

Comparative Study of Physicochemical and Nutritional Properties of Vinegar Produced From Date Palm and Cherry Fruits

Abba, O.¹, Iheukwumere, I. H.², Iheukwumere, C. M.³, Ike, V. E.⁴, Ezendianefo, J. N.⁵ and Okongwu, D. J.⁶

¹Department of Microbiology, Federal University of Gusau, Zamfara State.

²Department of Microbiology, Faculty of Natural Sciences, Chukwuemeka Odumegwu Ojukwu University, Uli, Campus, Anambra State, Nigeria.

³Department of Applied Microbiology and Brewing, Faculty of Biosciences, Nnamdi Azikiwe University, Awka, Nigeria.

⁴Department of Microbiology, University of Agriculture and Environmental Sciences, Umuagwo, Imo State, Nigeria.

⁵Department of Microbiology, Tansian University, Umuanya, Anambra State, Nigeria.

⁶Department of Chemistry, Nwafor Orizu College of Education, Nsugbe.

*Corresponding author email: oluchiipan@fufusau.edu.ng / ik.iheukwumere@coou.edu.ng

ABSTRACT

Vinegar is a globally consumed condiment whose final quality is intrinsically linked to its raw material. The physicochemical and nutritional profiles of vinegars derived from many fruits remain insufficiently documented, particularly for underutilized yet nutritionally dense substrates such as *Phoenix dactylifera* (date palm) and *Prunus avium* (cherry). Given the distinct compositional matrices of these fruits, characterized by differing sugar profiles, organic acid contents, and phenolic compounds, this study aimed to conduct a comparative analysis of the quality and composition of vinegar produced from their extracts. Yeast (*Saccharomyces cerevisiae* strain SR 128) and acetic acid bacteria (*Acetobacter aceti* strain WI) were isolated from spoiled fruits and utilized to ferment the respective fruit musts via submerged fermentation. Standard gravimetric and instrumental methods were employed to analyze key physicochemical and proximate nutritional parameters. Data were analyzed using Analysis of Variance (ANOVA) followed by Tukey's post-hoc test at a 95% confidence level. Results showed only slight variations in measured parameters between the two vinegars, which were statistically non-significant ($p > 0.05$). The compositional ranges were: moisture (98.70–99.55%), ash (0.27–1.11%), protein (0.10–0.12%), and fat (0.06–0.08%). All parameters for both samples conformed to established quality standards. Therefore, the prepared vinegar samples from PA 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*

How to cite this article: Abba, O., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Ezendianefo, J. N., & Okongwu, D. J. (2026). Comparative study of physicochemical and nutritional properties of vinegar produced from date palm and cherry fruits. *International Journal of Global Trends and Research*, 3(1), 90–102. <https://doi.org/10.54117/0zpwqa65>

INTRODUCTION

Vinegar is a globally consumed fermented product traditionally produced through the microbial oxidation of ethanol to acetic acid, primarily facilitated by acetic acid bacteria of the genera *Acetobacter* and *Komagataeibacter* (Hazzouri *et al.*, 2015; Iheukwumere *et al.*, 2025a; Dim *et al.*, 2025a). It can be synthesized from a wide array of alcoholic substrates, ranging from diluted alcohol solutions to fermented fruit musts, with its characteristic color, aroma, and flavor being intrinsically linked to the source material (Jamaludin *et al.*, 2016; Iheukwumere *et al.*, 2025b; Ekechukwu *et al.*, 2025a). As a product with ancient origins in food preservation and culinary practice, vinegar is fundamentally defined as a sour liquid resulting from the fermentation of natural, food-grade substances rich in fermentable carbohydrates (Bhat *et al.*, 2014; Henke *et al.*, 2019; Dim *et al.*, 2025b). While traditional substrates include fruits, grains, and honey, the essential functional and antimicrobial agent in all vinegar remains acetic acid (Matthew *et al.*, 2019; Tumane *et al.*, 2018; Ejike *et al.*, 2017; Amadi *et al.*, 2017). In recent decades, vinegar has evolved beyond its traditional roles to be recognized as a functional beverage, with its nutritional profile and content of bioactive phytochemicals linked to various health-promoting properties (Cusano *et al.*, 2020; Nwike *et al.*, 2017; Obianom *et al.*, 2024). Fruit-derived vinegars, in particular, are valued for their content of essential minerals and polyphenolic compounds, which are associated with antioxidant, anti-inflammatory, and cardioprotective effects (Arfaoui, 2021; Tumane *et al.*, 2018; Iheukwumere *et al.*, 2022a). These attributes underscore the growing industrial and nutraceutical significance of artisanal and fruit-based vinegars.

