Tropical Journal of Applied Natural Science
ISSN: 2449-2043
Vol. 3 Issue 1 (2025)
https://tjansonline.org/view-paper.php?id=72; **Volume/Issue:** Volume 3, Issue 1
Published: July 19, 2025

PHYSICOCHEMICAL AND NUTRITIONAL PROPERTIES OF VINEGAR PRODUCED FROM DATE PALM AND APPLE FRIUT EXTRACTS: A STUDY ON QUALITY AND COMPOSITION

Ajeh, J.C.[1], Iheukwumere, I.H.[1], Iheukwumere, C.M.[2], Ike, V.E.[3], Obianom, A.O.[2], Dim. C. N.[4], Igboanugo, E.U.[5], Onwuasoanya, U.F.[6], Okereke, F.O[7], Nnadozie, C.H.[1], Agbaugo, C.F.[1], Nwike, M.I.[8] , Nwakoby, N.E[1]. and Ilechukwu, C. C.[9]

1. Department of Microbiology, Faculty of Natural Sciences, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.
2. Department of Applied Microbiology & Brewing, Faculty of Biosciences, Nnamdi Azikiwe University Awka, Nigeria.
3. Department of Biology, University of Agriculture and Environmental Sciences Umuagwo, Imo State.
4. Department of Physiology, Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria.
5. Department of Microbiology, Faculty of Applied and Natural Sciences, Legacy University, Okija, Anambra State, Nigeria
6. Department of Medical Microbiology and Public Health, Faculty of Medical Laboratory Science, NAU
7. Department of Biological Sciences (Microbiology), Spiritan University, Nneochi, Abia State.
8. Department of Biology, Nwafor Orizu College of Education, Nsugbe, Anambra State
9. Department of Biochemistry, Faculty of Natural Science,Chukwuemeka Odumegwu Ojukwu University, Anambra State, Nigeria

Corresponding Author's Email: ik.iheukwumere@coou.edu.ng./ ikpower2007@yahoo.com

ABSTRACT

Vinegar is a widely consumed condiment globally, and its nutritional and physicochemical properties can vary significantly depending on the raw materials. *Phoenix dactylifera* (PD) and Malus sylvestris (MS) fruits are rich in nutrients and bioactive compounds, but there is limited

research on the nutritive and physicochemical properties of vinegar produced from these fruits. This study focused on nutritive and physicochemical properties of vinegar from Date palm and apple fruit extracts.Yeast and acetic acid bacterium were isolated from spoilt fruits and characterized using appropriate microbiological techniques. Vinegar production was carried out using submerged fermentation of must extracted from *Phoenix dactylifera* (PD) and *Malus sylvestris* (MS) fruits. The nutritive and physicochemical composition of the fruit vinegar were determined using gravimetric and instrumental techniques. The data generated from this study were analyzed at 95% confidence level using Analysis of Variance (ANOVA), and post-hoc analysis using Turkey's test. There was also a slight variation in the physicochemical and nutritive parameters of the vinegar produced from MS and PD using *Saccharomyces cerevisiae* strain SR 128 (CS 128) and *Acetobacter aceti* strain WI (AAWI), but this was statistically non-significant ($P > 0.05$). The moisture, ash, protein and fat contents ranges from 98.70 – 99.55%, 0.27 – 1.11%, 0.10 – 0.12% and 0.06 – 0.08% respectively. Therefore, the prepared vinegar samples from MS and PD had physicochemical and nutritive parameters that conformed with the stipulated standard and the sample prepared from PD was slightly better.

Keywords: Physicochemical, Vinegar, *Saccharomyces, Acetobacter, Malus, Phoenix*

INTRODUCTION

Vinegar is a product obtained from the conversion of ethyl alcohol to acetic acid by a genus of bacteria known as *Acetobacter* (Hazzouri *et al.,* 2015). Therefore, vinegar can be produced from any alcoholic material from alcohol-water mixtures to various fruit wines (Jamaludin *et al*., 2016). Its color and aroma are significantly dependent on the material from which it is made. Vinegar is the world's oldest cooking ingredient and food preservative. The predominant type of vinegar in the United States is white or distilled vinegar (Jamaludin *et al*., 2016).

Vinegar has also been described as sour and sharp liquid used as a condiment and food preservative (Henke *et al.,* 2019). Vinegar can also be viewed as an acetic acid produced through fermentation using an ideal substrate of natural origin, which contains starch or sugar as a carbon source, also fit for human consumption (Bhat *et al.,*2014). Some of the substrates used for vinegar production include rice, grapes, malt, apple, honey, potatoes, whey, and other foods that contain sugar, especially sucrose (Tumane *et al.,* 2018). Acetic acid is the essential flavor and antimicrobial component in vinegar (Matthew *et al.,* 2019). The origin of vinegar can barely be differentiated from the origin of wine (Jia *et al.,* 2012). Although vinegar had been numbered among the lowest quality products of fermented foods, it had also been used as a food condiment, as preservative agent, and in some countries as a healthy juice (Cusano *et al*., 2020).

Research had revealed that nutritive composition in vinegar enables most people to develop an interest in its consumption (Arfaoui, 2021). Vinegar produced using date and apple contains calcium, iron, magnesium, selenium, copper, phosphorus, potassium, zinc, sulfur, cobalt, fluorine, manganese, and boron as minerals (Tumane *et al*., 2018). This product is also rich in bioactive compounds; therefore, vinegar has gained industrial value. Another study has demonstrated that date vinegar is good for health in terms of antioxidant properties, cholesterol-lowering, cancer, diabetes and the prevention of cardiovascular diseases due to its phytochemical properties (Cusano *et al.,* 2020).

