine but also exerts a profound influence on the wine's flavour and aroma. The choice of yeast strains is pivotal, as different strains can impart distinct characteristics to the wine.

Additionally, factors such as temperature control during fermentation and oxygen exposure during aging significantly influence the final product (Uushona 2013). Proper temperature management ensures that the fermentation process proceeds as intended, while careful control of oxygen exposure is vital to prevent spoilage and oxidation (Wojciechowski, 2022).

Comparison of Jackal berry Wine Production with Other Fruit Wines

Although the fundamental winemaking process for fruit wines shares commonalities, the unique qualities of each fruit introduce distinctions and challenges. In the case of Jackal berry wine production, the specific attributes of Jackal berries, including their flavour profile ranging from sweet to sour-sweet, necessitate tailored adjustments in the winemaking process (Uushona 2013). The choice of yeast strains and fermentation temperature may differ to enhance and preserve the unique flavours of Jackal berries. When compared to other fruit wines, Jackal berry wine offers a distinct flavour profile and nutritional content, making it a captivating addition to the world of fruit wines. This comparison underscores the uniqueness of Jackal berry wine, highlighting

its individual qualities and potential market niche (Mileti, Baldino, Carmona, Lupi, Muñoz & Gabriele, 2022).

Sensory Evaluation and Consumer Acceptability

Factors Influencing the Sensory Qualities of Jackal berry Wine

The sensory qualities of Jackal berry wine, encompassing its aroma, taste, and overall flavour profile, are subject to a constellation of factors. These elements intricately interplay to craft the wine's unique sensory experience, making it essential for winemakers to appreciate and manage these factors effectively. The following factors exert influence on the sensory attributes of Jackal berry wine:

1. Quality and Ripeness of Harvested Fruit: The foundation of Jackal berry wine's sensory characteristics is laid during the harvesting phase. The quality and ripeness of the harvested Jackal berries play an instrumental role in shaping the wine's flavour. Ripe Jackal berries provide a diverse range of flavours, from sweet to sour-sweet. As such, the choice of fruit at this initial stage significantly dictates the wine's eventual taste and aroma.

2. Fermentation Process: The fermentation process stands as a pivotal factor in determining the wine's sensory qualities. During fermentation, yeast interacts with the fruit's natural sugars, converting them into alcohol and carbon dioxide. The duration and management of fermentation have direct repercussions on the wine's taste, aroma, and mouthfeel. Depending on the winemaker's objectives, variations in fermentation techniques can be applied to accentuate specific sensory attributes.

One of the world's earliest methods of food preservation is fermentation (Talib, Samad, Hossain, Muazzam, Anwar, Atique & Joo, 2024). For thousands

of years, indigenous people have made and consumed fermented foods like bread, cheese, and wine. These foods are deeply ingrained in culture and custom, particularly in rural homes and village communities. In the midst of history, fermentation technology advancement gets lost (Thompson, 2022). According to anthropologists, yeast need nitrogenous substance in order to flourish. The most prevalent wild yeast genera used in winemaking are Zygo saccharomyces, Candida, Klöckera/Hanseniaspora, Metschnikowiaceae, and Pichia (Aidoo, 2011). Under controlled circumstances, this biotechnology is used in the production of wines and brews. For centuries, alcoholic beverages have been made in a variety of societies. They frequently play a key role in the most prized social and personal rituals in both contemporary and less literate countries. In customary events like child naming, wedding feasts, and funerals, alcohol is frequently served. Nutrient beers and wines are fermented in Africa using a variety of fruits, millet, bananas, honey, palm and bamboo saps, and maize. Palm wines and kaffir beer are the most well-known (Vilela, Cosme, & Inês, 2023).

One of the oldest human technologies, wine fermentation is currently one of the most economically successful biotechnological processes. Since the beginning of civilisation, winemaking has been practiced, and it has developed alongside agricultural and human advancements (Brito, Pereira, Martins, Monteiro, Moutinho-Pereira & Dinis, 2024). Early Neolithic times in China and the Middle East, when the first plants and animals were domesticated and served as the foundation for a sophisticated society and permanent settlements, are when the earliest biomolecular archaeological evidence for plant additions in fermented beverages can be found. Rice, millet, and fruits were frequently used

to make fermented drinks in ancient China (Ray, Paramithiotis, Thekkangil, Nethravathy, Rai & Martin, 2024). However, in the past, Egypt made herbal medicinal wines by combining a variety of natural materials, particularly plants and tree resins, with grape wine (Morya, Menaa, Lourenço-Lopes, Jimenez-Lopez, Khalid, Moreno ... & Mugabi, 2024). Numerous bioactive substances, including polyphenols, are bound to insoluble plant molecules in the source materials.

3. Choice of Yeast Strains:

To produce fruit wines with unique but agreeable flavours, yeast selection is essential (Saranraj, Sivasakthivelan & Naveen, 2017; Padilla, Gil & Manzanares, 2016). The production of blueberry, plum, pineapple, and strawberry wines has made extensive use of commercial Saccharomyces cerevisiae yeasts, which provide controllability and reproducibility throughout the fermentation process as well as predictability in the sensory quality of the fermented beverages. Customers approved of the mixed fruit wine made by the Saccharomyces cerevisiae strain using pawpaw, bananas, and melons. The choice of yeast strains used in fermentation further contributes to the wine's sensory profile. Different yeast strains have unique characteristics and can impart distinct flavours and aromas to the wine. Yeast selection is a deliberate choice made by the winemaker to mould the wine's sensory qualities in alignment with their vision for the final product.

4. Aging Conditions: The conditions under which the wine undergoes aging are instrumental in refining its sensory attributes. Whether the wine is aged in stainless steel tanks or wooden barrels, the aging process allows for the maturation of flavours and the development of complexity. The choice of aging

vessel and duration of aging can influence the wine's taste, aroma, and overall sensory experience.

5. Overall Winemaking Techniques: The overarching winemaking techniques employed, from fruit preparation to bottling, impact the wine's sensory qualities. The cleanliness of the preparation process, the handling of the fruit, the meticulousness of pressing, and the precision of bottling all contribute to the wine's overall quality and sensory appeal.

Techniques for Sensory Evaluation of Jackal berry Wine

Sensory evaluation is a meticulous and systematic approach employed to comprehensively assess the sensory attributes of a product, and in the case of Jackal berry wine, these techniques are essential for gauging its flavour, aroma, appearance, and overall sensory experience. Several techniques are used by professionals and trained sensory panels to conduct a thorough evaluation of Jackal berry wine:

1. Descriptive Analysis: Descriptive analysis is a precise and structured technique in which trained sensory panelists identify and quantify specific sensory attributes present in the wine. These attributes may include descriptors such as sweetness, acidity, tannin levels, fruity notes, and any other distinct qualities. The use of standardized terminology ensures clarity and consistency in the assessment.

2. Hedonic Scale: The application of a hedonic scale allows for consumer testing, providing insights into the preferences and likability of Jackal berry wine among the target audience. Consumers are asked to rate the wine on a scale, typically ranging from 'dislike very much' to 'like very much.' This technique helps determine the wine's consumer acceptability and desirability.

3. Trained Panel Evaluation: Trained sensory panels, comprising experts or individuals with specialized training in sensory analysis, assess various attributes of the wine. These panels evaluate attributes such as taste, aroma, appearance, and overall sensory impression. Trained panellists rely on their expertise to provide a comprehensive sensory evaluation.

4. Aroma and Flavour Profiling: Aroma and flavour profiling involves an in-depth examination of the wine's scent and taste. Trained evaluators use their olfactory and gustatory senses to discern and describe the specific aromas and flavours present. This technique is vital for characterizing the wine's sensory attributes.

5. Appearance Assessment: The visual aspect of the wine is also a key component of sensory evaluation. Panellists examine the wine's colour, clarity, and viscosity. These visual cues can provide valuable information about the wine's quality and style.

Factors Influencing Consumer Acceptability of Wines

Consumer acceptability of wines is a multifaceted phenomenon, influenced by an array of factors that encompass sensory perceptions, market dynamics, and brand-related considerations. According to Yang and Lee (2020), consumer acceptability of wines is influenced by the following factors:

1. Taste and Aroma: Taste and aroma are paramount factors in influencing consumer acceptability. The sensory experience of wine, including its flavour profile, sweetness, acidity, and aromatic notes, plays a significant role in consumer preferences. For Jackal berry wine, the sweet-sour taste and distinct aroma derived from the fruit are critical aspects. These qualities may appeal to consumers seeking unique and exotic flavour experiences.

2. Colour: The visual aspect of wine, its colour, is another pivotal element that affects consumer acceptability. Jackal berry wine, with its potential range of colours, from deep red to purplish hues, may attract consumers interested in visually distinct and vibrant wines. The colour can evoke a sense of curiosity and anticipation.

3. Price: The price point of a wine is a decisive factor for consumers. It often reflects the perceived value and quality. Understanding the price sensitivity of consumers and positioning Jackal berry wine within the context of its price segment is crucial for acceptability. The affordability and value for money of Jackal berry wine may influence consumer choices.

4. Brand Reputation: Brand reputation and recognition are powerful drivers of consumer choices. For Jackal berry wine, positioning it as a distinctive and reliable brand with a focus on traditional production methods or unique flavour profiles can impact consumer perceptions. Established brands often instil trust and confidence in consumers.