The quality, stability, and bioactivity of vinegar are fundamentally governed by its physicochemical properties. Critical parameters, including pH, total acidity, soluble solids content, and specific density, serve as essential indicators of product safety, shelf stability, and organoleptic quality (Sengun *et al.*, 2020; Dim *et al.*, 2025c). These characteristics are not static but are influenced by a complex interplay of factors, including raw material composition, fermentation methodology, microbial ecology, and processing conditions (Budak *et al.*, 2010). Consequently, the specific physicochemical profile directly determines the vinegar's sensory attributes, preservation potential, and physiological impact (Kim *et al.*, 2021).

While foundational research has established general principles regarding vinegar production and properties (Sengun *et al.*, 2020; Kim *et al.*, 2021), a dedicated comparative analysis of vinegar produced from *Phoenix dactylifera* (date palm) and *Prunus avium* (sweet cherry) remains notably absent. These two fruits possess distinct and potent phytochemical profiles—dates are rich in phenolic acids and flavonoids, while cherries are renowned for their anthocyanin and melatonin content—suggesting their derived vinegars may exhibit unique compositional and functional qualities. Therefore, this study aims to systematically evaluate and compare the key physicochemical properties and nutritional composition of vinegar produced from *Phoenix dactylifera* and *Prunus avium* fruit extracts.

MATERIALS AND METHODS

Isolation and Characterization of *Saccharomyces* species from Spoilt Fruit Samples

Sample collection

Spoilt *Phoenix dactylifera* and *Prunus avium* fruit extracts. 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 polythene 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 shaken, stoppered and kept for further analysis as described by Egbe *et al.* (2025a), Egbe *et al.* (2025b), Iheukwumere *et al.* (2025c), and Iheukwumere *et al.* (2025d).

Isolation of yeast

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 as described in a study published by (Egbe *et al.*, 2025c; Iheukwumere *et al.*, 2022b; Iheukwumere *et al.*, 2025e; Ekesiobi *et al.*, 2025).

Characterization of the yeast

The yeast isolate was characterized morphologically, biochemically, and molecularly using the method described in Cheesbrough (2010), Iheukwumere *et al.* (2020a), Iheukwumere *et al.* (2020b); Ekechukwu *et al.* (2025b). 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 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 (Chude *et al.*, 2020; Ekechukwu *et al.*, 2025c; Ezedianafa *et al.*, 2025a; Idigo *et al.*, 2025a; Iheukwumere *et al.*, 2025f).

Characterization of the Bacterial Isolate

The pure isolates will be characterized using the morphological, biochemical and molecular characteristics as described by Iheukwumere *et al.* (2017a); Iheukwumere *et al.* (2018a); Iheukwumere *et al.* (2020c). The cultural descriptions (size, appearance, edge, elevation, colour) of the isolates will be carried out as described in Iheukwumere *et al.* (2017b); Iheukwumere *et al.* (2018b), Iheukwumere *et al.* (2024). The Gram staining technique 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), Iheukwumere and Iheukwumere (2022a) and Iheukwumere *et al.* (2023a). The presence or absence of capsule will also be carried out as described by Iheukwumere *et al.* (2017c), Iheukwumere *et al.* (2017d), and Iheukwumere *et al.* (2022c). The presence or absence of flagellum will be determined by carrying out motility test as described by Cheesbrough (2010), Iheukwumere *et al.* (2023b), Ezedianafa *et al.* (2025b), Ike *et al.* (2025a). 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), Iheukwumere *et al.* (2018), Iheukwumere and Iheukwumere (2022c), Iheukwumere *et al.* (2022d). The molecular characterization involved DNA extraction, authentication, amplification and sequencing of the amplicons (Iheukwumere *et al.*, 2017e; Okeke *et al.*, 2017; Iheukwumere *et al.*, 2022e; Iheukwumere and Iheukwumere, 2022d).

Vinegar Production

Collection and preparation of fruit samples for production of vinegar

Phoenix dactylifera (commonly known as Date) and *Prunus avium* (commonly known as cherry) 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 (Iheukwumere *et al.*, 2022f; Iheukwumere and Iheukwumere, 2022e; Ezedianafu *et al.*, 2025c).

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 as described by (Ike *et al.*, 2025b; Obiefuna *et al.*, 2025b; Ugwu *et al.*, 2025a).

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 as described in a study published by Idigo *et al.* (2025b), Iheukwumere *et al.* (2025g), Ike *et al.* (2025c) and Ugwu *et al.* (2025b).