It is worthy to note that physicochemical characteristics of vinegar are highly essential to the optimum conservation of its nutritive and bioactive compounds (Sengun *et al*.,

2020). The final product of vinegars produced by different methods differs in its profile. In other words, there are various factors influencing the physicochemical and nutritive parameters of the final product of vinegar, such as the raw material, production methods, temperature, pH, conductivity, viscosity, and microorganisms involved in the fermentation process (Sengun *et al*., 2020). In fact, this variability influences its pharmaceutical and medicinal effects (Budak *et al*., 2010). Kim *et al*. (2021) also reported that the effect of vinegar on the human body is related to its phytochemical composition and its concentration.

Several researchers have worked on nutritional and physicochemical properties of vinegar produced from natural sources such as Sengun *et al*. (2020), Arfaoui (2021), and Kim *et al*. (2021), but there are few information on the nutritional sand physicochemical of vinegar produced from date palm and apple extract.. Hence, the aim of this study is to evaluate nutritional sand physicochemical of vinegar produced from date palm and apple extract.

MATERIALS AND METHODS

Isolation and Characterization of Saccharomyces species from Spoilt Fruit Samples

Sample collection

This was carried out using the method described by Iheukwumere *et al*. (2025a). Spoilt *Musa paradisicum* (Banana) and *Citrus aurantium* (orange) fruits were collected from different points in Nkwo Oba market, Idemili South LGA, Anambra State. The fruits were detected through sight and nasal perception; this was followed by carefully and selectively picking of the detected fruits into polyethene bags. The polythene bags were appropriately labeled and transported immediately to the laboratory for further analysis.

Sample preparation

The fruit samples were thoroughly washed using distilled water and their ectocarps were appropriately peeled using stainless chicken knife. The peeled fruits were pulverized using electric blender (SMX425/Japan). This was serially diluted (1:10) using 250 mL conical flask (Pyrex) in the capacity of 10 g of the fruit sample to make up 200 mL of the sample solution. The solution was thorough shaked, stoppered and

kept for further analysis (Iheukwumere *et al*., 2025; Ekesiobi *et al*., 2025a; Ekesiobi *et al*., 2025b; Ekesiobi *et al*., 2025c; Ekesiobi *et al*., 2025d).

Isolation of yeast

This was done using the method described by Iheukwumere *et al*. (2022). The Sabouraud Dextrose Agar (SDA) and Yeast Extract Agar (YEA) were prepared according to the manufacturer's direction. The prepared media were autoclaved at standard conditions (121◦C 15PSI at 15 min). The media were aseptically poured in Petri dishes and allowed to solidify. An aliquot of 0.1 mL of the prepared sample was aseptically spread on the surfaces of the agar poured plates and incubated at an inverted position at 35±2◦C for 24 hours.

Characterization of the yeast

The yeast isolate was characterized morphologically, biochemically, and molecularly using the method described in Cheesbrough (2010) and Iheukwumere *et al*. (2020) Ekesiobi *et al*. (2025e) and Ekesiobi *et al.* (2025f). The yeast isolate was physically examined; the colour, the shape, texture, elevation and the consistency were examined and recorded.

Isolation of Acetic Acid Bacterium from Spoilt Fruit Samples

This was carried out using the method described in Okpalla *et al*. (2012), Glucose-Yeast Extract Calcium Carbonate (GYC) agar prepared from glucose (10%), CaCO3 (2%) and agar (1.5%). The re-constituted medium was autoclaved at standard conditions (121◦C, 15 PSI at 115 min). The medium was aseptically distributed into different Petri dishes and allowed to solidify. An aliquot of 0.1 mL of the prepared sample from the spoilt fruits was aseptically spread on the surfaces of the prepared agar medium and these were incubated on inverted position at room temperature (30±2◦C) for 48 h. Colonies with large clear zones around them were subcultured.

Characterization of the Bacterial Isolate

The pure isolates will be characterized using the morphological, biochemical and molecular characteristics as described by Iheukwumere *et al.* (2018a). The cultural descriptions (size, appearance, edge, elevation, colour) of the isolates will be carried out as described in Iheukwumere *et al*. (2018b). The Gram staining t

echnique which revealed the Gram reaction, cell morphology and cell arrangement will also be carried out using the procedure described by Cheesbrough (2010), Iheukwumere *et al*. (2018c). The presence or absence of capsule will also be carried out as described by Iheukwumere *et al*. (2018d). The presence or absence of flagellum will be determined by carrying out motility test as described by Cheesbrough (2010). The capability of the isolates to produce catalase, indole, oxidase, acetoin, grow in 6.55 % NaCl and to utilize sugars, sugar alcohols and other substances (ribose, sorbitol, arabinose, sacharose, glucose trehalose, lactose, starch, inulin, salicin, hiparate) and also the haemolytic activity of the isolates were done using the methods described by Cheesbrough (2010) and Iheukwumere *et al*. (2018b). The molecular characterization involved DNA extraction, authentication, amplification and sequencing of the amplicons (Iheukwumere *et al*., 2018a)

Vinegar Production

Collection and preparation of fruit samples for production of vinegar

Phoenix dactylifera (commonly known as Date) and *Malus sylvestris* (commonly known as English Apple) fruits were bought from Eke Awka Market, Anambra State. The fruit samples were thoroughly washed using distilled water and their ectocarps were thoroughly peeled. These were separately pulverized using electric blender (SMX 425/Japan). The pulverized fruits were extracted using distilled water. The solutions were then filtered using muslin cloth.