5. Packaging: The visual appeal of the packaging, including labels and bottle design, significantly influences consumer acceptability. For Jackal berry wine, packaging that reflects the essence of the fruit and its cultural significance may resonate with consumers. Unique and artistic packaging can create a strong visual impact.

6. Marketing and Promotion: Effective marketing and promotion strategies play a substantial role in shaping consumer preferences. Communicating the story, heritage, and distinctiveness of Jackal berry wine can enhance its appeal. Social media, tastings, and events can create a buzz and pique consumer interest.

7. Food Pairing Recommendations: Suggesting suitable food pairings can influence consumer acceptability. Providing guidance on what dishes complement Jackal berry wine can enhance its versatility and encourage consumers to experiment with it in culinary contexts.

8. Peer Recommendations and Reviews: Peer recommendations and reviews hold sway over consumer choices. Positive feedback and endorsements from peers or wine critics can bolster the acceptability of Jackal berry wine. Leveraging these testimonials can build trust.

9. Cultural and Regional Significance: The cultural and regional significance of Jackal berry wine can be a compelling factor. Highlighting its connection to traditional practices and cultural heritage can attract consumers interested in unique and authentic products.

10. Health and Nutritional Aspects: The perceived health and nutritional benefits of Jackal berry wine can be influential. Emphasizing its nutritional content, including antioxidants and natural sugars, can appeal to health-conscious consumers seeking a balance between indulgence and well-being.

Conceptual Framework

The conceptual framework for the study on Jackal berry wine has been designed based on the research theories and the objectives to understand the complex relationships between various factors and their impact on consumer acceptability. The theories are the Sensory Evaluation and Consumer Behaviour Theories, Nutrition and Health Behaviour Theories and Diffusion of Innovation Theory. The sensory evaluation theory helps in assessing how sensory attributes, such as taste and aroma, influence consumer preferences.

Consumer behaviour theory provides insights into the decision-making processes, including factors like attitudes, preferences, and the impact of demographic variables (Livio & Hodhod, 2018). The Diffusion of Innovation Theory comes into play when examining consumer preferences for non-grapefruit fruit wines (Clapham, Belissa, Inghelbrecht, Pensé-Lhéritier & Tuleu, 2023).

The study's primary objective is to assess consumer acceptability, with consumer characteristics acting as moderating variables that influence the connections between the nutritional value of the wine, sensory qualities, and overall acceptability. At the core of the framework is the "Consumer Acceptability of Jackal berry Wine," which is the dependent variable. This represents the ultimate outcome of the study and reflects how consumers perceive and accept Jackal berry wine. The independent variables include the mineral value and sensory qualities of the wine, which are pivotal factors influencing consumer preferences. The nutritional value is assessed with respect to two production methods: natural fermentation and culture-to-ferment. The sensory qualities encompass taste, aroma, and appearance, all of which significantly affect consumer perceptions.

The moderating variables, which are "Consumer Characteristics," play a crucial role in shaping the relationships between the independent and dependent variables. These characteristics encompass demographic aspects like age, gender, and cultural background. They act as moderators, influencing how mineral value, sensory qualities, and ultimately, consumer acceptability are interconnected. For example, individuals from different age groups may have

varying taste preferences or cultural backgrounds that influence their acceptance of the wine.

The links within the framework highlight the direct connections between the independent variables (nutritional value and sensory qualities) and the dependent variable (consumer acceptability). The nutritional value directly influences the sensory qualities of the wine, which, in turn, have a direct effect on consumer acceptability. However, the impact of these links is contingent on the moderating variables – consumer characteristics – which influence the strength and nature of these relationships based on the specific characteristics of the consumers.

As shown in Figure 1, jackal berry wine could be either fermented or non-fermented. Thus, the nutritional values of the wines depend on either the wine is fermented or nonfermented. The nutritional values or the sensory evaluation helps determine consumer acceptability of the wine that would be produced. The conceptual framework demonstrates that knowing the kind of wine either fermented or non-fermented helps determine the nutritional value of the jackal berry wine that would be produced, difference in the nutritional value of jackal berry wine produced from both the natural fermentation process and the culture-to-ferment process and establish the association between jackal berry wine produced and consumer acceptability. This idea is explained by theories that the varying levels of acceptance and preferences for different fruit wines is based on their sensory attributes and nutritional qualities. Therefore, the conceptual framework shows that there is a complex interplay between sensory perceptions, nutritional beliefs, and the adoption of innovative food and jackal berry wine products.

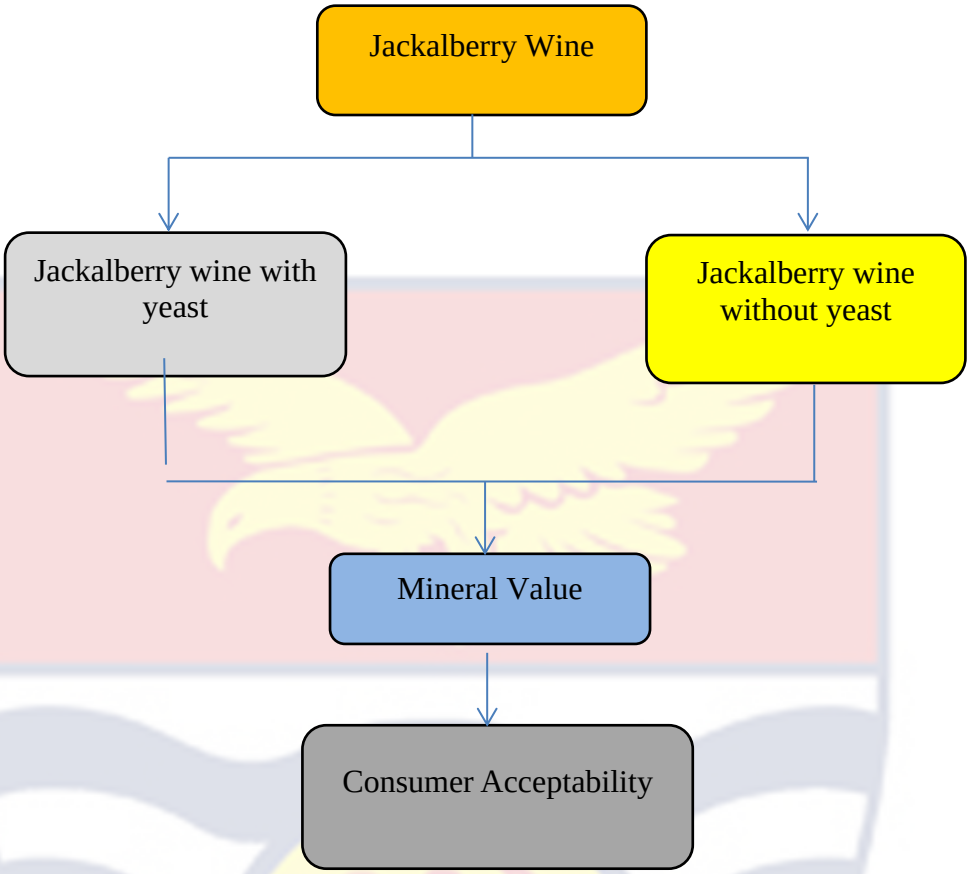

Figure 1: Conceptual Framework
Source: Author's Construct (2024)

Empirical Review

Nutritional value of the jackal berry wine

Magaji (2019) investigated the nutritional composition of the edible portion of jackal berry fruits. The study aimed at shedding light on its potential in alleviating malnutrition and supporting local communities. Mature fruit samples were meticulously gathered from the Bakiya village in Katsina state, and the edible portion was subjected to a comprehensive analysis of its proximate, ascorbic acid, and mineral content, employing established procedures. The outcomes of this investigation revealed critical nutritional insights.

Proximate analysis yielded essential data, with values (g/100g) including Moisture content (13.11 ± 0.35), Crude fibre (3.37 ± 0.26), Ash content (2.20 ± 0.17), Crude fat (19.08 ± 0.46), Crude protein (6.01 ± 0.37), and Carbohydrate (56.55 ± 0.72). These findings highlight the fruit's potential as a valuable source of nutrients, particularly carbohydrates and fats, which can aid in enhancing the diets of rural communities. Moreover, the analysis of mineral content (mg/100g) revealed critical elements, including Copper (30.30 ± 5.833), Lead (5.063 ± 1.253), Iron (9.88 ± 2.136), Zinc (4.63 ± 2.12), Magnesium (24 ± 22.52), Calcium (69.44 ± 12.73), Sodium (14.45 ± 3.85), and Potassium (8.44 ± 4.43).

The abundance of Calcium in the fruit's edible portion is particularly noteworthy, suggesting its potential role in addressing conditions like Osteomalacia, a debilitating bone disorder. Furthermore, the Vitamin C content analysis yielded a value of (24.56 ± 0.16 mg/100g), which shows the fruit's contribution to essential vitamin intake. The comprehensive results indicate that the Jackal berry fruit pulp can serve multifaceted purposes, from enhancing dietary carbohydrate and fat content for rural communities to acting as a valuable raw material for the production of juice and jam.