Determination of Physicochemical Parameters of the Vinegar

The Physical parameters determined were pH, temperature, acidity, total solid, total dissolved solid, and total suspended solid as described in the study published by Iheukwumere *et al.* (2025h), Idigo *et al.* (2025c), Idigo *et al.* (2025d), Ike *et al.* (2025d).

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), Ezedianafu *et al.* (2025d); Idigo *et al.* (2025d); Idigo *et al.* (2025e).

Total Solid in the Sample: This was carried out using the method of AOAC (2019) Obiefuna *et al.* (2025b); Ike *et al.* (2025d); Idigo *et al.* (2025f). 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°C to dryness. The total solid was determined as follows:

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

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 (AOAC, 2019; Idigo *et al.*, 2025g; Idigo *et al.*, 2025h).

Total suspended solids (TSS) determination: The method of AOAC (2019), Idigo *et al.* (2025i); Idigo *et al.* (2025j) 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), Idigo *et al.* (2025k); Idigo *et al.*, (2025l). 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:

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

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; Idigo *et al.*, 2025m; Idigo *et al.*, 2025n; Idigo *et al.*, 2025o).

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 - dinitrosalicylic 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; Idigo *et al.*, 2025p; Idigo *et al.*, 2025q).

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°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:

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

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°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:

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

Fat content: A soxhlet extractor was used, the soxhlet flask was dried in an oven at 105°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°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:

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

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

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

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.*, 2017b, Idigo *et al.*, 2025r; Iheukwumere *et al.*, 2025h; Iheukwumere *et al.*, 2025i; Idigo *et al.*, 2025s, Idigo *et al.*, 2025t, Manasseh *et al.*, 2025).

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 cerevisiae* 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 VC 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 VC (Table 6).

Nutritional Constituents of the Vinegar

The study revealed that fibre and carbohydrate were not detected in the vinegar samples as shown in Table 7. 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	<i>Saccharomyces cerevisiae</i>	<i>Saccharomyces cerevisiae</i>

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	<i>Acetobacter</i> species	<i>Acetobacter</i> 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	<i>Acetobacter aceti</i> strain W2 (AAW1) 16S rRNA gene partial sequence	<i>Saccharomyces cerevisiae</i> 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/mL)	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 6: Physicochemical properties of the prepared vinegars

Parameter	VC	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

VC=Vinegar from Cherry; VD= Vinegar from Dates; VS= Vinegar from supermarket

Table 7: Nutritional constituents of the vinegars

Parameter	VC	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

VC=Vinegar from Cherry; VD= Vinegar from Dates; VS= Vinegar from supermarket

DISCUSSION

This study evaluated the physicochemical and nutritional profile of vinegar produced from *Phoenix dactylifera* (date palm) and cherry fruit extracts. As a fermented product, fruit vinegar is a rich source of organic acids, vitamins, minerals, and bioactive phytochemicals such as phenolics and flavonoids, contributing to its nutritional and functional properties (Hamidalu, 2014). The successful fermentation of these fruit substrates is consistent with established literature on fruit-based vinegar production (Tengberg, 2012; Cantadori et al., 2022; Habiba et al., 2024; Iheukwumere et al., 2025j).

Microbiological characterization confirmed the presence of typical fermentative microbes. The yeast isolated from date vinegar displayed morphological and biochemical traits aligning with *Saccharomyces cerevisiae*, as reported in prior studies (Mohammed et al., 2021; Chibi and El Haldi, 2019; Atitallah et al., 2021; Ahmad et al., 2021). Molecular identification further supported the presence of related strains, including *Saccharomyces cerevisiae* Ysr128, corroborating findings by Ahmad et al. (2021) and Ugobogu et al. (2025). Similarly, the bacterial isolate from cherry vinegar exhibited profiles characteristic of *Acetobacter* species, consistent with descriptions by Fatima and Mishra (2015), Prisacaru and Oroian (2018), and Armi et al. (2023). The isolate showed close similarity to *Acetobacter aceti* strain w1, as previously documented (Boonsupa et al., 2019; Iheukwumere et al., 2025k).

Notably, the acetic acid content of date fruit vinegar reached 5.2%, a yield that surpasses those reported for many other fruit vinegars. This higher productivity likely reflects the high sugar content of dates, which facilitates efficient acetous fermentation. Similar elevated acetic acid yields have been observed in other sugar-rich substrates, such as green apple and mango juice (Klawplyapamornkun et al., 2015; Ouattara et al., 2018; Iheukwumere et al., 2025l). These findings underscore the influence of substrate composition on vinegar quality and fermentation efficiency.