Production of alcohol

Here, 400 mL of the fruit extract was dispensed each into 500 mL conical flask (Pyrex). The extracts were sterilized using an Autoclave at standard conditions (121◦C, 15 PSI at 115 min). The sterilized extracts were allowed to cool. The extracts were each inoculated *Saccharomyces cerevisiae* strain and allowed for 28 days with manually daily shaking at 30±2◦C. After the fermentation, the alcohol was decanted and poured into sterile 2000 mL bottle and allowed open for 2 days.

Alcohol tolerance test

The ability of the acetic acid bacterium to grow in the presence of alcohol was carried out using the method described in the study published by Tharinee *et al*. (2015). The tested isolate was grown in yeast extract agar (0.50% yeast extract, 2% agar) supplemented with 2%, 4%,

6%, 8%, and 10% (v/v) absolute ethanol. The above procedure was then modified by growing the isolate in Glucose-Yeast Extract Calcium Carbonate (GYC) broth/agar supplemented with 2%, 4%, 6%, 8%, and 10% (v/v) absolute ethanol.

Vinegar production

The colonies of *Acetobacter aceti* strain was aseptically transferred into the container containing the alcohol. The bottles were thereafter covered with sac cloth to prevent the entry of insect. The set-up was allowed for 28 days at room temperature (30±2◦C.). At the end of the fermentation period, a thick film known as mother of vinegar had covered the surface of the vinegar and was carefully scooped out to avoid contamination. The vinegar was thereafter filtered.

Determination of Physicochemical Parameters of the Vinegar

The Physical parameters determined were pH, temperature, acidity, total solid, total dissolved solid, and total suspended solid.

Determination of pH: The pH of the water samples was determined using a pH meter (PHS-3CU/Mainland, China). The pH meter was first standardized using a phosphate buffer to pH value of 4.0 and 7.0. After that, the electrode was dipped into the sample contained in a beaker and the pH value was taken. This was done in triplicate as described by AOAC (2019).

Total Solid in the Sample: This was carried out using the method of AOAC (2019).The weight of crucible was taken and recorded, and a known amount of the sample was measured into the crucible, and the weight was also measured and recorded. The crucible and its content were heated in an oven at 105^0C to dryness. The total solid was determined as follows:

$$\text{Total Solid (Mg/L)} = \frac{\text{Weight Crucible + Dried Sample – Weight of empty crucible}}{\text{Volume of sample used}} \times 100$$

Total Dissolved Solid (TDS) of the Sample: This was carried out using TDS meter in Mg/L. The sample (100 ml) was measured into 200 ml beaker. A Digital TDS meter was powered and allowed for 30 minutes and the probe was carefully inserted to take the measurement of the TDS of each of the samples. This was done in triplicate (A0AC, 2019).

Total suspended solids (TSS) determination: The method of AOAC (2019) was used. The total suspended solids were determined by subtracting the result of total dissolved solids from total solid as follows:

Total solids (TS) – Total dissolved solids (TDS) = Total Suspended solids (TSS)

Determination of acidity

This was carried out using the method of AOAC (2019). Prepared vinegar sample (10 mL) was added into cleaned and dried 250 mL conical flask (Pyrex). This was titrated with 0.1N standard sodium hydroxide (NaOH) solution using phenolphthalein as an indicator. The titrated volume was observed as soon as the solution turned light purple (end point) and the acidity of the sample was calculated as follows:

$$\text{Acidity (w/v\%)} = \frac{\text{Titre X Factor}}{\text{Volume of Sample}} \times 100$$

Factor=0.006005 (for acetic acid)

Determination of alcohol content

The alcohol content of prepared vinegar was determined using Alcoholmeter at room temperature (30±2◦C) as described in the study published by Khlin and Thwe (2016).

Specific gravity

The specific gravity of the sample was determined using 25 mL density bottle (S-Pyrex) at 20◦C. The ratio of the weights of equal volume of the sample and water was determined and matched the respective values with specific gravity chart (AOAC, 2019).

Total sugar content

Vinegar samples were first hydrolyzed with HCl at 100◦C for 30 min, and then neutralized with NaOH. The solution was further diluted with water.

Then 3 mL of 3,5 – dinitrosalicyclic acid (DNSA) was added into 1 mL of the hydrolyzed samples or standard glucose solution (0 – 2.0 mg/mL), respectively and heated at 100◦C in water bath for 5 min. After cooling, 10 mL of water was added to the reaction solution and absorbance was measured at 540 nm using UV/visible spectrophotometer (UV – 6100/ China). Total sugar content was quantified by extrapolating the absorbance value from the standard glucose curve (AOAC, 2019).

Viscosity

Here, 100 mL of the sample was measured into 250 mL beaker (S – Pyrex). A selected spindle in Viscometer was then used to read the viscosity of the sample at 25◦C (AOAC, 2019)

Nutritional Constituents

Moisture content: A crucible was dried and cooled, then initial weight of the crucible was taken as W_1, 10 mL of the sample was transferred into the crucible and the weight of the crucible was taken W_2 .The crucible and its content were then heated in an oven at 105^{o}C for 4-6 h. After which the final weight of the crucible and its content were taken as W_3. Then the percentage moisture content was calculated as follows:

$$\% \text{ moisture content} = \frac{W2 - W3}{W2 - W1} \times \frac{100}{1}$$

Ash Content: A crucible was dried and cooled, then initial weight of the crucible was taken as W_1, 10 mL of the sample was transferred into the crucible and the weight of the crucible was taken W_2 .The crucible and its content were then heated in a furnace at 550^{o}C for 3-5 h until the content became gray in colour, after which the crucible was removed and allowed to cool. The final weight of the crucible and its content was taken after drying/ashing as W_3. The percentage ash content was then calculated as follows:

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Fat content: A soxhlet extractor was used, the soxhlet flask was dried in an oven at 105^{o}C and allowed to cool, after which the weight of the flask was taken as W_1. Then 10 mL of the sample was taken as W_2 and transferred into the thimble of the extractor, the sample was extracted using 250 ml of hexane for 4-5 h. After 5 h the chaff was emptied properly for the determination of the fibre content and all the solvent were recovered. The flask that contains all the extract were dried in an oven at 105^{O}C until all the water have been evaporated leaving the oil only, the weight of the flask and oil content was taken as W_3.The percentage fat was calculated as follows:

$$\% \text{ Fat} = \frac{W_3 - W_1}{W_2} \times \frac{100}{1}$$

Fiber content: The residue was then transferred into a beaker and boiled for another 30 minutes with 200 mL of dilute sodium hydroxide solution and filtered, transferred into an ignited crucible.