Ilouno et al. (2018) assessed the nutritional composition of dried seeds flour from *Diospyros mespiliformis* using standard procedures. The proximate analysis revealed that the seeds had a moisture content of 9.00 ± 0.00 g/100g, ash content of 4.75 ± 1.06 g/100g, crude fat content of 2.22 ± 0.37 g/100g, crude fibre content of 2.67 ± 0.76 g/100g, crude protein content of 5.44 ± 0.88 g/100g, carbohydrate content of 76.35 ± 0.58 g/100g, and an energy value of 345.45 ± 0.58 kcal/100g.

In terms of mineral composition, the seeds were found to be rich in calcium (180.26 ± 0.76 mg/100g), followed by magnesium (92.18 ± 1.24 mg/100g) and iron (90.48 ± 0.98 mg/100g), while zinc was present in the lowest concentration (0.97 ± 0.73 mg/100g). Anti-nutritional factors such as oxalate (0.004 ± 0.00 mg/100g), phytates (0.880 ± 0.13 mg/100g), alkaloids (16.780 ± 4.29 mg/100g), flavonoids (29.300 ± 0.63 mg/100g), tannins (0.040 ± 0.98 mg/100g), and saponins (31.450 ± 2.12 mg/100g) were also assessed. The results indicate that *Diospyros mespiliformis* seeds have nutritional value comparable to conventional food crops and could be a valuable source of nutrients, particularly in times of scarcity. However, when used as animal feed, further processing may be required to mitigate the presence of certain anti-nutritional factors.

Sensory evaluation of Jackal Berry Wine

Zhu et al. (2023) investigated consumer preferences and sensory descriptors for various non-grapefruit fruit wines, each of which offered unique sensory properties and potential health benefits. A total of 234 participants took part in an online survey, where they were asked to express their preferences for different fruit wines, including grape, blueberry, hawthorn, goji, Rosa roxburghii, and apricot. Additionally, the survey collected data on participants' general health interests, food neophobia, attitudes towards alcoholic drinks, and their preferences for sweetness in wines.

The study found that participants generally consumed fruit wines infrequently and were categorized as 'users' or 'non-users' based on their consumption frequency. Preferences varied by gender, with female consumers showing a preference for grape and hawthorn wines. Attitudes toward general

health interests, food neophobia, alcoholic drinks, and sweetness had less influence on fruit wine preferences than sensory characteristics like taste and aroma. A sensory characterization of fruit wines involved 89 participants who provided descriptors for distinguishing 10 fruit wines.

The analysis of these sensory evaluations revealed that consumers could distinguish between the various fruit wines based on sensory attributes. Participants generally preferred fruit wines that were perceived as "sweet," "sour," and with a "balanced fragrance." On the contrary, attributes such as "bitter," "astringent," "deep appearance," and "medicinal fragrance" were associated with lower preferences. The findings suggested that sensory characteristics, particularly taste and aroma, had a more significant impact on consumer preferences than these other factors. Participants who reported more frequent wine consumption tended to have higher consumption frequency and more favourable ratings for the fruit wines compared to non-users.

Chapter Summary

This chapter reviewed literature relevant to the study and could be related to the findings of the study. It also highlights the theoretical review, conceptual review and conceptual framework as well as the empirical review and summary of the chapter. From the review, studies are conducted on the nutritional content of Jackal berry fruits, revealing their potential to alleviate malnutrition and enhance diets in rural areas due to their rich carbohydrate and fat content, along with significant calcium levels.

Another study focused on *Diospyros mespiliformis* seeds and highlighted their nutritional value with notable levels of protein, carbohydrates, and various minerals. A separate investigation delved into consumer

preferences for non-grapefruit wines, underscoring the impact of sensory attributes like taste and aroma on their choices, with gender-related variations and categorization into 'users' and 'non-users' based on consumption frequency. These studies collectively emphasized the nutritional benefits of these food sources and the key role of sensory factors in shaping consumer preferences. However, there are limited studies on Production and Consumer Acceptability of alcoholic Jackal berry wine in Ghana, particularly in the Daffiama Bussie Issa District.

CHAPTER THREE

RESEARCH METHODS

The methodology aspect of this research describes the overall framework within which the research was conducted. It encompasses the research design, the study area, the study population, sample size and sampling procedures, instruments for data collection, data analysis, and ethical issues. This comprehensive approach ensured that the research was conducted systematically, allowing for reliable and valid results.

Research Design

The experimental research design, particularly the true experimental research design, was adopted for this study. Experimental research design is a structured approach for conducting research involving two sets of variables (control and test variables) (Jiang, 2023). This design was chosen to scientifically assess the production and consumer acceptability factors of Jackal Berry fruit wine.

Experimental research design aids in establishing high-quality techniques, framing the research to facilitate data analysis, and addressing the primary research questions (Willimack, Ridolfo, Riemer, Cidade & Ott, 2023). Specifically, this design allows the researcher to employ quantitative techniques to collect data, providing a robust framework for testing hypotheses and validating results. Additionally, the experimental design enables researchers to test ideas in a controlled environment before introducing them to the market, ensuring the reliability and validity of the findings.

The adoption of a true experimental research design allowed the researcher to have a stronger hold over the research problem, thereby obtaining desired results (Bhat, 2020). This design involved using a pre-experimental approach to gauge public reaction to the new Jackal Berry fruit wine and to determine whether the wine contains nutritional values that could reduce the risk of diseases and other illnesses. True experimental studies employ statistical analysis to support or refute a study's hypothesis, making them one of the most precise research types as they provide detailed scientific proof and can demonstrate a cause-effect relationship (Forbes, Travers & Johnson, 2023).

The selection of this research design was due to its incorporation of a control group, which was not subjected to changes, and an experimental group, which was subjected to the interventions. The manipulation of variables and their random distribution further strengthened the study's validity. Moreover, this design was chosen for its efficiency in producing precise results and saving time, making it suitable for rigorous scientific investigation.

In essence, the true experimental research design provided a solid foundation for this study, allowing the researcher to systematically test the production and consumer acceptability of Jackal Berry wine under controlled conditions. This approach not only ensured the accuracy and reliability of the data but also facilitated a comprehensive understanding of the potential market reception and health benefits of the wine.

Study Area

Daffiama Bussie Issa District is in Ghana situated close to Sabogo and Kparedabuo. The district is centrally located in the Upper West Region of Ghana and lies between Latitudes 11° 30″ and 10° 20″ north and Longitudes 3°

10″ and 2° 10″ west (Tiibo, 2020). It was carved out of the erstwhile Nadowli District in 2012 through Legislative Instrument 2100 with Issa as the capital. It is bordered on the south by the Wa Municipality, west by the Nadowli Kaleo District, north by the Sissala West District and east by the Wa East District. The population of the district according to 2021 population and housing census stands at 38,754 with 18,923 males and 19,831 females. The district has a household population of 32,185 with a total number of 5,030 households (Normaah, 2021).

In terms of size, it covers a total land area of 1,315.5 square kilometres and extends from the Billi Bridge (four kilometres from Wa) to the Dapuori Bridge (almost 28 kilometres from Nadowli) on the main Wa-Tumu Road and also from west to east it extends from the Black Volta to Daffiama Issa, the district capital, is 57 kilometres from the regional capital, Wa. About 73.0 percent of the population aged 15 years and older are economically active while 27.0 per cent are economically not active.

Of the economically active population, 98.2 percent are employed while 1.8 percent are unemployed. For those who are economically inactive, a larger percentage of them are students (49.3%) and 20.0% perform household duties. Again, about 56.8 percent of the unemployed had worked before and were seeking for work, while 43.2 percent were seeking for work for the first time and were available for work (Sumankuuro, Crockett & Wang, 2018).

Commonly economic activities in the district include farming. The inhabitants grow crops such as yam, cassava and plantain. Jackal berry trees are predominant in the Dafiama Bussie Issa District with the fruits usually flowering within the rainy season and ripping during the dry season. Of the

employed population, about 78.0 percent are engaged as skilled agricultural, forestry and fishery workers, 10.4 percent in craft and related trade and 5.8 percent in service and sales (Agbenyo, Wisdom & Akanbang, 2021). About 3.5 percent are engaged as managers, professionals, and technicians. Conducting the study in this area therefore help to generate relevant knowledge about the jackal berry fruits.

Study Population

The group of people or entities that the study focused on is called the 'population of interest'. This included individuals, pairs, groups, organisations, or other similar entities. The study's findings could be applied to or used for this group, and they are the main group that the research was about. The study population comprised adults in the Daffiama Bussie Issa District who had full knowledge of Jackal Berry fruits and various experiences with them. This specific demographic was significant to the study because it was assumed that they were better placed to provide accurate and specific information about the nutritional values of Jackal Berry fruits and their various uses.

The Daffiama Bussie Issa District was chosen due to its abundance of Jackal Berry trees and the familiarity of the local population with the fruit. These individuals were not only familiar with the fruit in its raw form but also with traditional methods of utilising it for various purposes, including culinary and medicinal applications. Their insights were invaluable for understanding both the potential benefits and consumer acceptability of Jackal Berry wine.

Additionally, the inclusion criteria for the study population were adults who had resided in the district for at least five years. This criterion ensured that participants had a comprehensive understanding of the local practices and

cultural significance of Jackal Berry fruits. The study aimed to capture a wide range of experiences and perspectives; thus, participants were selected from different age groups, genders, and socioeconomic backgrounds within the district.