The physicochemical parameters of the prepared vinegar samples correlated with the findings of other researchers (Morhtar et al., 2016; Sengun et al., 2020; Iheukwumere et al., 2025m). The pH and specific gravities of the vinegar samples agree with those of the apple cider and Nipa vinegars analysed 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 the high content of sugar present in the juice sample.

The detection of moisture, ash, protein and fat in the vinegar samples supported the findings of Mornhtar et al. (2016) and Iheukwumere et al., (2025n). The absence of carbohydrate in the vinegar samples pointed out that most carbohydrates have

been converted to sugar during the fermentation process, and these were converted to ethanol, which later formed the acetic acid.

CONCLUSION

The study has shown that the prepared vinegar samples from *Prunus avium* (PA/Cherry) 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

- Akara, G., Tomar, O., Caglar, A. and Istek, O. (2020). Physicochemical 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
- Akpınar-Bayazit, A., Turan, M.A., Yilmaz-Ersan, L. and Taban, N. (2010). Inductively coupled plasma optical-emission spectroscopy determination of major and minor element in vinegar. *Journal of Botany and Horticulture* 38: 877 – 887.
- Al-Ghoori, B. and Krepl, V. (2010). Importance of date palms as a source of nutrition. *Agricultural, Tropical, and Subtropical Journal* 43: 341 – 347.
- Amadi, R.E., Iheukwumere, I.H. and Unaeze, B.C. (2017). Effects Of Crude Alkaloid Extracted From *Ocimum Gratissimum* On The Activity Of Ciprofloxacin Against *Salmonella Enterica* Serovar Typhi. *Advances in Life Science and Technology* 58.
- Ameyapoh, Y., Leveau, J.Y., Karou, S.D., Bouix, M., Sossou, S.K. and de Souza, C. (2010). Vinegar production from Togolese local variety mangori of *Mangifera indica* L. *Pakistan Journal of Biological Science* 13: 132 – 137.
- Amul, N., Shafkat, S.R., Mdahboob, 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 characterization of *Acetobacter* and *Gluconobacter* 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.
- Chude, C.O., Iheukwumere, I.H., Iheukwumere, C.M., Nwaolisa, C.N., Egbuna, C., Nwakoby, N.E. and Egbe, P.A. (2020). Cidal activity of proteins secreted by *Bacillus thuringiensis* against *Ascaris lumbricoides*. *International Journal of Research Publications* 49(1): 1033 – 1045.
- Cusano, 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.
- Dabija, A. and Hatnean, C.A. (2014). Study concerning the quality of apple vinegar obtained through classical method. *Journal of Agroalimentary Process and Technology* 20(4):304-310.
- Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025a). Multiple Antibiotic Resistance Bacterial Strains in Frozen Meat Sold at Abagana, Anambra State: A Public Health Concern. *IPS Journal of Applied Microbiology and Biotechnology*, 4(3), 181–186. <https://doi.org/10.54117/ijamb.v4i3.75>
- Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025b). The Burden of Antibiotic Resistance: Evaluating the Impact of Multiple Antibiotic-Resistant Enteric Bacteria in Academic Environments. *IPS Interdisciplinary Journal of Biological Sciences*, 4(4), 144–149. <https://doi.org/10.54117/ijbs.v4i4.78>
- Dim, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Ugwu, C. H., Ike, V. E., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025c). Antimicrobial resistance in aquaculture: evaluating *Pseudomonas aeruginosa* from fish ponds. *IPS Intelligentsia Multidisciplinary Journal*, 4(1), 32–36. <https://doi.org/10.54117/iimj.v4i1.10>
- Du, B., Zhu, F.M. and Li, F.Y. (2012). Measurement and analysis of mineral components in grape wine by inductively coupled plasma-optical emission spectrometer. *Advanced Journal of Food Science and Technology* 4: 277 – 280.
- Duarte, W.F., Dias, D.R., Oliveira, J.M., Teixeira, J.A., Silva, J.B.A. and Schwan, R. (2010). Characterization of different fruit wines made from cacao, cupuassu, gabioba, jaboticaba, and umbu. *Journal of Food Science and Technology* 43:1564 – 1572.
- Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., & Ezeumeh, E. N. (2025a). Antibiotic Susceptibility of *Helicobacter pylori* Isolates from Patients at Nnewi Teaching Hospital, Anambra State. *IPS Journal of Basic and Clinical Medicine*, 2(2), 51–57. <https://doi.org/10.54117/ijbcm.v2i2.11>.
- Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., Ezeumeh, E. N., & Egbuna, C. (2025b). *Helicobacter pylori* Inhibition by Medicinal Plant Extracts: An In Vitro Assessment. *IPS Journal of Drug Discovery Research and Reviews*, 3(1), 32–37. <https://doi.org/10.54117/ijddr.v3i1.28>.