The residue was then washed 3 times with 20ml ethanol and 2 times with 10 mL petroleum ether. The residue was dried in an oven and cooled, then weighed (w_2). The dried residue was transferred into a furnace and ignited, cooled and weighed (w_3).

Calculation

$$\text{Percentage Crude Fibre} = \frac{w_2 - w_3}{w_1} \, x \, \frac{100}{1}$$

Protein

A 1.0 mL of the sample was weight and transferred into a digestible flask, 20 mL of sulphuric acid and 0.5g of selenium powder (catalyst) were added, this mixture were heated in a fume cardboard for about 7 h (i.e until a clear or colourless solution is seen). The sample generated was diluted (1:4 dilution was carried out), 5ml of the diluted sample was collected into a distillation flask and 5ml of 40% NaOH was added, then 10 mL of 10 % boric acid was put inside a conical flask, 5 drops of bromocresol green and 1drop of methyl red was also added and was properly mixed. The conical flask was placed under the tip of the condenser and the distillation started, 50 drops of the distillate was allowed to enter into the conical and then the color of

the solution was turned blue. A burette was filled with 0.01 HCl and titrated against the content of the flask until the colour was changed to wine red, the titrate value was taken

% Nitrogen = titre x molarity of acid used (0.01M) x atomic mass of nitrogen x DF

Statistical Analysis

The data generated from this study were analyzed at 95% confidence level using Analysis of Variance (ANOVA), and post-hoc analysis using Turkey's test (Iheukwumere *et al*., 2022a; Ekesiobi *et al*., 2025g; Iheukwumere *et al*., 2025a; Iheukwumere *et al*., 2025b; Iheukwumere *et al*., 2025c; Iheukwumere *et al*., 2025d; Iheukwumere *et al*., 2025e).

RESULTS

Characterization of the Yeast Isolate and Acetic Acid Bacteria Strains

The yeast isolate (XI) showed characteristic features of yeast such as cream white colonies on Sabouraud Dextrose Agar (SDA) plate, smooth surface, spherical morphology and utilization of glucose and sucrose. The yeast was also resistant to cycloheximides as shown in Table. The acetic acid bacterium (AI) showed cream to yellow colonies on glucose yeast extract calcium carbonate agar (GYA). The isolate was also Gram negative rod, motile, catalase, methyl red and Voges Prokauer positive, but indole, oxidase and citrate negative as shown in Table 2. The quality and nature of the extracted nucleic acid revealed 260/280. Hence, Deoxyribonucleic acid (DNA) as shown in Table 3. The molecular identities of the isolates revealed 100% query cover and 100% identities. This revealed that sample 1D AI was *Acetobacter aceti* strain WI (AAWI) whereas sample ID XI was *Saccharomyces cerevisae* strain Ysr128 (SC 128) as shown in Table 4

Alcohol Tolerance Potential of the Test Isolate

The study revealed that the test isolate was able to grow in the presence of 10% absolute alcohol. There was significant ($P < 0.05$) number of colonies of acetic acid bacteria in 10% absolute alcohol level in both yeast extract agar (YEA) and glucose-Yeast extract calcium carbonate agar (GYA). The number of colonies slightly decreased as the concentration of alcohol increased as shown in Table 5 but the decrease was statistically non-significant ($P > 0.05$).

Physicochemical Properties of the Vinegars

The study revealed that the studied vinegars had varying pH, total soluble solid (TSS), acidity and total sugar content. There was no alcohol detected in the three samples. The specific gravities and their viscosities were slightly similar. Sample VA recorded the highest values pH, TSS, and acidity but these variations were statistically non-significant ($P > 0.05$) except the level of acidity that showed significant difference ($P < 0.05$) when compared to that of sample VD. The study also revealed that total sugar content was non-significantly ($P > 0.05$) detected

most in sample VD but least in sample VA (Table 8).

Nutritional Constituents of the Vinegar

The study revealed that fibre and carbohydrate were not detected in the vinegar samples as shown in Table 9. There were presence of fat, proteins, and ash, and these occurred in very low amount. The ash and fat contents were slightly detected most in sample VA but this variation was statistically ($P > 0.05$). The major component of this sample was mainly moisture, and this was slightly and non-significantly ($P > 0.05$) detected most in sample VD.