Engaging this diverse and knowledgeable population was crucial for the study's objectives. Their feedback and evaluations provided a rich dataset that helped to assess the sensory qualities, nutritional benefits, and overall acceptability of the Jackal Berry wine. This approach ensured that the findings were reflective of the community's views and preferences, making the results more relevant and actionable for potential commercial production.

The study population's familiarity with Jackal Berry fruits also enabled them to provide detailed sensory evaluations, comparing the new wine products with traditional uses of the fruit. Their historical and experiential knowledge contributed to a deeper understanding of how the new wine formulations could be perceived and accepted within the community. This comprehensive insight was essential for developing a product that aligns with local tastes and preferences, thus increasing the likelihood of successful adoption and marketability.

Sampling Size

Researchers use sampling methods to select a smaller subset of individuals from a larger population for study purposes. A sample is a smaller group used to conclude the larger population (Tyrer & Heyman, 2016). For this study, a sample size of 100 respondents was used. This sample size was deemed sufficient to ensure the representativeness of the population in the study area and to reduce the margin of error. The criteria for selecting the target population

included individuals who had extensive knowledge of Jackal Berry fruits and could provide accurate and specific information about their nutritional values and other uses. This criterion ensured that the sample consisted of knowledgeable individuals capable of contributing valuable insights to the study. This sampling size helped the researcher to accurately represent the population by employing sample selection procedures that accounted for bias and data distortion and obtained a homogenous sample.

Sampling Technique

There are two types of sampling methods: probability and non-probability (Tyrer & Heyman, 2016). Probability sampling methods employ random selection to ensure equal chances of selection for individuals or items from a group. Various methods of probability sampling include simple random sampling, systematic sampling, stratified sampling, and cluster sampling. On the other hand, non-probability sampling methods rely on the researcher's discretion in selecting the sample, using techniques such as convenience sampling, purposive sampling, snowball sampling, and volunteer sampling (Elfil & Negida, 2017).

In this study, a combination of simple random sampling and purposive sampling techniques was used to select respondents. Simple random sampling was employed to choose participants through a community group meeting. This technique ensured that every individual in the population had an equal chance and likelihood of being selected, providing a fair and unbiased sample. The selection was achieved by using the lottery method, where values were assigned to participants, and those selected values determined the individuals included in the study. The simple random sampling technique ensured that all participants

had equal chances of being included, thus enhancing the representativeness of the sample. This method, known for its simplicity and fairness, relied entirely on chance or probability, thereby minimizing potential selection bias.

In addition to simple random sampling, purposive sampling was also adopted. This technique was used to intentionally select community members with extensive experience and knowledge of Jackal Berry fruits. This approach ensured that the study included participants who could provide in-depth and accurate information about the fruit's nutritional values and uses. By focusing on knowledgeable individuals, the purposive sampling technique enhanced the quality and relevance of the data collected.

The combined use of simple random sampling and purposive sampling provided a robust sampling framework. The simple random sampling offered a broad representation of the population, while the purposive sampling ensured the inclusion of key informants with specific expertise. This dual approach helped to reduce bias and improve the overall quality of the data. A sample size of 100 respondents was used, which was sufficient to ensure the representativeness of the population and to obtain reliable data. After selecting the respondents, Jackal Berry fruits were harvested to allow for proper assessment and experimentation, focusing on their application in wine production.

This sampling approach was chosen because it reduced bias compared to other methods and facilitated the selection of a manageable sample size from a larger population. The simplicity of the simple random sampling method made it a fundamental technique for data collection, requiring no technical knowledge. The combination of random and purposive sampling provided well-

informed data, enhancing the study's validity and reliability. The larger the sample size, the better the quality of the data, ensuring that the findings were comprehensive and representative of the population's views and experiences.

Data Collection Instrument

For this study, a sensory evaluation form was used as the primary data collection instrument. Sensory evaluation is a scientific method used to measure, analyse, and interpret reactions to the characteristics of foods and beverages as they are perceived by the senses of sight, smell, taste, touch, and hearing. The purpose of sensory evaluation is to understand how people perceive various sensory attributes of a product, which in turn influences their acceptance and preference. The sensory evaluation form was a structured questionnaire designed to collect data on the sensory attributes of the Jackal Berry wine samples. It included several key sections:

- Socio-Demographic Characteristics: This section collected basic demographic information about the participants, such as age, gender, marital status, and religion. This information helped to contextualise the sensory evaluation results and ensured that a diverse and representative sample of the population was included in the study.
- Instructions: Participants were provided with clear instructions on how to use the form. They were asked to taste the wine samples and rate them based on specific sensory attributes.
- Sensory Attributes: The form included a detailed assessment of various sensory attributes, which are critical for evaluating the quality and acceptability of the wine. The attributes assessed were:

- Appearance: Visual assessment of the wine, including colour and clarity.
- Aroma: Olfactory assessment, which involves smelling the wine to evaluate its fragrance.
- Taste: Gustatory assessment, where participants taste the wine to judge its flavour profile.
- Overall Acceptability: A holistic assessment that considers all sensory attributes to determine the overall appeal of the wine.
- Rating Scale: Each sensory attribute is rated using a scale that allows participants to indicate their level of preference. Commonly, a hedonic scale is used, which may range from "like extremely" to "dislike extremely." This scale helps in quantifying subjective perceptions, making it easier to analyse and interpret the data.

Processing of Jackal Juice

The jackal berry fruits were harvested from the farm and brought home. The fruits were thoroughly washed and cleaned to remove any dirt. While washing, any spoilt fruits were excluded to prevent contamination of the juice produced. The good fruits were picked one after the other and peeled. A spatula was used to mash the fruits, and sugar was weighed and added to the mashed fruits, then stirred together. Water was added to the mixture, stirred with a wooden spatula, and transferred into a container. The prepared and unfermented liquid in the container was covered with a tight-fitting lid and placed in a dark location for fermentation.

First of the jackalberry is harvested from the farm. Washed thoroughly to remove all debris. The fruits are then mashed. Water is added to the mashed

fruits and stirred together. The liquid is strained from the chaff. The liquid is strained again to remove the debris from the liquid. Sugar is added to water to make a syrup. The syrup is allowed to be cooled down thoroughly before adding it to the strained jackalberry liquid. The cooled syrup is then added to the liquid and stired together. The liquid is stained again to remove the debris.

Your non-alcoholic jackalberry fruit juice is ready.The container containing the unfermented juice was opened every two days for two weeks to check for foams on the surface, which were gently removed or collected with a cup. This was done carefully to ensure the wine did not become discoloured. After two weeks, when the wine was well-formed, it was filtered from the fruits into another container. The container was again covered, and the liquid was left to stand for a second fermentation for another two weeks.

After the second fermentation, the wine was collected and put into a clean bottle to settle. The wine was continuously separated from the debris beneath, a process repeated until a clean, clear wine was collected. Finally, the wine was collected and stored.

Data Processing and Analysis

The data was analysed according to the research questions. Data collected was cleaned, coded, entered into the computer, and processed using Statistical Package for the Social Sciences (SPSS) version 26.0 for Windows and GraphPad Prism 9 for Windows. Data was analysed using both descriptive and inferential statistical tools like frequencies, percentages, and mean. The minerals in the samples have been analysed with mean and standard deviation as the statistical tool in Microsoft Excel 2010. Tables and graphs were used to present the respondents' responses that addressed the various research

questions. The researcher manually or through content analysis, examined the information gathered from the participants. The arrangement and division of data into manageable parts, as well as its synthesis into patterns in order to reach a trustworthy and significant conclusion, were all part of qualitative data analysis.

Analysis of Respondents' Demographic Characteristics

Several statistical methods were used to organise, analyse, and interpret the data. The questionnaire's questions on the respondents' demographic information were analysed using straightforward percentages and frequencies. In particular, frequency tables and direct percentages were used to analyse the data. Inferences were made to respond to research question 1 and were explained using descriptive statistics like means and standard deviations.

Analysis of Objective 1: To Formulate Different Types of Wine from Jackal Berry Fresh Fruit

The objective was to assess the feasibility of using jackal berry fruit to prepare wine with and without yeast i.e spontaneously. A recipe flow chart was used to guide the preparation process. This involved detailing each step in the winemaking process, from the selection and preparation of the fruit to fermentation and maturation. The results were analysed to determine the effectiveness of each method and identify the most suitable approach for producing jackal berry wine.

Analysis of Objective 2: To Evaluate the Mineral Value of the Jackal Berry Wine Produced

Research Objective 2 sought to evaluate the mineral value of the jackal berry wine that was produced. Descriptive statistics, such as mean and standard

deviation, were used to analyse Atomic absorption spectroscopy **of the** mineral components was used (e.g., copper, zinc, sodium, etc.) of the jackal berry wine samples. This analysis helped determine the nutritional benefits of the wine and compared these values to established nutritional standards.

Analysis of Objective 3: To Conduct a Sensory Evaluation on the Consumer Acceptability of the Jackal Berry Wine

Research Objective 3 aimed to evaluate the sensory attributes and overall consumer acceptability of the jackal berry wine. A consumer preference test, such as a Nine Point Hedonic scale or preference ranking test, was used to analyse the sensory evaluation of the jackal berry wine samples by the target consumers. The nine-point hedonic scale ranged from "extremely unpleasant" to "extremely pleasant," represented by numbers 1-9, with 1 representing "extremely unpleasant" and 9 representing "extremely pleasant." Mean scores were estimated for each sensory attribute and overall liking of the wine. This helped identify any significant differences between the sensory attributes and determined the overall acceptability of the wine. Wines rated low for certain attributes were adjusted to improve their palatability.