- Egbe, P. A., Umeaku, C. N., Iheukwumere, I. H., Iheukwumere, C. M., Onwuasoanya, U. F., Ezenwata, I. S., Afulukwe, S. C., Ike, V. E., & Ezeumeh, E. N. (2025c). Medicinal Plant Extracts Enhance Conventional Antibiotic Activity against *Helicobacter pylori*: An In Vitro Assessment. *IPS Interdisciplinary Journal of Biological Sciences*, 4(2), 93–99. <https://doi.org/10.54117/ijbs.v4i2.51>.
- Ejike, C.E., Iheukwumere, I.H. and Armadi, R.E. (2017). Susceptibility of *Escherichia coli* Isolated from Oligospermia Patient to *Gongronema latifolium* leaves extract. *J. Biol. Agriculture. Healthcare* 7(14).
- Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025a). Bacterial Loads of Smoked Fish and Chicken: Role of pH and Moisture Content. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, 3(1), 44–49. <https://doi.org/10.54117/iajnfms.v3i1.102>.
- Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025b). Biological Inhibition of Pathogenic Bacteria Isolated from Smoked Fish and Chicken: An In Vitro Study. *IPS Interdisciplinary Journal of Biological Sciences*, 4(2), 85–92. <https://doi.org/10.54117/ijbs.v4i2.50>.
- Ekechukwu, C. C., Umeh, S. O., Iheukwumere, I. H., & Iheukwumere, C. M. (2025c). Prophylactic Potential of the Most Potent Synergistic Biological Agent against Bacterial Infections from Smoked Fish and Chicken. *IPS Journal of Applied Microbiology and Biotechnology*, 4(2), 153–160. <https://doi.org/10.54117/ijamb.v4i2.57>.
- Ekesiobi, A. O., Iheukwumere, C. M., Iheukwumere, I. H., Ejike, C. E., Ekechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025). Hyping the Inhibitory Activity of *Xylopi 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>.
- Ezedianafo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025a). *Musca domestica*: A vector of multidrug-resistant enteric bacteria. *Journal of Veterinary, Allied, and One Health Sciences*, 1(2), 30–38. <https://doi.org/10.54117/3vwwg0p36>.
- Ezedianafo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025b). Occurrences of meropenem- and imipenem-resistant *Klebsiella pneumoniae* in *Musca domestica* in hospital landfills. *African Journal of Applied Research & Sustainable Development*, 1(2), 25–35. <https://doi.org/10.54117/wjmyv91>.
- Ezendianefo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025c). Multiple antibiotic resistance indices of enteric bacteria isolated from *Musca domestica*. *Journal of Public Health, Policy, and Society*, 1(2), 29–37. <https://doi.org/10.54117/k8r78723>.
- Ezendianefo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025d). *Klebsiella pneumoniae* isolated from *Musca domestica*: Antibiotic susceptibility and resistance patterns. *Journal of Veterinary, Allied, and One Health Sciences*, 1(2), 39–47. <https://doi.org/10.54117/vy6y8f94>.
- Ezendianefo, J. N., Iheukwumere, I. H., Iheukwumere, C. M., Okolo, O., Nwike, I., & Ubajekwe, C. C. (2025e). *Musca domestica* as vectors of pathogenic enteric bacteria: A public health concern. *African Journal of Applied Research & Sustainable Development*, 1(2), 36–45. <https://doi.org/10.54117/s671mk28>.
- Garcia-Garcia I, Cantero-Moreno D, Jimenez-Ot C, Baena-Ruano S, Jimenez-Hornero J, Santos-Duenas I.B. (2017). Physicochemical properties, total phenolic content, and antioxidant capacity of home-made and commercial date (*Phoenix dactylifera* L.) vinegar. *Journal of Food Science and Technology* 6: 45 – 56.
