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Nutritional Composition of Yeast (*Saccharomyces cerevisiae)* Isolated from Selected Local Fruits

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Abstract

Yeast, specifically Saccharomyces cerevisiae, is commonly used in the leavening of dough in bakeries and food industries. This study aimed to isolate and identify S. cerevisiae from ten local fruits and analyze the proximate and nutritional composition of the yeast isolates. Yeast was isolated from orange, mango, guava, apple, watermelon, sweet melon, pineapple, pawpaw, banana, and sugarcane using morphological, biochemical and microscopic characteristics. The proximate analysis revealed significant variations in nutritional composition. Watermelon exhibited the highest protein content at 73.47%, while pawpaw showed the lowest at 53.88%. Pawpaw also had the highest carbohydrate content (25.51%) but the lowest moisture (7.66%) and ash (3.95%) levels. Comparatively, sugarcane had the highest moisture content at 15.06%, and banana had the highest ash content at 8.32%. The fat content across the fruits was relatively low, with mango showing the highest value at 1.28%. These findings suggest that some local fruits are a potential source of indigenous S. cerevisiae, which could serve as effective leavening agents in food production.

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Keywords: Local fruits, yeast isolation, Saccharomyces cerevisiae, nutritional composition, leavening agent.

INTRODUCTION

Baker's yeast, which is derived from the species *S. cerevisiae*, is a microorganism that is utilized in the baking industry for dough fermentation. The desired texture and flavour of bread and baked items are produced by the dough rising as a result of the yeast's metabolic activity (Khan *et al*., 2018). The production of high-quality Baker's yeast is critical to ensuring consistent and efficient bread-making processes while meeting the demands of the global bakery market. The extensive research and diverse applications of *S. cerevisiae* across many industries, particularly in food and beverage production, justify its significant economic importance. A succession of yeast populations in such products involves in a variety of biochemical processes carried out by yeast to utilize simple sugars present in the agricultural products. According to Eldarov & Mardanov, (2020). This yeast species has proven its value in numerous sectors, exemplifying its broad-ranging significance. The ability of *S. cerevisiae* to metabolize a wide range of carbohydrates, combined with its high fermentation efficiency, makes it an ideal yeast for industrial use. High-quality yeast production is essential for maintaining consistent bread-making processes, and understanding the factors influencing its growth—such as temperature, pH, and nutrients and/or growth substrate—remains a critical area of study (Jiang *et al*., 2019). The nutritional composition of *S. cerevisiae* particularly strains isolated from local fruits is widely used in fermentation processes and has potential health benefits due to high protein profile containing essential amino acid, vitamins particularly B1 (thiamine), B2 (riboflavin), B3 (niacin), B5 (pantothenic acid), B6 (pyridoxine), B7 (biotin), B9 (folate) and B12 (cobalamin). These vitamins play crucial roles in metabolism and health benefits as reported by Kaur and Sharma (2021).

The isolation of *S. cerevisiae* strains from different fruits, it is crucial to acknowledge the rich biodiversity of yeast strains present in nature. A study by Sampaio and Gonçalves (2008) highlighted the diversity of *S. cerevisiae* strains in various ecological niches, including fruits. These yeast strains can exhibit distinct characteristics influenced by the fruit's microbiota and environmental factors; thus, the isolation and characterization of these strains are vital for understanding their potential utility in various applications. The major types of yeast include *S. cerevisiae*, used in beer and wine production, and *S. pastorianus*, primarily for lager beer. *S. cerevisiae* is crucial in beer brewing due to its fermentation capacity and flavor contribution (Kato and Takahashi, 2023).

The yeast contains essential minerals such as selenium, zinc, iron and magnesium which are important for various body functions, *S. cerevisiae* contains compounds that can act as antioxidants helping to combat oxidative stress in the body and also is low in fatty acids like omega-3 and omega-6 fatty acids according to Mazzoli and Biachi (2023).