Hypothesis Testing

Null Hypothesis 1: H0: There is no statistically significant difference in the mineral value of jackal berry wine produced from natural (spontaneous) and cultured fermentation processes.

Research Hypothesis 1 was determined to see if there was any statistically significant difference in the mineral value of jackal berry wine produced from both the natural (spontaneous) fermentation process and the starter culture (cultured-to-ferment) process. The one-way Analysis of Variance (ANOVA) was conducted to test the hypothesis at an alpha value of 0.05 (5%) p-value. The null hypothesis was rejected if $p > 0.05$ and the alternative hypothesis was accepted if $p < 0.05$.

Data Management

Effective management of data is critical to maintaining the integrity, security, and confidentiality of research data. The collected data was stored in both digital and physical formats to ensure redundancy and facilitate convenient access as needed. Digital copies were securely stored on the researcher's Google Drive, protected by a password known only to the researcher. This ensured protection against unauthorised access and allowed the researcher easy retrieval of data when required. However, the data was accessible to the supervisor upon request.

In addition to digital storage, physical copies of the data were retained. These hard copies were stored in a locked drawer at the researcher's residence, ensuring secure storage and protection from unauthorised individuals.

Data will be retained for five years. This duration is chosen for several reasons. Firstly, it allows the researcher to refer back to the data for any follow-up studies or publications. Secondly, it provides a timeframe during which the data can be reviewed in case of queries or allegations of research misconduct.

Thirdly, to enable the researcher to comply with the university's regulations concerning data storage. Maintaining data for five years aligns with

standard research practices, allowing adequate time for verification and validation if necessary.

Upon expiration of the five years, the data will be permanently disposed of to uphold participant confidentiality and privacy. Digital copies will be permanently deleted from Google Drive to eliminate any digital footprint. Hard copies would be securely shredded or burnt to prevent reconstruction or unauthorized access.

Ethical Issues

Informed consent, voluntary participation, right to privacy, plagiarism, anonymity, and confidentiality difficulties are among the fundamental rules of ethics in data gathering proposed by Ubi, Orji and Osang (2020). Ethical considerations were very important for every research endeavour. As such, the main purpose of the research and the format of the questionnaire were discussed with the participants. Participation in the study was solely based on individuals' willingness. Confidentiality of participants was ensured by avoiding means of identification such as surnames, residences, and contact details.

Respondents were made aware of their involvement in the data-gathering method as far as informed consent was concerned. In practice, this was accomplished by first obtaining consent from the several manufacturing companies under scrutiny. A copy of the authority notification was also sent with each questionnaire. In terms of voluntary participation, none of the respondents was coerced into taking part in the survey against their will. Furthermore, the respondents' right to privacy was assured and maintained by giving them the option of participating or not participating in the survey.

Data gathered was strictly secured in a password-protected computer, and individual respondents who contributed to the study were not linked or identified with their real names. All other ethical protocols were observed at each study stage as and when needed. Clearance was sought from the Ethical Review Board of the University of Cape Coast before proceeding with the study. The researcher administered the questionnaires to the respondents, clarified the questions on the questionnaire to the respondents, and asked the respondents if there was a need for further clarification before responding to the questionnaire.

Chapter Summary

Chapter three outlines the methodological framework for assessing the production and consumer acceptability of jackal berry wine. The study utilised an experimental research design, specifically a true experimental approach, to test hypotheses and obtain precise results. Conducted in the Daffiama Bussie Issa District, the research targeted adults knowledgeable about jackal berry fruits. A sample size of 100 respondents, selected through simple random and purposive sampling techniques, ensured representativeness and reduced bias.

Data collection relied on a sensory evaluation form to assess the wine's appearance, aroma, taste, and overall acceptability. Data was cleaned, coded, and analysed using SPSS version 26.0, employing descriptive and inferential statistical tools like frequencies, percentages, means, and standard deviations. Hypothesis testing involved one-way ANOVA to compare mineral values between different fermentation processes.

Ethical considerations included informed consent, voluntary participation, confidentiality, and anonymity. Participants were fully informed about the study, ensuring their voluntary involvement, and data was securely

stored. Ethical clearance was obtained from the University of Cape Coast. Overall, Chapter 3 provides a succinct overview of the methodological rigour ensuring the reliability and validity of the study's findings.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter presents the findings from the study and includes an analysis of the demographic characteristics of the panellists, the research objectives, and the hypothesis. The demographic information was analysed using frequencies and percentages. The first research objective, which focused on formulating different types of wine from jackal berry fresh fruit, was evaluated using the recipe chart designed for this purpose. The second objective, aimed at evaluating the mineral value of the jackal berry wine, was analysed using means and standard deviations.

To test the third objective, which involved a sensory evaluation of the consumer acceptability of the jackal berry wine, a one-way Analysis of Variance (ANOVA) was employed. The hypothesis regarding the statistically significant difference in the mineral value of jackal berry wine produced from natural and cultured fermentation processes was tested using an independent t-test. Results have been presented in the form of figures and tables to facilitate understanding and interpretation. Overall, this chapter integrates statistical analyses with visual data presentations to comprehensively discuss the findings of the research objectives and hypothesis.

Demographical Information of Panelists

The demographic information about the panellists is presented in Table 1, covering gender, age, marital status, and religious affiliation. Out of the 100 panellists who participated in the study, 56% were female, and 44% were male,

with females outnumbering males by 12%, reflecting the general demographic trend in Ghana where females typically exceed males.

The age distribution ranged from 20 to 59 years. The age group 20-29 years had the least number of panellists, totalling 15. The age group 50-59 years had the highest number, with 40 panellists. In the age groups 30-39 and 40-49 years, the number of panellists aged 40 and above was 67, while those below 40 were 33. According to Ghana's national classification of adults (18 years and above), all the panellists were adults. This suggests that all 100 panellists possessed the mental capacity to make informed decisions, including their preferences in wine formulation.

Regarding marital status, eight panellists were widowed, 47 were married, 40 were never married, and five were divorced. The results indicate that 43 panellists were not living with spouses, whereas 47 had spouses. While having a spouse does not directly influence wine formulation acceptability, it may impose additional responsibilities on the panellists.

In terms of religious affiliation, the majority of the panellists were Christians, followed by a smaller number of Traditional worshippers and Muslims. This diversity in belief systems reflects the religious landscape of Ghana, where individuals have the freedom to choose their religion.

Table 1: Demographic information of Panellists

Characteristics	Frequency	Percentage
Gender		
Male	44	44
Female	56	56
Age		
20 – 29	15	15
30 – 39	18	18
40 – 49	27	27
50 -59	40	40
Marital status		
Married	47	47
Never married	40	40
Widowed	8	8
Divorced	5	5
Religious status		
Christian	58	58
Muslim	3	3
Traditional	39	39

Source: Field data, Loge (2024)

Research Objective 1

Formulate different types of wine from jackal berry fresh Fruit

Using fresh fruit of jackal to formulate wines was possible. Two different wine formulations were done using different flow charts as shown in Figures 2 and 3. The flow charts present a detailed step-by-step approach for each type of wine formulation. These wines are presented in Figures 4 and 5 using coded names; Samples A and B.