Table 1: Morphological and biochemical characteristics of the yeast isolates

Parameter	X1	X2
Appearance on GYA	Cream white colonies	Cream white colonies
Surface	Smooth	Smooth
Margin	Circular	Circular
Elevation	Convex	Convex
Shape	Spherical	Spherical
Bud	Present	Present
Ascospore	Present	Present
Glucose	+	+
Sucrose	+	+
Maltose	+	+
Gelactose	+	+
Raffinose	+	+
Mannitol	_	_
Lactose	_	_
Xylose	_	_
Cyclohexide	Resistance	Resistance
Suspected yeast	Saccharomyces cerevisae	Saccharomyces cerevisae

Table 2: Morphological and biochemical characteristics of the acetic acid bacterium

Parameter	A1	A2
Appearance on GYA	Cream to yellow colour	Cream to yellow colour
Surface	Smooth	Smooth
Elevation	Convex	Convex
Opacity	Opaque	Opaque
Shape	Rod	Rod
Arrangement	Clustered	Clustered
Gram Reaction	_	_
Motility	+	+
Indole	_	_
Citrate	_	_
Catalase	+	+
Methyl red	+	+
Voges Proskauer	+	+
Oxidase	__	__
Glucose	+	+
Sucrose	+	+
Mannitol	+	+
Bacterium	*Acetobacter* species	*Acetobacter* species

Table 3: Quality and nature of the extracted nucleic acid

Sample ID	Nucleic acid(μg/mL)	260 nm	280 nm	260/280
A1	120.20	3.412	1.875	1.82
X1	102.10	3.104	1.687	1.84

Table 4: Molecular identities of the isolates

Parameter	A1	X1
Max Score	2676	6205
Total Score	2676	6604
Query Cover (%)	100	100
E-Value	0.0	0.0
Identity (%)	100	100
Accession Length	1449	224595
Accession Number	1ICC662508.1	CP036471.1
Description	*Acetobacter aceti* strain W2 (AAW1) 16S rRNA gene partial sequence	*Saccharomyces cerevisiae* strain Ysr128 (SC128) chromosome 1, complement sequence

Table 5: Alcohol tolerance of the test isolate

Alcoholic Content (%)	Yeast Extract Agar		Glucose-Yeast Extract Calcium Carbonate	
	Count (CFU/mL)	Log CFU/mL	Count (CFU/m)L	Log CFU/mL
2.0	$5.10X10^2$	2.71	$6.40X10^2$	2.81
4.0	$4.70X10^2$	2.67	$6.10X10^2$	2.79
6.0	$4.30X10^2$	2.63	$5.70X10^2$	2.76
8.0	$4.10X10^2$	2.61	$5.40X10^2$	2.73
10.0	$3.80X10^2$	2.58	$5.10X10^2$	2.71

Table 8: Physicochemical properties of the prepared vinegars

Parameter	VA	VD	VS
pH	3.10±0.00	2.70±0.00	3.05±0.00
TSS(%)	4.96±0.11	4.20±0.14	4.05±0.00
Acidity (%)	4.15±0.01	1.80±0.01	2.34±0.00
Alcohol Content (%)	0.00±0.00	0.00±0.00	0.00±0.00
Specific gravity	1.014±0.001	1.011±0.001	1.014±0.00
Total Sugar (%)	9.20±0.14	13.21±0.41	10.80±0.00
Viscosity(cSt)	2.20±0.00	2.40±0.00	2.10±0.00

VA=Vinegar from Apple; VD= Vinegar from Dates; VS= Vinegar from supermarket

Table 9: Nutritional constituents of the vinegars

Parameter	VA	VD	VS
Moisture (%)	98.70±1.89	99.55±1.92	99.54±1.86
Ash (%)	1.11±0.01	0.31±0.01	0.27±0.01
Protein (%)	0.11±0.00	0.11±0.00	0.12±0.00
Fat (%)	0.08±0.00	0.06±0.00	0.07±0.00
Fibre (%)	0.00±0.00	0.00±0.00	0.00±0.00
Carbohydrate (%)	0.00±0.00	0.00±0.00	0.00±0.00

VA=Vinegar from Apple; VD= Vinegar from Dates; VS= Vinegar from supermarket

DISCUSSION

The presence of *Saccharomyces cerevisiae* strain Ysr128 (SC 128) from the spoilt banana samples corroborated with the findings of Jayamma *et al*. (2022). The characteristic features of the yeast isolate such as cream white appearance on Sabouraud Dextrose Agar (SDA), resistant to cycloheximide, utilization of sugars were also reported by many researchers (Amanul *et al.,* 2017; Kechkar *et al*., 2019; Kumari *et al*., 2019; Jayamma *et al.,* 2022; Petruzziello *et al*., 2023). The presence of *Acetobacter aceti* strain w1 (AAWI) in banana juice supported the findings of Srivastava and Rani (2019) and Wang *et al*. (2022). The characteristic features of *Acetobacter* revealed in this study corroborated with the findings of Afrifuzzaman *et al.* (2018), Quattara *et al*. (2018), Srivastara and Rani (2019) and Wang *et al*. (2022).

Vinegar is a liquid fermented product that contains fruits juice as the main ingredients which contain many functional compounds such as organic acids, vitamins, minerals, amino acids and phytochemicals such as phenolics, flavonoids, tannins and other phytochemicals. Similar reported was stated by Hamidalu (2014). In the present study, the production of vinegar from Malus sylvestris (green apple) and Phoenix dactylifera (date) agree with the findings of Kechka *et al*. (2019). Other researchers (Quattera *et al*., 2018; Srivastara and Rani, 2019; Wang *et al*., 2022; Safrida *et al*., 2023) produce vinegar from various plants. The maximum acetic acid using green apple agrees with water Klawplyapamornkun *et al*. (2015) and Quattara *et al*. (2018) produced from fruits and mango juice, respectively. Vinegar produced from date fruits gave 5.2% of acetic acid and this was more than acetic acid produced from many other fruits.

The physicochemical parameters of the prepared vinegar samples correlated with the findings of other researchers (Morhtar *et al.,* 2016; Sengun *et al*., 2020). The pH and specific gravities of the vinegar samples agree with the apple cidar and Nipa vinegars analyzed in the study published by Morhtar *et al.* (2016) but disagree with the findings of Akarca *et al*. (2020). The low pH and acidity reported in the vinegar produced from *P. dactylifera* could be attributed to high content of sugar present in juice sample.