It is worth knowing that, in wine production, non-Saccharomyces yeasts like *Schizosaccharomyces pombe* and *Torulaspora delbrueckii* are essential for enhancing aroma and taste complexity (Maicas and Mateo, 2023). But on the other hand, *S. cerevisiae* is not only significant in food and beverage industries but also in biofuel production due to its fermentation capabilities and resilience to adverse conditions (Parapouli *et al*., 2020; Mitsui and Yamada, 2021). Different *Saccharomyces* species exhibit varying fermentation efficiencies and stress tolerances, with *S. cerevisiae* and *S. paradoxus* being the most robust (Zemančíková *et al*., 2018). These yeast types play pivotal roles in various industries, contributing to the unique characteristics and flavors of fermented products. The acids production contributes to the flavour of the finished bread and enhance the bread storage properties as reported by Azmuda, *et al*. (2006).

However, evaluating the nutritional value of baker's yeast strains, aligns with the importance of yeast as a potential source of essential nutrients. It is certain that baker's yeast is a rich source of protein, B vitamins, and minerals (Gélinas *et al*., 2012). These nutrients play a significant role in human nutrition and have led to increased interest in utilizing yeast as a nutritional supplement. Furthermore, studies have shown that the nutritional content of yeast can vary depending on the strain and growth conditions (Frengova *et al*., 2012). Despite extensive research on yeast isolated from commercial and industrial sources, there is limited information regarding the isolation and nutritional potential of indigenous yeast strains from local fruits, particularly in regions like Nigeria. Therefore, assessing the nutritional composition of yeast strains isolated from different fruits is essential to identify potential sources of nutritionally-rich yeast. However, this study aims to address this gap by isolating *S. cerevisiae* from various local fruits, analysing their morphological characteristics, and assessing their nutritional profiles. Through exploration of underutilized fruit sources for yeast isolation, this research attempts to identify potential alternatives to commercial yeast strains and contribute to the body of knowledge on indigenous yeast species.

Yeast is a biological leavening agent that is essential in raising flour dough. Biological leavening agents are organisms that can produce carbon dioxide from the breakdown of sugar (Ray & Ramesh, 2016). Yeast plays a vital role in various fermentation processes including baking and brewing. In brewing, the alcohol produced by the fungus during fermentation is essential while carbon dioxide is of essential need for the rising of flour dough, maturation and development of fermentation flavour (Maryam *et al*., 2017). Leavening is the increase in the area of dough by aerating agents such as air, CO2 and water vapour. The leavening of dough is a result of CO2 produced by the fermenting organism which is usually *Saccharomyces* species. Yeast specifically *S. cerevisiae*, is used in baking as a leavening agent where it converts fermentable sugars present in the dough into carbon dioxide. This causes the dough to expand as the carbon dioxide forms bubbles (Maryam *et al*., 2017).

MATERIALS AND METHODS

Experimental Site and Sample Collection

The experiment was conducted in the Microbiology Laboratory, Department of Microbiology, Sa'adu Zungur University, formally known as Bauchi State University Gadau, Bauchi State. A diverse range of local fruit samples, including grape, apple, banana, pineapple, orange, pawpaw, water melon, sweet melon, mango and sugar cane were collected in a sterile plastic bag from Azare market and transported in ice bag container at 4°C to Microbiology lab. BASUG. The collection was carried out aseptically to minimize contamination and preserve the integrity of the samples (Smith *et al*., 2020).

Sample Preparation and Isolation of *S. cerevisiae*

Using a sterile inoculating loop, small pieces of the fruit surface were taken and directly streaked onto Yeast extract Peptone Dextrose (YPD) agar plates, with each plate receiving an equal number of streaks to ensure even distribution (Musa *et al*., 2023). The inoculated plates were incubated at 30°C for 48 hours, during which colonies of yeast were expected to develop. After the incubation period, the plates were examined for yeast colony formation, noting distinct colonies exhibiting a creamy, white appearance, indicative of potential *S. cerevisiae* growth (Musa *et al*., 2023; Johnson *et al*., 2018).

Sub-culturing and Identification

Selected colonies were sub-cultured onto new YPD agar plates to obtain pure cultures. A sterile loop was used to take a single colony and streak it onto a fresh plate, which was then incubated at 30°C for another 48 hours to ensure robust growth of the isolated yeast. After sufficient growth, a small amount of the culture from the newly sub-cultured plates was transferred to a microscope slide and mixed with a drop of distilled water to form a smear, and lactophenol cotton blue was used to stain the smear and observed under the microscope at 100× magnification (Musa *et al*., 2023). The morphology and staining characteristics were compared with established descriptions of *S. cerevisiae*.