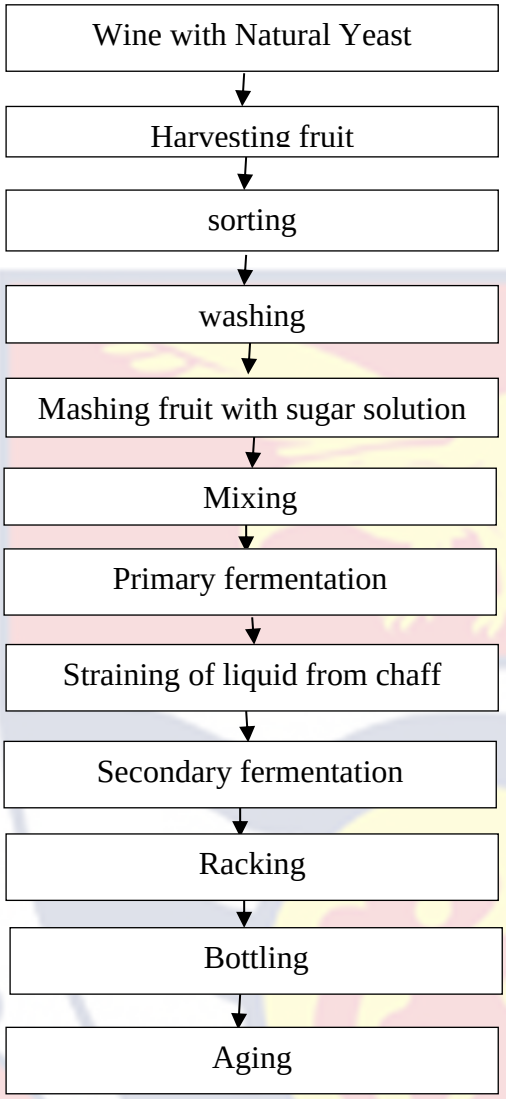

Figure 2: Wine without yeast

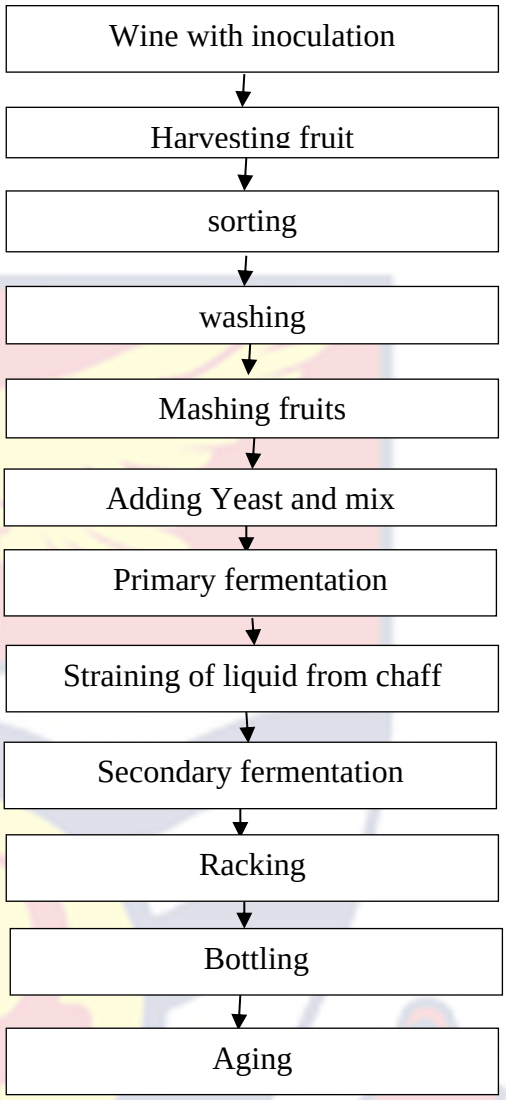

Figure 3: Wine with yeast

Source: Field data, Loge (2024)

The successful wine formulations from the jackal berry fruit suggested that wine could be produced from the fruit. The formulations of the wine used the potentials in the fruit as its ability to ferment with and without inoculation. Two different wine samples were produced from the fruit. Sample A is wine produced under natural or spontaneous fermentation process and the second formulation; Sample B was produced using Saccharomyces *cerevisiae* yeast.

Figure 4: Sample A wine

Figure 5: Sample B wine
Source: Field data, Loge (2024)

Research Objective 2: To evaluate mineral content in the jackal berry fruit Wine

The second research objective was to find out the kind of minerals that were present in the wine formulated from jackal berry fruit. Samples A and B were analysed in the chemical laboratory to determine the kind of minerals present. The mineral determination procedure by the Association of Official Analytical Chemists was adopted (AOAC, 2008). The results from the chemical laboratory show that the wines contained eight different minerals. The value of each mineral was measured in triplicate to reduce the error margin. Means and standard deviation were used as the statistical tool and the result is presented in Table 2.

Table 2: Minerals available in the Jackal Berry Wine formulated

Sample		Cu (mg/L)	Zn (mg/L)	P (mg/L)	Fe (mg/L)	Ca (mg/L)	Mg (mg/L)	K (mg/L)	Na (mg/L)
Sample A	Mean	38.30	78.67	479.14	87.65	435.53	50.40	1220.93	163.64
(Spontaneous	N	3	3	3	3	3	3	3	3
fermentation)	Std. Deviation	.26	.64	7.05	1.47	12.88	.78	33.57	2.02
Sample B (cultured	Mean	46.23	89.29	491.43	97.14	452.90	62.42	1311.40	172.49
with yeast)	N	3	3	3	3	3	3	3	3
	Std. Deviation	.55	.49	1.32	1.40	.52	.71	1.55	1.52
Total	Mean	42.27	83.98	485.29	92.39	444.22	56.41	1266.17	168.07
	N	6	6	6	6	6	6	6	6
	Std. Deviation	4.36	5.84	8.11	5.36	12.53	6.61	53.92	5.11

Source: Field data, Loge (2024) *N= number of times the sample measurement was taken (triplicate)

The result as presented in Table 2 shows the presence of eight different minerals which were assayed for. These minerals were copper (Cu), zinc (Zn), phosphorus (P), iron (Fe), calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na). The minerals found are essential for the development, maintenance and protection of the cells in human. The quantity of the minerals present in the formulated wines have been taken in triplicate per the standards of AOAC (2008) to reduce the error margin.

The mean value of Sample A was less than that in Sample B by 7.93 and the Std. deviation was 0.286 respectively for copper. In the case of zinc, Sample B had more quantity than Sample A with a difference of 10.63 for mean and Std. deviation of 0.15. The mean value for phosphorus was more in the cultured wine with yeast (Sample B) as compared to the natural yeast wine (Sample A) as presented in Table 2. The rest of the minerals (iron, calcium, magnesium, potassium, sodium) had higher mean values in the cultured wine than the uncultured wine. The mean values of those minerals were at least 8.00 higher than the mean values in Sample A. For instance, Mg and Na had 12.01 and 8.87 means higher respectively in favour of Sample B.

The quantity of minerals found in the wine produced with yeast had higher means and lower standard deviations when compared case-by-case. It can, however, be concluded that the eight different minerals found in the wine formulations varied in quantities. For all eight minerals, the mean value for the wine formulations with yeast was higher than the spontaneously fermented wine.

Research Objective 3

Sensory evaluation of the formulations for Acceptability

The acceptability of the formulations ('Sample A' and 'Sample B') was assessed through a comprehensive sensory evaluation. The panellists evaluated three sensory attributes—appearance, aroma, and taste—along with the overall acceptability of each formulation. The descriptive statistical analysis presented in Table 3 reveals distinct preferences for each attribute.

Sample B had a higher mean value for appearance, with a difference of 0.9 compared to Sample A. This suggests that the visual appeal of Sample B was more attractive to the panellists, possibly due to its colour, clarity, or presentation, which are critical factors influencing consumer choices in the wine market.

For aroma, Sample B also had a slightly higher mean value (0.14) than Sample A. This indicates that Sample B's bouquet or scent was preferred, which could be attributed to the fermentation process or the inherent characteristics of the jackal berry fruit when cultured yeast is used. Aromatic compounds play a significant role in the sensory experience of wine, contributing to its complexity and appeal.

Interestingly, the taste attribute showed a different trend, with Sample A having a higher mean value than Sample B. This reversal suggests that despite its lower scores in appearance and aroma, Sample A was preferred for its flavour profile. The taste is a critical determinant of wine quality and consumer preference, encompassing factors such as sweetness, acidity, and balance. The higher taste preference for Sample A might be due to the natural fermentation process, which could produce a more complex or palatable flavour.

The overall mean acceptability score for spontaneously fermented jackal berry wine was marginally higher than the jackal berry wine fermented with starter culture, with a difference of 0.04. While this difference is slight, it indicates a slight preference for spontaneously fermented jackal berry wine among the panellists. This could be due to the interplay of the various sensory attributes, where the favourable taste of spontaneously fermented jackal berry wine may have outweighed its lesser appearance and aroma scores.

Table 3: Descriptive response on mean and standard deviation on formulations by Panellists

		N	Mean	Std. Deviation	Std. Error
Appearance	Sample A	100	3.84	1.405	.141
	Sample B-yeast	100	4.74	.579	.058
	Total	200	4.29	1.163	.082
Aroma	Sample A	100	4.56	.608	.061
	Sample B	100	4.70	.689	.069
	Total	200	4.63	.652	.046
Taste	Sample A	100	4.80	.829	.083
	Sample B	100	4.66	.728	.073
	Total	200	4.73	.781	.055
Overall Acceptability	Sample A	100	4.48	.858	.086
	Sample B	100	4.44	1.192	.119
	Total	200	4.46	1.036	.073

Source: Field data, Loge (2024)

The One-Way ANOVA results, detailed in Table 4, examined the statistical significance of the differences in sensory attributes between and within groups. The appearance attribute showed a significant difference ($p<0.05$) between and within groups, suggesting that the variation in appearance between the samples was statistically significant. In contrast, the aroma and taste attributes did not show significant differences ($p>0.05$), indicating that the panellists' preferences for these attributes were relatively uniform across both samples.

The overall acceptability, evaluated through sum of squares and mean square analysis, also did not show a significant difference ($p>0.05$) between and within groups. This suggests that while there were individual preferences for specific attributes, the general acceptability of both wine samples was relatively similar.

From this analysis, it can be concluded that while Sample A was slightly preferred overall, particularly for its taste, the differences between the two samples were minimal. This indicates that both formulations were well-received, with subtle distinctions in sensory attributes influencing the slight preference for Sample A. This information is crucial for future product development and marketing strategies, highlighting the importance of taste in consumer acceptability of jackal berry wine.

Table 4: ANOVA Results on the Acceptability of the Formulations

Characteristics		Sum of Squares	df	Mean Square	F	Sig.
Appearance	Between Groups	40.50	1	40.50	35.07	.00
	Within Groups	228.69	198	1.16		
	Total	269.18	199			
Aroma	Between Groups	.98	1	.98	2.32	.13
	Within Groups	83.64	198	.42		
	Total	84.62	199			
Taste	Between Groups	.98	1	.98	1.61	.21
	Within Groups	120.44	198	.61		
	Total	121.42	199			
Overall Acceptability	Between Groups	.08	1	.08	.07	.79
	Within Groups	213.60	198	1.08		
	Total	213.68	199			

Source: Field data, Loge (2024)

Hypothesis 1

H_0: There is no statistically significant difference in the mineral values in jackal berry wine produced from the natural and culture fermentation processes.