- Guedes, J.D.S., Magalhaes-Guedes, K.T., Dias, D.R., Schwan, R.F. and Braga-Jr, R.A. (2014). Assessment of biological activity of kefir grains by laser biospeckle technology. *African Journal of Microbiological Research* 4(28): 2639 – 2642.
- Hafzan, Y., Saw, J.W. and Fadzilah, I. (2017). Physicochemical Properties, Total Phenolic Content, and Antioxidant Capacity of Home-made and Commercial date (*Phoenix dactylifera* L.) Vinegar. *International Food Research Journal* 24(6): 2557 – 2562.
- Hamidatun, 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
- Han, K., Meng, W., Zhang, J.J., Zhou, Y., Wang, Y.L., Su, Y., Lin, S.C., Gan, Z.H., Sun, Y.N. and Min, D.L. (2016). Luteolin inhibited proliferation and induced apoptosis of prostate cancer cells through MIR-301. *Journal of Onco Targets and Therapy* 26 (9): 3085 - 3094
- Hazzouri, 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.
- Hazzouri, 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.
- Henke, J., Rasane, P., Kaur, S. and Kumbhar, P. (2019). Vinegar: a traditional functional food. *Think India Journal* 22(34):581 – 629.
- Hidalgo, C., Vegas, C., Mateo, E., Tesfaye, W. and Cerezo, A.B. (2010). Effect of barrel design and inoculation of *Acetobacter pasteurianus* in wine vinegar production. *International Journal of Food Microbiology* 141: 56 – 62.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025a). Bacterial symbionts of *Rhynchophorus phoenicis*: Modulation of rat lymphocyte function and immunity. *Journal of Tropical Medicine and Public Health Solutions*, 1(2), 55–63. <https://doi.org/10.54117/jtmphs.v1i2.36>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025b). Multidrug-resistant *Klebsiella pneumoniae* in *Musca domestica*: A potential public health threat. *Journal of Tropical Medicine and Public Health Solutions*, 1(2), 46–54. <https://doi.org/10.54117/jtmphs.v1i2.35>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025c). Termite-derived antimicrobials: A novel approach to control *Bacillus cereus* in food products. *International Journal of Global Trends and Research*, 1(2), 45–57. <https://doi.org/10.54117/2mgwn270>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025d). Bacterial diversity in insect guts and their potential applications in industry. *International Journal of Global Trends and Research*, 1(2), 36–44. <https://doi.org/10.54117/2k0d9t18>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025e). Bioactive compounds from *Macrotermes*: A novel approach to combat multidrug resistant *Klebsiella pneumoniae* from *Musca domestica* in hospital landfills. *IPS Journal of Biotechnology and Applied Biochemistry*, 1(2), 82–92. <https://doi.org/10.54117/ijbab.v1i2.111>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025f). Assessment of blood indices in rats supplemented with *Macrotermes*-derived nutrient-enhanced bacteria. *IPS Journal of Basic and Clinical Medicine*, 2(4), 143–151. <https://doi.org/10.54117/ijbcm.v2i4.39>.
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaedozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025g). Exploring the potential of termite gut bacteria