The detection of moisture, ash, protein and fat in the vinegar samples supported the findings of Morhtar *et al*. (2016).

The absence of carbohydrate in the vinegar samples pointed the fact that most carbohydrates have been converted to sugar during the fermentation process, and these were converted to ethanol that later formed the acetic acid.

CONCLUSION

The study has shown that the prepared vinegar samples from *Malus sylvestris* (MS/Apple) and *Phoenix dactylifera* (PD/Date) fruits had physicochemical and nutritive parameters that conformed with the stipulated standard, the sample prepared from PD was slightly better.

Acknowledgment : We are grateful to all our study participants who join the study voluntarily. We are grateful to ZAHARM Analytical and Research Laboratory, Amawbia, Awka Anambra State, Nigeria for providing enabling environment, resources and techniques for this study. We really salute their wonderful efforts.

Conflict of interests: The authors declare that they have no conflict of interests.

Funding: This research did not receive specific grant from any funding agencies.

Ethical approval: Not applicable

Authors Contributions: All contributed towards the study design, experiment execution, data analysis, and manuscript drafting.

Availability of Data and Materials: All datasets analyzed and described during the present study are available from the corresponding author upon reasonable request.

REFERENCES

ara, G., Tomar, O., Caglar, A. and Istek, O. (2020). Physicochemicl and sensory quality properties of vinegar produced by traditional method from Persian Mazafati date (*Phoenix dactylifera*). *European Journal of Science and Technology* 19: 429 – 434

nul, N., Shafkat, S.R., Mdmahboob, H. and Naiyyum, C. (2017). Isolation of *Saccharomyces cerevisiae* from pineapple and orange and study of metal's effectiveness of ethanol

production. *European Journal of Microbiology and Immunology* 7(1): 76 – 91

Arfaoui, L. (2021). Dietary plant polyphenols: Effects of food processing on their content and bioavailability. *Molecules* 26: 29 – 59

Arifuzzaman, M., Hasan, M.Z., Rahman, S.M.B. and Pramanik, M.K. (2014). Isolation and characterizxation of *Acetobacter* and *Gluonobacter* spp. from sugarcane and rotten fruits. *Biosciences* 8(9): 359 – 365

Association of official Analytical chemist (AOAC) (2019). Official methods of Association of official Analytical Chemist (AOAC): Official methods of Analysis of AOAC International, 21st Edition. AOAC, Washington DC, PP.121-130.

Bhat, S. V., Akhtar, R. and Amin, T. (2014). An overview on the biological production of vinegar. *International Journal of Fermented Foods* 3(2):139.

Budak, H.N. and Guzel-Seydim, Z.B. (2010). Antioxidant activity and phenolic content of wine vinegars produced by two different techniques. *Journal of Science, Food, and Agriculture* 90: 2021–2026.

esbrough, M. (2010). District Laboratory Practice in Tropical Countries, Part 1, Second Edition. Cambridge University Press, Cambridge, pp. 333−361.

sano, E., Cagliani, L.R., Consonni, R., Simonato, B. and Zapparoli, G. (2020). NMR-based metabolic profiling of different yeast fermented apple juices. *International Journal of Food Microbiology* 118: 108 – 171.

Ekesiobi, A. O., Iheukwumere, C. M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025a). Hyping the Inhibitory Activity of Xylopia aethiopica against Vibrio cholerae using Azithromycin. IPS Journal of Basic and Clinical Medicine, 2(3), 93–98. https://doi.org/10.54117/ijbcm.v2i3.16

Ekesiobi, A. O., Iheukwumere, C. M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025b). Natural Product-Based Therapies: Exploring the Potential of Ocimum gratissimum and Vitamin C Combination against Vibrio cholerae Infections. IPS Interdisciplinary Journal of Biological Sciences, 4(3), 119–124. https://doi.org/10.54117/iijbs.v4i3.64.

Ekesiobi, A. O., Iheukwumere, C. M**.,** **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Dim, C. N., Okereke, F. O., & Ochibulu, S. C. (2025c). Soil Bacterial Dynamics: Assessing the Effects of Urine on Lipolytic and Cellulytic Bacteria. IPS Journal of Advanced and Applied Biochemistry, 1(2), 34–37. https://doi.org/10.54117/ijaab.v1i2.66

Ekesiobi, A. O., Iheukwumere, C. M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., … Dim, C. N. (2025d). Public Health Implications of Shigella Contamination in Borehole Water Sources in Uli Community. IPS Journal of Public Health, 5(3), 265–269. https://doi.org/10.54117/ijph.v5i3.48.

Ekesiobi, A. O., Iheukwumere, C. M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., Ochibulu, S. C., & Agbaugo, C. F. (2025e). Upshot of Urine on Beneficial Soil Bacteria. Journal of Pollution Monitoring, Evaluation Studies and Control, 4(2), 100–103. https://doi.org/10.54117/jpmesc.v4i2.18

Ekesiobi, A. O., Iheukwumere, C. M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C.C., Ike, V. E., Ikejiaku, C. C., Okereke, F. O., & Ochibulu, S. C. (2025f). Cross-Sectional Study of Salmonella Species among Ready-To-Eat Fruit Salads. Journal of Pollution Monitoring, Evaluation Studies and Control, 4(2), 104–109. https://doi.org/10.54117/jpmesc.v4i2.19.