The hypothesis aimed to determine whether there were significant differences in mineral content between jackal berry wines produced using natural and cultured fermentation processes. To test this hypothesis, the means of the eight different minerals were computed and analysed using an independent t-test. The results of this analysis are presented in Table 5.

Table 5: Independent t-test of mineral values present in the formulations

Sample	N	Mean	Std. Dev.	t	df	Sig. (2-tailed)
Sample A	3	319.28	3.52	-10.235		
Sample B (cultured)	3	340.42	0.62		2.125	.008

Source: Field data, Loge (2024)

The findings in Table 5 indicate that the cultured sample, which involved the introduction of yeast, had a higher mean mineral content than the naturally fermented sample, Sample A. Specifically, the cultured sample exhibited a mean difference of 21.14 more than Sample A. The hypothesis was tested by comparing the significance value (p-value) to an alpha value of 0.05. The mineral values for the two samples were as follows: Sample A (M=319.28, SD=3.52) and Sample B (M=340.42, SD=0.62). The highest mean score was observed in Sample B (M=340.42, SD=0.62); t (2.125) = -10.2125, p = .008.

Given that the p-value of 0.008 is less than the alpha value of 0.05 ($p<0.05$), the null hypothesis (H_0) was rejected in favour of the alternative hypothesis (H_1). Therefore, it can be concluded that there is a statistically significant difference in the mineral content of jackal berry wine produced from natural versus cultured fermentation processes. This result underscores the impact of the fermentation method on the nutritional profile of the wine, which is a critical factor for both production and consumer acceptability.

Discussion of Results

Objective 1 focused on the use of jackal berry fruit to formulate wine using both natural and yeast fermentation methods. The natural fermentation technique allowed the inherent flavours and aromas of the jackal berry fruit to develop over time, creating a unique sensory profile that was well-received by consumers. This approach not only added value to the seasonal fruit but also ensured a year-round supply by preserving it. The value addition to the fruit, which would otherwise perish due to its seasonal availability and high moisture content, enhances its utility and market potential. Yeast fermentation, particularly with Saccharomyces cerevisiae, enhanced the mineral content of

the wine formulations, underscoring the nutritional benefits of this method. Future research could explore additional yeast strains to further optimise both flavour profiles and nutritional content, potentially catering to diverse consumer preferences and expanding the market reach.

Economically, the integration of jackal berry fruits into wine production could stimulate local economic growth by creating employment opportunities in processing, distribution, and marketing. This is particularly beneficial for rural communities, where such initiatives can leverage existing agricultural resources for value-added products. By expanding market reach beyond local boundaries, these communities can benefit from increased income and economic development.

The study identified eight essential minerals in the jackal berry wine formulations: copper (Cu), zinc (Zn), phosphorus (P), iron (Fe), calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na). These findings align with prior research by Ilouno et al. (2018), though variations in mineral composition could be due to differences in fruit maturity, processing methods, and analytical techniques. The use of Atomic absorption spectroscopy (AOAC, 2008) methodology ensured robust mineral analysis, highlighting the nutritional significance of consuming jackal berry wine. These minerals play crucial roles in physiological functions such as enzyme activity, bone health, and tissue repair, making jackal berry wine a potentially valuable dietary supplement when consumed in moderation.

The varying quantities of minerals observed in different wine formulations indicate the influence of fermentation methods, particularly the yeast strain used. *Saccharomyces cerevisiae* yeast notably increased mineral

content compared to natural fermentation alone, suggesting a strategic advantage in mineral enrichment through fermentation processes. Further research could delve into the biochemical mechanisms behind these variations and their implications for human health and product quality. Exploring different yeast strains and fermentation conditions could optimise the nutritional and sensory attributes of the wine, making it more appealing to a broader market.

Regarding sensory evaluation, Sample A, which underwent natural fermentation, was the most accepted formulation. This preference might be due to the absence of introduced yeast, which affects the taste, appearance, and aroma of the wine. The quantity of yeast used in Sample B might have been suboptimal, affecting its acceptance. Despite the higher mean values for appearance and aroma in Sample B, the overall acceptance was slightly lower, indicating that sensory attributes did not significantly influence the final choice of the panellists.

The research hypothesis tested whether there was a statistically significant difference in the mineral values of jackal berry wine produced from natural versus cultured fermentation processes. The results showed that the mineral content was significantly higher in the cultured fermentation sample (Sample B), leading to the rejection of the null hypothesis in favour of the alternative hypothesis. This confirms that there is a statistically significant difference in the mineral values of wines produced by the two fermentation methods, highlighting the importance of the fermentation process in determining the nutritional profile of the final product. This finding underscores the potential for improving the nutritional quality of jackal berry wine through controlled fermentation processes, which could be a key selling point in health-

conscious markets. By providing a thorough analysis of the economic, nutritional, and sensory implications, this discussion enhances the understanding of jackal berry wine production and its potential benefits.

Chapter Summary

This chapter presented the findings from the study, addressing the demographic characteristics of the panellists, the research objectives, and the hypothesis. The demographic analysis revealed a diverse group of 100 panellists, with a higher representation of females and an age range from 20 to 59 years. Most panellists were adults, capable of making informed decisions during the sensory evaluation.

The first research objective demonstrated the feasibility of formulating wines from jackal berry fruit using natural and yeast fermentation methods. Natural fermentation highlighted the fruit's inherent flavours, while yeast fermentation, particularly with *Saccharomyces cerevisiae*, enhanced the wine's mineral content, adding nutritional value.

The second objective evaluated the mineral content in the jackal berry wine. The analysis identified eight essential minerals, with higher concentrations in the yeast-fermented wine. This underscores the role of yeast fermentation in enriching the nutritional profile of the wine, in agreement with findings from previous studies.

For the third objective, sensory evaluation showed that spontaneously fermented jackal berry wine was more accepted by panellists than jackal berry wine fermented using *Saccharomyces cerevisiae* as starter culture. Despite higher mean values for appearance and aroma in the jackal berry wine fermented using *Saccharomyces cerevisiae* as starter culture, the spontaneously

fermented jackal berry wine., taste and overall acceptability were higher for the spontaneously fermented jackal berry wine, indicating a preference for spontaneously/natural fermentation.

The hypothesis tested the significance of mineral differences between the two fermentation methods. Results showed a statistically significant difference, with higher mineral content in the yeast-fermented wine, leading to the rejection of the null hypothesis. This highlights the impact of fermentation processes on the wine's nutritional quality.

Overall, the chapter concluded that both fermentation methods are viable for producing jackal berry wine, with natural fermentation preferred for sensory attributes and yeast fermentation enhancing nutritional value. These findings have important economic, nutritional, and market implications for jackal berry wine production.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Overview of the Study

The study was on the possibility of using wild edible fruit called jackal berry to produce wine. The wine formulations were two; one without yeast and the other with *Saccharomyces cerevisiae* yeast. The study had three research objectives and one research hypothesis guiding it. Literature was reviewed to give perspective to what was being studied and to help support the findings from the current study.

The methodologies used to conduct the study were in the direction of what exactly to do at each stage of the study. The sample size for the sensory evaluation was 100 and all were adults per the Constitution of Ghana. The data collection was approved by the Intuitional Review Board of the University of Cape Coast. The reason was to ensure that all the ethical concerns have been adhered to. The result for each research question was tabulated, analysed and discussed. The main findings have been presented below.

Summary of Key Findings

The first research objective was to formulate two types of wine from jackal berry fruit. The findings showed that the fruit can be used to process wine. The wine has two types of formulations; one with yeast and the other without yeast. The yeast used was *Saccharomyces cerevisiae* which aided in the fermentation process for the wine to be formed. The second research objective was to determine the kind of minerals present in the wine formulations (with and without the addition of yeast) and compare the quantity in each case. The result thus indicated that copper (Cu), zinc (Zn), phosphorus (P), iron (Fe),

calcium (Ca), magnesium (Mg), potassium (K), and sodium (Na) were present. The results indicated that the mean mineral value for Sample B (*Saccharomyces cerevisiae*) was higher than Sample A (natural yeast). The minerals found were essential for the human body and the consumption of such minerals could be beneficial to the consumers.

The sensory evaluation of the formulated wines as in the third research objective showed that Sample A was the preferred formulation. The hypothesis of the study showed that there was a statistically significant difference between the mineral values found in samples A and B ($p<0.05$).

Conclusions

The study has demonstrated the feasibility of using jackal berry fruit for wine production, highlighting its potential to contribute to both nutritional and economic benefits. The research focused on formulating two types of wine: one using natural fermentation and the other using *Saccharomyces cerevisiae* yeast. Both formulations were successfully produced, with distinct differences in their mineral content and sensory attributes.

The findings revealed that the jackal berry wine produced through yeast fermentation had a higher mineral content, including essential minerals such as copper, zinc, phosphorus, iron, calcium, magnesium, potassium, and sodium. These minerals are vital for various physiological functions, suggesting that jackal berry wine could be a valuable dietary supplement. The higher mineral content in the yeast-fermented wine underscores the role of fermentation techniques in enhancing the nutritional value of the product.