Biochemical Identification.

The biochemical characterization of the yeasts (S. cerevisiae) was done using the API20C AUX KIT (BioMeriux) according to the method described by Soliman, *et al* (2011).

Yeast Harvesting

The baker's yeast cells were harvested at the logarithmic growth phase, a stage characterized by active cellular metabolism and rapid proliferation. Harvesting at this phase ensures a higher yield of viable yeast cells, which contributes to the success of subsequent processing steps (Smith & Johnson, 2022).

Proximate Analysis

Determination of Moisture Content

The moisture content of the yeast biomass was determined using standard drying methods. This involves subjecting a known quantity of yeast biomass to controlled drying conditions until a constant weight is achieved, allowing for the calculation of moisture content (AOAC, 2016).

Measurement of Protein Content

Protein content was quantified using the Kjeldahl method, a widely accepted technique for nitrogen determination. Protein content was calculated based on the nitrogen content of the yeast biomass (Nelson & Schmidt, 2019).

Assessment of Carbohydrate Content

Total carbohydrate content was determined through the phenol-sulfuric acid method, which involves reacting carbohydrates with sulfuric acid and phenol to generate a coloured complex that can be quantified spectrophotometrically (Dubois *et al*., 1956).

Analysis of Lipid Content

Lipid content was determined using solvent extraction followed by gravimetric analysis. Yeast biomass was extracted with an appropriate solvent, and lipids was separated, dried, and weighed to determine lipid content (Folch *et al*., 1957).

Quantification of Ash Content

Ash content, representing the inorganic residue of yeast biomass, was determined by incinerating the biomass at high temperatures to remove organic matter. The remaining ash will be weighed and expressed as a percentage of the initial biomass weight (AOAC, 2016).

Statistical Analysis

Data obtained from the proximate analysis were subjected to One-Way Analysis of Variance (ANOVA) to determine the significant differences between the means at P≤0.05. Where means were significant, Tukey's Honestly Significant Difference (HSD) test was performed to determine the significance within the means. All statistical analyses were performed using SPSS version 20.

RESULTS

Morphological Features of *S. cerevisiae* Isolated from Different Fruits

Table 1: Morphological, Macroscopic and Microscopic Properties of Mould and Yeast Isolated from the Fruit Samples

	Morphological Description of Colonies	Microscopy	Inference
	Colony appeared to be circular, white and creamy, aromatic smell.	Single cells oval in shape with some cells showing budding	*Saccharomyces cerevisi*

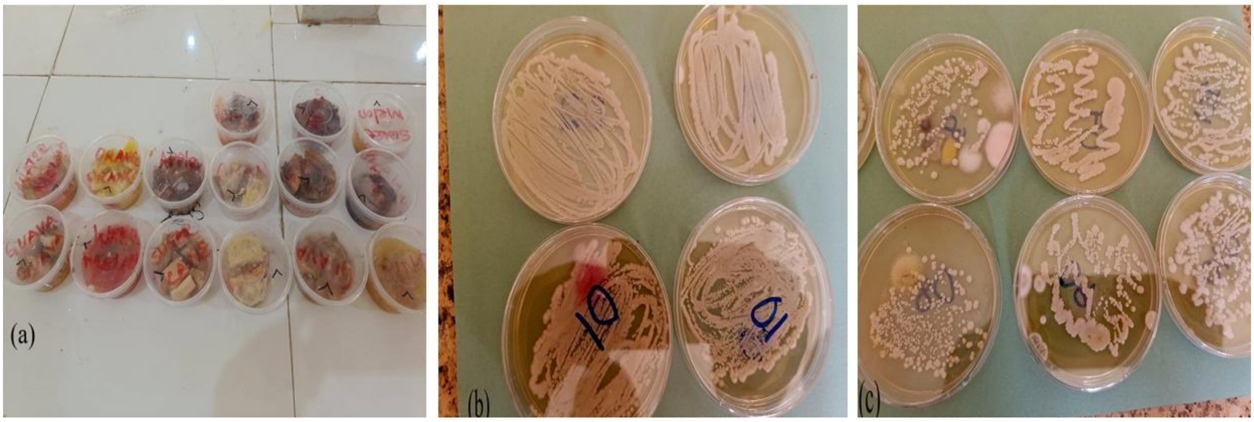

Plate 1: Processed Fruit Samples Obtained from Azare Market, Katagum, Bauchi State (a); colony Morphological Appearance of *S. cerevisiae* on Potato Dextrose Agar (PDA) after Sub-culturing (b-c).