Ekesiobi, A. O., Iheukwumere, C.M., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025g). Combination Therapy: Investigating the Combined Effects of Zingiber officinale and Azithromycin against Vibrio cholerae. IPS Journal of Drug Discovery Research and Reviews, 3(2), 44–50. https://doi.org/10.54117/ijddrr.v3i2.34.

nidatun, H., Mandasavi, O.K., Rosdiana, I. and Widiyana, S.D. (2014). Effect of salak vinegar on blood glucose reduction and pancreas histopathology of diabetic rats. National student scientific week of research-student creativity program, 2014, Indonesian Ministry of Research, Technology and Higher Education pp 14 – 24

zzouri, K.M., Flowers, J.M., Visser, H.J., Khierallah, H.S., Rosas, U., Pham, G.M., Meyer, R.S., Johansen, C.K., Fresquez, Z.A., Masmoudi, K., Haider, N., El Kadri, N., Idaghdour, Y., Malek, J.A.,

Thirkhill, D., Markhand, G.S., Krueger, R.R., Zaid, A., Jin, Q., Qureshi, N., Wang, H. and Huang, H. (2019). Acetone-butanol-ethanol (ABE) fermentation of soluble and hydrolyzed sugars in apple pomace by *Clostridium beijerinckii Journal of Food Microbiology* 244: 536 – 544.

Henke, J., Rasane, P., Kaur, S. and Kumbhar, P. (2019). Vinegar: a traditional functional food. *Think India Journal* 22(34):581 – 629.

Iheukwumere, C. M., Umeaku, C. N., Chukwura, E. N., & Iheukwumere, I. H. (2022). Characterization of the indigenous fermenters for the production of fermented condiments from soybean seeds. *World Journal of Advanced Research and Reviews*, *14*(2), 423-434.

Iheukwumere, I. H., Dimejesi, S. A., Iheukwumere, C. M., Chude, C. O., Nwaolisa, C. N., Ukoha, C. C., Nwakoby, N. E., Egbuna, C., and Egbe, P. A. (2020). Diversity and molecular characterization of keratinophilic fungi from different soil samples. *International Journal of Research Publications*, 50(1), 1–17.

Iheukwumere, I. H., Iheukwumere, C. M., Obiefuna, O. H., Unaeze, B. C., Nwike, M. I., Obianom, A. O., ... & Nwakoby, N. E. (2025a). Mycological Medium for the Production of Antibiotics against Urogenital Bacterial Pathogens from Natural Sources. *Journal of Pharmaceutical Research International*, *37*(3), 79-93.

ukwumere, I. H., Iheukwumere, C. M., Obiefuna, O. H., Unaeze, B. C., Nwike, M. I., Obianom, A. O., ... & Nwakoby, N. E. (2025). Structural Elucidation of Some Antibiotics against Wound Bacterial Pathogens from Penicillium Species Using Agrowastes. *Journal of Pharmaceutical Research International*, *37*(3), 102-114.

ukwumere, I.H., Olusola, T.O. and Chude, C. (2018a). Molecular characterization and diversity of enteric bacteria isolated from chicken feeds. *Journal of Natural Sciences Research* **8**: 21–33

ukwumere, I.H., Amadi, E.R. and Chude, C. (2018d). Synergistic effects of probiotics and antogenous bacterin against inositol negative motile Salmonella Species. *Journal of Biology, Agriculture and Healthcare* **9**: 37–49.

ukwumere, I.H., Chude, C. and Unaeze, B.C. (2018b). Toxicological study and antibacterial activities of effectively validated medicinal plants against enteric bacteria isolated from chicken feeds. *Journal of Health, Medicine and Nursing* **7**: 19–34.

Iheukwumere, I.H., Chukwura, E.I. and Chude, C. (2018c). *In vivo* activities of some selected antimicrobial agents against enteric bacteria isolated from chicken feeds on broiler layers. *Journal of Biology, Agriculture and Healthcare* **9**: 21–36.

Iheukwumere, I. H., Opara , G. R., Iheukwumere, M. C., Okafor, . C. F., & Nwakoby, N. E. (2022a). Prophylactic Potential of Essential Cream Produced from Chromolaena odorata Leaf Extract against Cladophialophora bantiana Strain D12E. *IPS Journal of Applied Microbiology and Biotechnology*, *1*(1), 1–11.

Iheukwumere, C. M., Ekesiobi, A. O., **Iheukwumere, I. H**., Okoli, U. O., Dim, C. N., Ejike, C. E., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., Nwankwo, A. K., & Ochibulu, S. C. (2025a). Bacteriological Study of Urine Samples from Obstetric Patients in Onitsha Metropolis: Public Health Implications. IPS Journal of Basic and Clinical Medicine, 2(3), 99–107.https://doi.org/10.54117/ijbcm.v2i3.17

Iheukwumere, C. M., Ekesiobi, A. O., **Iheukwumere, I. H**., Okoli, U. O., Ejike, C. E., Dim, C. N., Ilechukwu, C. C., Ike, V. E., Okereke, F. O., Nwankwo, A. K. ., & Ochibulu, S. C. (2025b). Waterborne Pathogen Research: Examining Shigella species in Fish Ponds of Uli Community. IPS Interdisciplinary Journal of Biological Sciences, 4(3), 125–129. https://doi.org/10.54117/iijbs.v4i3.65

Iheukwumere, C. M., Ekesiobi, A. O., **Iheukwumere, I. H**., Okoli, U. O., Ejike, C. E., Ilechukwu, C. C., … Ochibulu, S. C. (2025c). Public Health Risk of Vibrio cholerae Contamination in Streams of Uli Community. IPS Journal of Public Health, 5(3), 270–275. https://doi.org/10.54117/ijph.v5i3.49.

Iheukwumere, C. M., Ekesiobi, A. O., **Iheukwumere, I. H**., Ejike, C. E., Ilechukwu, C. C., Dim, C. N., & Ochibulu, S. C. (2025d). Dual Approach Therapy: Assessing Xylopia aethiopica and Ciprofloxacin Synergy against Salmonella enterica Serovar Typhi. IPS Intelligentsia Multidisciplinary Journal, 4(1), 27–31.