- as growth promoters and organ function enhancers in albino Wistar rats. *Health Science Research International*, 1(2), 43–52. <https://doi.org/10.54117/hsri.v1i2.38>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025h). Assessment of hematological parameters in albino Wistar rats fed with *Rhynchophorus phoenicis* larvae enriched with autochthonous bacteria. *Health Science Research International*, 1(2), 34–42. <https://doi.org/10.54117/hsri.v1i2.37>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025i). Entomopathogenic bacteria-mediated management of *Delia radicum*: A step towards eco-friendly pest control. *Journal of Agriculture, Food Technology and Sustainability*, 2(2), 112–121. <https://doi.org/10.54117/jafts.v2i2.110>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025j). Antimicrobial activity of *Macrotermes*-derived eluates against multidrug resistant *Pseudomonas* species: Implications for aquaculture disease management. *Journal of Agriculture, Food Technology and Sustainability*, 2(2), 102–111. <https://doi.org/10.54117/jafts.v2i2.109>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025k). Exploring the potential of entomopathogenic bacteria for sustainable management of *Sitophilus zeamais* in maize storage systems. *IPS Journal of Plant, Animal, and Environmental Sciences*, 1(1), 11–20. <https://doi.org/10.54117/ijpae.v1i1.108>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025l). Biological control of *Acanthoscelides obtusus* using entomopathogenic bacteria. *IPS Journal of Plant, Animal, and Environmental Sciences*, 1(1), 1–10. <https://doi.org/10.54117/ijpae.v1i1.107>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025m). Modulation of phagocytic index in albino Wistar rats via bacterial symbionts from *Rhynchophorus phoenicis* larvae. *African Journal of Nutrition and Applied Research*, 1(2), 27–36. <https://doi.org/10.54117/fm3vgt16>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025n). Bacterial symbionts of insect larvae: A novel approach to improving micronutrient content. *African Journal of Nutrition and Applied Research*, 1(2), 27–36. <https://doi.org/10.54117/960k2266>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025o). Unlocking the potential of termite gut microbiome: Enhancing nutritional value through bacterial symbionts. *IPS Journal of Nutrition and Food Science*, 5(1), 636–645. <https://doi.org/10.54117/ae6gj081>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025p). Enhancing nutritional parameters with bacterial symbionts from *Macrotermes* species: A potential frontier in nutritional biotechnology. *IPS Journal of Nutrition and Food Science*, 5(1), 625–635. <https://doi.org/10.54117/a2b7jb52>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025q). Bacterial symbionts of *Macrotermes* species: Assessing their impact on phagocytic indices of albino Wistar rats. *IPS Interdisciplinary Journal of Biological Sciences*, 5(1), 187–196. <https://doi.org/10.54117/ijbbs.v5i1.106>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025r). Bacterial symbionts of insects: Exploring their role in insect nutritional composition. *IPS Interdisciplinary Journal of Biological Sciences*, 5(1), 177–186. <https://doi.org/10.54117/ijbbs.v5i1.105>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025s). Augmenting rat lymphocyte function by bacterial symbiont of *Macrotermes* species. *IPS Journal of Applied Microbiology and Biotechnology*, 5(1), 281–290. <https://doi.org/10.54117/ijamb.v5i1.104>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefo, J. N., Ike, V. E., Nnaeozie, A. O., Ezekwueche, S. N., Anagor, I. S., Aniekwe, C. C., Ezeoke, F. C., Okereke, F. O., & Ochibulu, S. C. (2025t). Antimicrobial peptides from insects: A study on their efficacy against pathogens. *IPS Journal of Applied Microbiology and Biotechnology*, 5(1), 271–280. <https://doi.org/10.54117/ijamb.v5i1.103>
- Iheukwumere, C. M., & Iheukwumere, I. H. (2022a). Nutritive and Antinutrient Values of Soybean Condiments Produced from Indigenous Fermenters. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, 1(1): 1-5. <https://doi.org/10.54117/iajnfms.v1i1.8>
- Iheukwumere, C. M., & Iheukwumere, I. H. (2022e). Hematological indices and sensory quality of fermented soybean condiments. *World Journal of Advanced Research and Reviews*, 14(2), 435-42
- Iheukwumere, C. M., Ekesiobi, A. O., Iheukwumere, I. H., Ejike, C. E., Ilechukwu, C. C., Dim, C. N., & Ochibulu, S. C. (2025g). Dual Approach Therapy: Assessing Xylopiia aethiopica and Ciprofloxacin Synergy against Salmonella enterica Serovar Typhi. *IPS Intelligentsia Multidisciplinary Journal*, 4(1), 27–31. <https://doi.org/10.54117/ijimj.v4i1.9>
- 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. (2025h). 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. <https://doi.org/10.54117/ijnfs.v4i3.111>
- Iheukwumere, C. M., Iheukwumere, I. H., Nwakoby, N. E., Idigo, M. A., & Ike, V. E. (2025m). Evaluation of fermented chicken feather meal as a dietary supplement on rat lipid metabolism and immune response. *African Journal of Nutrition and Applied Research*, 1(1), 17–26. <https://doi.org/10.54117/qbwbp15>
- Iheukwumere, C. M., Iheukwumere, I. H., Okoli, U. O., & Ugwu, C. H. (2023a). Immunological Impact of Fermented Soybean Condiments Produced from Indigenous Fermenters. *Journal of Advances in Microbiology* 23(10): 27-37
- Iheukwumere, C. M., Iheukwumere, I. H., Ugwu, C. H., & Okoli, U. O. (2023b). Toxicity of Prepared Fermented Soybean Condiments from Indigenous Fermenters. *Journal of Advances in Microbiology* 23(10): 38 – 51.
- Iheukwumere, C. M., Umeaku, C. N., Chukwura, E. N., & Iheukwumere, I. H. (2022f). 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., & Ejike, C. E. (2017b). Comparative study of the inhibitory activities of *Ocimum gratissimum* and *Nepeta cataria* against *Salmonella enterica* serovar Typhi and their larvicidal effect against *Anopheles gambiae*. *African Journal of Education, Science and Technology (AJEST)*, 3(4), 16-24
- Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnaeozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025c). Exploring the Phytochemical and Antimicrobial Properties of Fruit Vinegar: A Study on *Phoenix Dactylifera* and *Malus Sylvestris*. *IPS Journal of Applied Microbiology and Biotechnology*, 4(1), 115–122. <https://doi.org/10.54117/ijamb.v4i1.48>
- Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnaeozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025d). Microbial Quality and Sensory Assessment of Vinegar from