Table 2: Biochemical Characteristics of Yeast Isolated from Local Fruits

Characteristics	OR	GU	SC	BN	WM	SM	MG	PP	PW	AP	Control
Isolates	S/c	S/c	S/	S/c	S/c	S/c	S/c	S/	S/c	S/	S/c
Catalase	+	+	c	+	+	+	+	c	+	c	+
Glucose	+	+	+	+	+	+	+	+	+	+	+
Sucrose	+	+	+	+	+	+	+	+	+	+	+
Mannitol	-	-	+	-	-	-	-	+	-	+	+
Sorbitol	-	-	-	-	-	-	-	-	-	-	-
Lactose	-	-	-	-	-	-	-	-	-	-	-
Galactose	-	-	-	-	-	-	-	-	-	-	-
Fructose	+	+	-	+	+	+	+	-	+	-	-
Maltose	+	+	+	+	+	+	+	+	+	+	+
Urease	+	+	+	+	+	+	+	+	+	+	+
Oxidase	-	-	+	-	-	-	-	+	-	+	-
	+	+	-	+	+	+	+	-	+	-	+
Starch test			+					+		+	

Key: += Positive (Acid production), - = Negative (No acid production, OR= Orange, GU=Guava, SC= Sugar cane, BN= Banana, WM= Water melon, SM= Sweet melon, MG= Mango, PP= Pineapple, PW= Pawpaw, AP= Apple and S/c = Saccharomyces cerevisiae.

Table 3: The result of proximate Composition of Yeast (*S. cerevisiae*) Isolated from Different Fruits Samples

	Proximate Parameters					
Samples	**Moisture**	**Ash**	**Fat**	**Protein**	**Carbohydrate**	
Orange	13.94±0.08^{b}	6.13±0.01^{c}	0.90±0.00^{b}	60.81±1.15^{c}	19.16±1.17^{c}	
Guava	12.65±0.04^{c}	7.00±0.00^{b}	0.87±0.01^{b}	65.75±0.00^{b}	10.73±0.03^{e}	
Sweet Melon	13.26±0.06^{bc}	5.12±0.00^{d}	1.05±0.07^{a}	61.69±0.79^{c}	16.87±0.81^{c}	
Banana	11.19±0.02^{d}	8.32±0.03^{a}	0.98±0.01^{b}	61.44±0.17^{c}	13.57±0.82^{d}	
Sugarcane	15.06±0.09^{a}	4.82±0.07^{e}	1.12±0.01^{a}	64.78±0.74^{b}	14.22±0.89^{d}	
Apple	9.73±0.06^{c}	5.16±0.07^{d}	0.99±0.00^{b}	61.20±1.04^{c}	22.90±1.03^{b}	
Pineapple	13.82±0.55^{b}	6.12±0.03^{c}	0.81±0.00^{b}	59.88±0.00^{d}	19.38±0.54^{c}	
Watermelon	10.57±0.63^{cd}	7.18±0.05^{b}	0.77±0.01^{b}	73.47±0.23^{a}	8.01±0.37^{f}	
Pawpaw	7.66±0.16^{e}	3.95±0.07f	1.01±0.02^{a}	53.88±0.00^{e}	25.51±0.23^{a}	
Mango	12.46±0.02^{c}	5.77±0.01^{d}	1.28±0.06^{a}	64.25±0.00^{b}	16.24±0.73^{c}	