Sensory evaluation showed a preference for the naturally fermented wine (Sample A) over the yeast-fermented wine (Sample B), although the

difference in acceptability was minimal. This preference may be attributed to the unique sensory profile developed through natural fermentation, which preserved the inherent flavours and aromas of the jackal berry fruit. Despite the slight preference for naturally fermented wine, the acceptance of both formulations indicates a promising market potential for jackal berry wine.

The hypothesis testing confirmed a statistically significant difference in the mineral values between the two wine formulations, supporting the conclusion that the fermentation method influences the nutritional content of the wine. This finding is crucial for future research and development efforts aimed at optimising wine production techniques to enhance both the sensory and nutritional qualities of the product.

Economically, the integration of jackal berry fruits into wine production has the potential to stimulate local economic growth. It can create employment opportunities in various sectors, including farming, processing, distribution, and marketing. By leveraging local agricultural resources, communities can produce value-added products that extend their market reach beyond local boundaries.

In conclusion, the jackal berry fruit presents a valuable resource for wine production, with significant nutritional benefits and economic potential. The study has laid the groundwork for further exploration into optimising fermentation techniques, protecting natural resources, and promoting the product to health-conscious consumers. With continued research and development, jackal berry wine could become a notable addition to the array of fruit wines available, contributing to improved nutrition, economic development, and sustainable agricultural practices in the Dafiama Bussie Issa District and beyond.

Recommendations

The findings of this study underscore the potential of jackal berry fruit for wine production, particularly highlighting the product's nutritional benefits and consumer acceptability. Based on the results, several recommendations can be made to further explore and enhance the utilisation of jackal berry fruits for wine production.

Firstly, the study demonstrated the possibility of using *Saccharomyces cerevisiae* yeast in wine production with jackal berry fruit. It is recommended that further research be conducted to experiment with different volumes of Saccharomyces cerevisiae and other synthetic yeasts. This could help optimise the fermentation process and allow for the production of a variety of wine types to cater to diverse consumer preferences. Moreover, the impact of different yeast strains on the sensory attributes and mineral content of the wine should be explored to ensure the production of high-quality, nutritionally rich wines.

Protecting the jackal berry trees from environmental threats such as cutting and bushfires is crucial. Local authorities and environmental organisations should collaborate to implement conservation strategies and educate farmers about the importance of preserving these trees. Protecting the jackal berry trees will ensure a sustainable supply of the fruit, which is essential for ongoing wine production and other potential uses.

Education and awareness campaigns should be conducted to inform local farmers and communities about the economic and nutritional benefits of jackal berry wine production. Farmers should be trained on the best practices for cultivating and harvesting jackal berry fruits to maximise yield and quality. Additionally, local communities should be encouraged to incorporate jackal

berry wine into their diet, considering its potential health benefits due to the presence of essential minerals such as copper, zinc, phosphorus, iron, calcium, magnesium, potassium, and sodium.

Given the positive consumer response to the naturally fermented wine (Sample A), efforts should be made to promote this variant while also improving the acceptance of yeast-fermented wine (Sample B). Marketing strategies should highlight the unique sensory attributes and nutritional benefits of each wine type to attract a broader consumer base.

The study's sensory evaluation involved 100 panellists, all adults. Future research should consider expanding the sample size and including a more diverse demographic to gain a comprehensive understanding of consumer preferences. This approach will provide more robust data to guide product development and marketing strategies.

Dieticians and health practitioners should be involved in promoting the consumption of jackal berry wine, especially given its mineral content and potential health benefits. Collaborating with health professionals can enhance the credibility of the product and encourage wider acceptance among health-conscious consumers.

Lastly, further studies should explore the economic impact of jackal berry wine production on local communities. Assessing the potential for job creation in processing, distribution, and marketing can provide valuable insights into how this industry can contribute to rural development and economic growth. Encouraging local entrepreneurship and small-scale businesses to engage in jackal berry wine production could stimulate economic activities and improve the livelihoods of people in the Dafiama Bussie Issa District.

In summary, by exploring various aspects of jackal berry wine production, protecting natural resources, educating the community, and conducting further research, the full potential of jackal berry fruits can be harnessed to benefit both local economies and consumer health.

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APPENDICES

APPENDIX A

INSTRUMENT: SENSORY EVALUATION FORM

We appreciate your involvement, please provide candidate responses to the following inquiries. The findings of these studies will be shared in a summarized manner, focusing on group characteristics. Your individual's identity and personal information will remain confidential and will not be revealed. Rest assured no names are included in this survey.

Confidentiality of answers given is assured. Thank you once again for your participation. Research topic: Production and Consumption Acceptability of Jackal Berry Wine.

Research objectives:

1. To formulate two types of wine from jackal berry fresh fruits.
2. To evaluate the mineral value of the jackal berry wine formulations.
3. Sensorily evaluate the two wine formulations for consumer acceptability.

INTRODUCTION

Please answer by ticking your response or filling in the space provided. Thank you.

SOCIO-DEMOGRAPHIC CHARACTERISTICS

1. Age (years) 20-29 ( ) 30-39 ( ) 40-49 ( ) 50-59 ( )

2. Gender: Male ( ) Female ( )

3. Marital Status: Never married ( ) Married ( )

Divorced/Separated ( ) Widowed ( )

4. Religion: Christian ( ) Muslim ( ) Traditionalist ( ) Others ( )

In front of you is a sample. Taste the sample and tick (V) how much you like or dislike each of the characteristics. You can taste the sample more than once. Please wash your mouth with the water provided before and after tasting each sample.

Table A1: Sensory Evaluation Form (Sample A)

	Appearance	**Aroma**	**Taste**	**Overall Acceptability**
Like a lot				
Like a little				
Neither like or dislike				
Dislike a little				
Dislike a lot				

Table A2: Sensory Evaluation Form (Sample B)

	Appearance	**Aroma**	**Taste**	**Overall Acceptability**
Like a lot				
Like a little				
Neither like or dislike				
Dislike a little				
Dislike a lot				

APPENDIX B

ETHICAL CLEARANCE

UNIVERSITY OF CAPE COAST

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IORG #: IORG0011497

15TH JANUARY, 2024

Ms Augustina Loge
Department of Vocational and Technical Education
University of Cape Coast

Dear Ms Loge

ETHICAL CLEARANCE – ID (UCCIRB/CES/2023/205)

The University of Cape Coast Institutional Review Board (UCCIRB) has granted Provisional Approval for the implementation of your research **Production and Consumer Acceptability of Jackalberry Wine.** This approval is valid from **15th January 2024 to 14th January 2025.** You may apply for an extension of ethical approval if the study lasts for more than 12 months.

Please note that any modification to the project must first receive renewal clearance from the UCCIRB before its implementation. You are required to submit a periodic review of the protocol to the Board and a final full review to the UCCIRB on completion of the research. The UCCIRB may observe or cause to be observed procedures and records of the research during and after implementation.

You are also required to report all serious adverse events related to this study to the UCCIRB within seven days verbally and fourteen days in writing.

Always quote the protocol identification number in all future correspondence with us about this protocol.

Yours faithful

Kofi F. Amuquandoh
Ag. Administrator

ADMINISTRATOR
INSTITUTIONAL REVIEW BOARD
UNIVERSITY OF CAPE COAST

Figure B2: Jackal Berry Plant

Figure B3: Jackal Berry Fruit

Figure B4: Mashing the Fruit for the Wine Production

Figure B5: *Saccharomyces cerevisiae* yeast used to prepare wine B (Sample B)

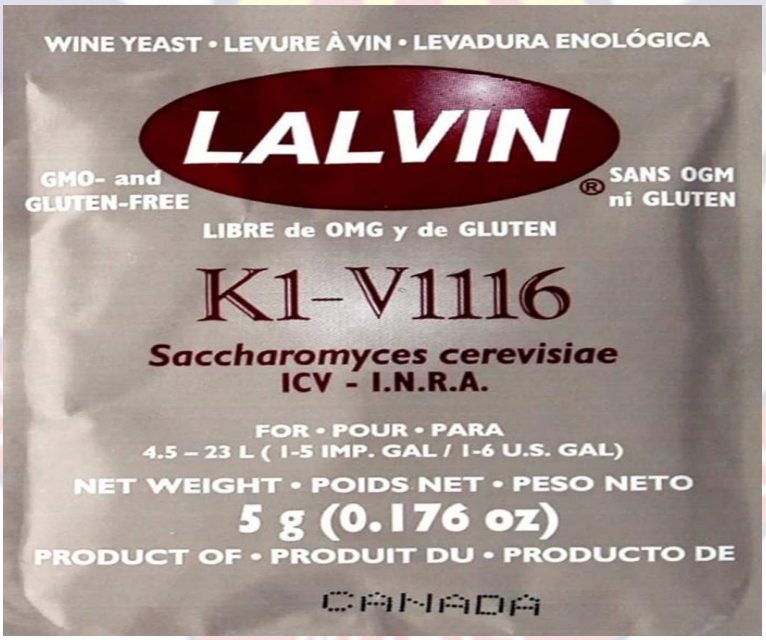

Figure B6: Preparation of the Wine

Figure B7: Panellist taking Part in Sensory Evaluation