Iheukwumere, C. M., Ekesiobi, A. O., **Iheukwumere, I. H.**, Ejike, C. E., Ilechukwu, C. C., Dim, C. N., Ochibulu, S. C., Unegbu, C. C., & Egbuna, C. (2025e). Food Safety Implications: Assessing the Potential of Desmodium velutinum Leaves Extracts to Control the Most Predominant Fungal Contamination

in Ready-To-Eat Fried Chicken. IPS Journal of Nutrition and Food Science, 4(3), 494–500.

Jamaludin, M.A., Hashim, D.M., Rahman, R.A., Ramli, M.A., Majid, M.Z.A., Othman, R. and Amin, A. (2016). Determination of permissible alcohol and vinegar in Shariah and scientific perspectives. *International Food Research Journal* 23(6):2737 – 2743.

Jayamma, P., Shirnalli, G.G., Goudar, D.G. and Olekar, S.N. (2022). Isolation and identification of thermotolerant yeast isolates from different fruit wastes. *The pharma Innovation Journal* 11 (i): 855 – 859

Jia, J., Wuc,Y., Kun, M., Fen, F., Zhangc, F. and Sheng, C. (2012), Biodiversity of yeasts, lactic acid bacteria and acetic acid bacteria in the fermentation of "Shanxi aged vinegar", a traditional Chinese vinegar. *Journal of Food Microbiology* 30: 289 – 297.

Kechkar, M., Sayed, W., Cabrol, A., Aziza, M., Zaid, T.A., Amrane, A. and Djelal, H. (2019). Isolation and identification of yeast strains from sugarcane molasses, dates, and figs for ethanol production under conditions stimulating algal hydrolysate. Brazilian Journal of Chemical Engineering 36(1): 157 – 169

m, E.-J.; Cho, K.-M.; Kwon, S.J.; Seo, S.-H.; Park, S.-E.; Son, H.-S. (2021). Factors affecting Vinegar metabolites during two-stage fermentation through metabolomics study. *LWT* 135: 110 – 118

wplyapamornkun, T., Bovnsombut, S. and Bovonsoombut, S. (2015). Isolation and characterization of acetic acid bacteria from from fruits and femented fruit juice for vinegar production. Food and Applied Bioscience Journal 3(1): 30 – 38

nari, S., Jha, A.K. and Singh, A.K. (2019). Isolation and characterization of temperature and ethanol tolerant strain of Saccharomyces cerevisiae strains from naturally fermented juices. Biosciences Biotechnology Research Asia 16 (1): 97 – 103

thew, B., Agrawal, S., Nashikkar, N., Bundale, S. and Upadhyay, A. (2019). Isolation of Acetic Acid Bacteria and preparation of starter culture for Apple cider vinegar fermentation. Advances in microbiological, chemical composition and sensory analysis. *Food Research International Journal* 48: 634 – 640.

khtar, S.I., Zakaria, F., Mohammad, A.A., Soon, S.W., Nuvshahida, A.S. and Latiff, Z.A.A. (2016).Stud6y on the nutritional values and customer acceptance of

Lansium domesticum and Nephelium lappaceum Newly fermented natural fruit vinegars in Malaysia. Asian Pacific Journal of Advanced Business and Social Studies 2(2): 404 – 413

Okpalla,J., Ubajekwe, C.C., Agu, K.C. and Iheukwumere, I. (2012). Biochemical changes of melon seeds (*Citrullus vulgaris*) fermented by pure cultures of *Bacillus licheniformis. International Journal of Agriculture and Biosciences* **1**(1): 42 – 45.

Ouattara, A., Somda, K.M., Ouattara, A.T.S., Traore, S.A. and Ouattara, S.A. (2018). Production of acetic acid by acetic acid bacteria using mango juice. International Journal of Biological and Chemical Sciences 12(5): 2309 – 2317

Petruzziello, E., Blaiotta, G., Pittari, E., Piombino, P. and Aponte, M. (2023). Isolation and characterization of cyotolerant yeast from Fianodi Avelliono grapes fermented at low temperatures. Foods 12 (3): 526 – 537

Safrida, F.A.U., Gholib, M.M., Raissya, A., Yelly, A.P. and Nadila, F. (2023). Phytochemicalcharacterization and sensory evaluation of vinegar from Melastoma malabathricum flower with variation in starter concentration and fermentation time. Journal of Panelitian Pendidikan 9(2): 706 – 713

ıgun, I.Y., Kilic, G. and Ozturk, B. (2020). Screening Physicochemical, Microbiological and Bioactive Properties of Fruit Vinegars Produced from Various Raw Materials. *Food Science Biotechnology* 29: 401–408

/astava, V. and Rani, R. (2019). Isolation and characterization of acetoacetic bacteria from decomposed fruits. *Journal of Biological, Chemistry and Chron* 5(1): 123 – 129

ırinee, K., Sakunne, B. and Sittisin, B.(2015). Isolation and characterization of acetic acidbacteria from fruits and fermented fruit juices for vinegar production. *Food and Applied Bioscience Journal* 3(1): 30-38.

nane, P. M., Sarkar, S., Wasnik, D.D. and Kolte, N. A. (2018). Production of vinegar frompineapple peels using *Acetobacter* species isolated from soil sample and its antibacterial activity. *International Journal of Life Sciences* 6(4):948 – 956.

ng, B., Rutherfurd-Markwick, K., Zhang, X. and Mutukumira, A.N. (2022). Isolation and characterization of dominant acetic acid bacteria and yeast isolated from Kombucha samples at point of sale in New Zealand. *Current Research in Food Science* 5: 835 – 844