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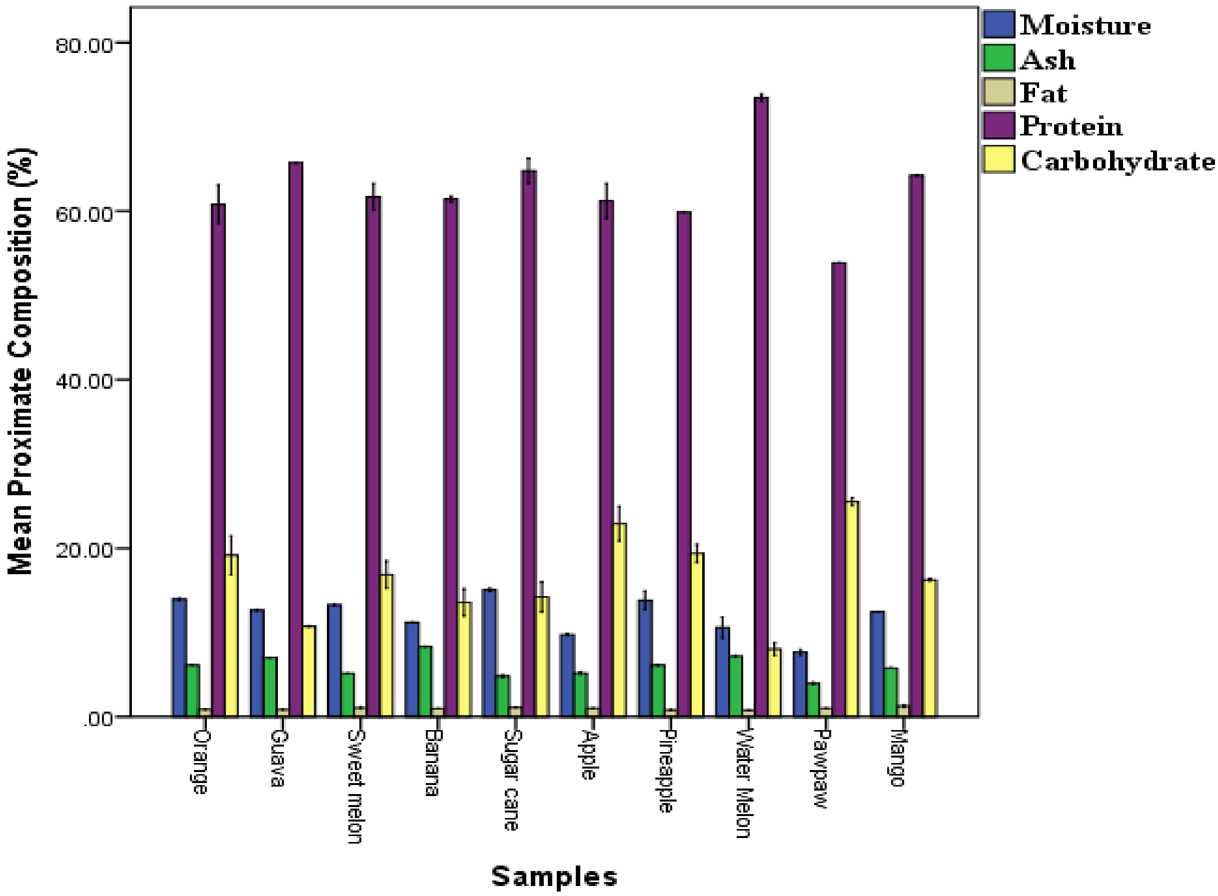

Figure 1: The bar chart representation of mean proximate Composition of Yeast (*S. cerevisiae*) Isolated from Different Fruit Samples

DISCUSSION

The macroscopic observation as observed in Plate 1b-1c and presented in Table 1, circular colonies with a white and creamy appearance corresponds to well-documented traits of *S. cerevisiae* colonies. According to Barnett *et al*. (2000), *Saccharomyces cerevisiae* colonies typically display a circular morphology and may exhibit variations in colour, including creamy or white appearances. This consistency in macroscopic features reinforces the reliability of these traits for the identification of *S. cerevisiae* isolates.

At the microscopic level, the oval shape of single cells and the presence of budding are key identifying features of Saccharomyces cerevisiae. Microscopic observations indicating oval-shaped cells with budding align with the classical characteristics of *S. cerevisiae* as documented by Kurtzman *et al*. (2011). The budding pattern, a distinctive mode of asexual reproduction, is a well-established feature in the life cycle of *S. cerevisiae* (Fleet, 2003). The inclusion of budding cells in the microscopic description further supports the accurate identification of *S. cerevisiae*. Characteristically, they showed moderate circular colonies, while the colonies of the isolate from the local fruits presented cream colour with large-raised flat cells or colonies and alcoholic odour on Yeast peptone dextrose agar. This result is similar to the findings of Peu, *et al*. (2012) who reported that typical yeast colonies were creamy and regular colony shape.

Ten different strains of yeast (*S. cerevisiae*) from local fruits were isolated and identified using cultural, biochemical and morphological characteristics. Biochemical characteristics of Yeast (*Saccharomyces cerevisiae*) isolated from fruits revealed that they are sugar lovers. This result is in agreement with the work of (Maryam *et al*., 2017).

The results of the biochemical characteristics of the yeast strain isolated from different local fruits Orange, Guava, Sugar cane, Banana, Water melon, Sweet melon, Mango, Pineapple, Pawpaw, Apple and Control (Bakers yeast) are presented in table 2 revealed that the yeast are facultative anaerobes and the biochemical tests carried out on yeast strain isolates from different local fruits indicated that all the isolates were urease positive, catalase positive and oxidase negative. Starch hydrolysis test of the yeast isolates from all the different local fruits and control (Bakers yeast) were positive.

The result of this finding is in line with the work of (Romano *et al*., 2018), who reported that yeast species isolated from different local fruits can ferment variety of sugars including glucose, fructose, maltose and sucrose The ability of yeast to produce gas (Co_2) or acid production indicate a positive fermentation test, which is associated with fermentation processes and therefore can be used to accomplish fermentation. They may also be used in bread making to speed up the baking process and increase carbon dioxide production and the production of flavour and aroma.

The moisture content (Table 3) of *S. cerevisiae* isolated from different fruit samples provides valuable insights into the water content of these isolates. This analysis is crucial for understanding the environmental conditions that may influence the growth and survival of yeast strains. The results indicate variations in moisture content among the different fruit samples, ranging from 7.66% in pawpaw to 15.06% in sugarcane. The observed differences in moisture content could be influenced by several factors, including the composition of the fruit matrix and the inherent water content of the fruits themselves. The high moisture content in sugarcane aligns with the known water-rich nature of sugarscane, a plant with a high-water content in its cellular structure (Firsov *et al*., 2018). On the other hand, the lower moisture content in pawpaw may be attributed to the inherent characteristics of pawpaw fruit, which typically has lower water content compared to succulent fruits (Fasoyiro *et al*., 2018).

Moreover, the moisture content of yeast isolates may also impact the morphology of the cells. Higher moisture content can influence cell shape, size, and budding patterns (Hagman *et al*., 2013). However, specific literature on the direct correlation between moisture content and *S. cerevisiae* morphology in fruit isolates is limited. It is essential to consider the role of moisture in the survival and fermentation activities of yeast. For example, *S. cerevisiae* is known to thrive in environments with moderate to high moisture levels, supporting its metabolic activities and cellular processes (Pretorius, 2000). The findings in this study could have implications for the potential applications of these yeast isolates in industrial processes, such as brewing and fermentation, where moisture content is a critical factor (Steensels *et al*., 2019).

Furthermore, the ash content of *S. cerevisiae* isolated from different fruit samples provides crucial information about the mineral composition of these yeast isolates. Ash content represents the inorganic residue left after complete combustion of organic matter and is indicative of the mineral content in the yeast cells. The results show variations in ash content among the different fruit samples, ranging from 3.95% in pawpaw to 8.32% in banana. The observed differences in ash content may be attributed to the mineral composition of the fruits from which the yeast isolates were obtained. High ash content in banana could be as a result that bananas are known to be rich in minerals such as potassium. On the other hand, the low ash content in pawpaw may be related to the fruit's lower mineral content compared to other fruits.

The ash content of yeast isolates may influence cell structure and morphology. Minerals play a vital role in various cellular processes, including cell wall formation and stability (Kapteyn *et al*., 2000). The correlation between ash content and microscopic features of *S. cerevisiae* in fruit isolates, however, requires further investigation as specific literature on this aspect is limited. The importance of ash content in yeast isolates extends beyond its influence on cell morphology. It can impact the use of yeast in various applications, including fermentation processes. For instance, the mineral content of yeast is crucial for its performance in brewing and winemaking, where specific minerals contribute to the flavour and quality of the final product (Bisson, 2012).

The fat content of *S. cerevisiae* isolated from different fruit samples provides insights into the lipid composition of these yeast isolates. The results reveal variations in fat content among the different fruit samples, ranging from 0.77% in watermelon to 1.28% in mango. The microscopic and macroscopic features related to fat content in yeast isolates are crucial for understanding the nutritional aspects and potential applications of these strains. While the literature on the direct correlation between fat content and the microscopic features of *S. cerevisiae* in fruit isolates is limited, studies on yeast lipid metabolism and composition offer valuable insights.
The fat content of yeast cells may influence their morphology and structure. Lipids play a vital role in the formation of cellular membranes, and changes in lipid composition can impact the fluidity and integrity of the cell membrane (Carman and Henry, 2007). However, specific literature on the direct correlation between fat content and microscopic features of *S. cerevisiae* in fruit isolates is needed. Macroscopically, the fat content is a crucial nutritional parameter that can influence the use of yeast isolates in various applications, including food and fermentation processes. For instance, the lipid composition of yeast can affect its performance in the production of biofuels (Miskovic *et al*., 2016). Understanding the fat content of yeast isolates is essential for optimizing their use in different industrial processes.

The protein content of *S. cerevisiae* isolated from different fruit samples provides crucial information about the nutritional composition of these yeast isolates. The results indicate variations in protein content among the different fruit samples, ranging from 53.88% in pawpaw to 73.47% in watermelon. The protein content of yeast isolates may influence their cellular structure, especially regarding cellular proteins involved in various metabolic and physiological processes. While specific literature on the direct correlation between protein content and microscopic features of *S. cerevisiae* in fruit isolates is limited, studies on yeast proteomics offer valuable insights into the diversity of proteins and their functions (Arike *et al*., 2012).

Additionally, the protein content is a crucial nutritional parameter that can impact the use of yeast isolates in various applications, including food and fermentation processes. The high protein content in watermelon aligns with the known protein-rich nature of seeds, and this has implications for potential applications in the food and feed industry (Kyriakopoulos *et al*., 2018). On the other hand, the lower protein content in pawpaw may be attributed to the characteristics of the fruit, which generally has lower protein content compared to other fruits (Adegunwa and Alamu, 2018). Understanding the protein content of yeast isolates is essential for optimizing their use in different industrial processes. For instance, in the brewing and fermentation industry, the protein content can influence the yeast's ability to perform fermentation and contribute to the flavor profile of the final product (Brányik *et al*., 2012).

The carbohydrate content of *S. cerevisiae* isolated from different fruit samples provides valuable information about the energy source and potential applications of these yeast isolates. The results show variations in carbohydrate content among the different fruit samples, ranging from 8.01% in watermelon to 25.51% in pawpaw. Microscopically, the carbohydrate content of yeast isolates may influence their cellular structure and function. Carbohydrates play a vital role in providing energy for cellular processes, and variations in carbohydrate content can impact the metabolism and growth of yeast cells (François and Parrou, 2001). While specific literature on the direct correlation between carbohydrate content and microscopic features of *S. cerevisiae* in fruit isolates is limited, studies on yeast metabolism offer insights into the role of carbohydrates in cellular processes.

Moreover, the carbohydrate content is a crucial nutritional parameter that can influence the use of yeast isolates in various applications, including food and fermentation processes. The high carbohydrate content in pawpaw aligns with the known high sugar content of the fruit, making it a potential candidate for applications in fermentative processes such as brewing or bioethanol production (Wang *et al*., 2016). On the other hand, the lower carbohydrate content in watermelon may impact its suitability for certain industrial processes. Understanding the carbohydrate content of yeast isolates is essential for optimizing their use in different applications. For instance, in the brewing and fermentation industry, the carbohydrate content can influence the yeast's ability to produce alcohol and contribute to the overall flavour profile of the final product (Walker, 2018).

CONCLUSION

It has been concluded that, yeast (*S. cerevisiae*) is found on fruits of different plant species. Yeast from Guava possessed a well-balanced composition of moderate levels of moisture (12.65±0.04%), ash (7.00±0.00%), fat (0.87±0.01%), protein (65.75±0.00%), and carbohydrates (10.73±0.03%). Conversely, watermelon is identified to possess highest protein content and minimal fat and carbohydrate content. Pawpaw, exhibiting reduced levels of moisture, ash, and heightened protein content, presents a distinctive profile in the realm of fruits.

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