- Date Palm and Apple Fruits: Implications for Consumer Preference. *IPS Journal of Nutrition and Food Science*, 4(2), 410–417. <https://doi.org/10.54117/ijnfs.v4i2.100>.
- Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025f). Safety Evaluation of Vinegar from Phoenix Dactylifera and Malus Sylvestris: Toxicity and Acetic Acid Content. *IPS Journal of Applied Microbiology and Biotechnology*, 4(1), 123–131. <https://doi.org/10.54117/ijamb.v4i1.49>
- Iheukwumere, I. H., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., Igboanugo, E. U., Onwuasoanya, U. F., Okereke, F. O., Nnadozie, C. H., Agbaugo, C. F., Nwike, M. I., Nwakoby, N. E., & Ilechukwu, C. C. (2025k). Exploring the Phytochemical and Antimicrobial Properties of Fruit Vinegar: A Study on Phoenix Dactylifera and Malus Sylvestris. *IPS Journal of Applied Microbiology and Biotechnology*, 4(1), 115–122. <https://doi.org/10.54117/ijamb.v4i1.48>
- Iheukwumere, I. H., Amadi, E. R., & Chude, C. (2018b). Synergistic Effects of Probiotics and Autogenous Bacterin Against Inositol Negative Motile Salmonella Species. *Journal of Biology, Agriculture and Healthcare* 8(6).
- Iheukwumere, I. H., Amadi, R. E., Unaeze, B. C., & Campus, N. (2017c). Enterotoxigenicity Profile of Salmonella Enterica Serovar Typhimurium in Suckling Albino Mice. *Journal of Natural Sciences Research* 7(14).
- Iheukwumere, I. H., Chukwura, E. I., & 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*, 8(6).
- Iheukwumere, I. H., Ejike, C. E., & Okeke, C. E. (2017d). A trial to prevent sorbitol negative Escherichia coli infections in chicks using autogenous bacteria and probiotics. *Journal of Natural Sciences Research*, 7, 56-63.
- Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., ... Ihenatuoha, U. A. (2025a). Cross-Sectional Study of Different Strains of Bacillus cereus among Pap Sold in Major Towns in Ihiala LGA, Anambra State. *IPS Journal of Public Health*, 5(2), 199–204. <https://doi.org/10.54117/ijph.v5i2.39>.
- Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., ... Destiny, E. C. (2025b). Cross-Sectional Study of Major Strains of Salmonella enterica Subspecies Enterica Serovar Typhi among Borehole Used in Uli Community. *IPS Journal of Public Health*, 5(2), 205–210. <https://doi.org/10.54117/ijph.v5i2.40>.
- Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., Udeagbara, O. E., Unaeze, B. C., Obiefuna, O. H., Ike, V. E., Onyemekara, N. N., & Ihenatuoha, U. A. (2025e). Quotidian of Substantial Strain of Shigella dysenteriae among Ready To-Eat Fruit Salad Sold in Uli Community. *Journal of Pollution Monitoring, Evaluation Studies and Control*, 4(1), 95–99. <https://doi.org/10.54117/jpmesc.v4i1.17>
- Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., ... Ihenatuoha, U. A. (2025i). Cross-Sectional Study of Different Strains of Bacillus cereus among Pap Sold in Major Towns in Ihiala LGA, Anambra State. *IPS Journal of Public Health*, 5(2), 199–204. <https://doi.org/10.54117/ijph.v5i2.39>.
- Iheukwumere, I. H., Iheukwumere, C. M., Obianom, A. O., Nnadozie, C. H., Okereke, F. O., Onwuasoanya, U. F., ... Destiny, E. C. (2025j). Cross-Sectional Study of Major Strains of Salmonella enterica Subspecies Enterica Serovar Typhi among Borehole Used in Uli Community. *IPS Journal of Public Health*, 5(2), 205–210. <https://doi.org/10.54117/ijph.v5i2.40>.
- Iheukwumere, I. H., Iheukwumere, M. C., & Nwakoby, N. E. (2022d). Sequential Pathogenicity Study of SOR+ and SOR-Escherichia coli Isolated from Roasted Meat. *IPS Interdisciplinaria Multidisciplinary Journal*, 1(1), 1-11.
- Iheukwumere, I. H., Nwankwo, A. K., Iheukwumere, C. M., Okorie, N. A., Nwakoby, N. E., Ekesiobi, A. O. and Okolo, O. C.. (2025n). Characterization and pathogenic profile of Aspergillus fumigatus isolated from landfills. *Microbes and Infectious Diseases* 6(4)
- Iheukwumere, I. H., Obi, P. C. and Unaeze, B. C. (2017a). A trial to prevent Vibrio cholerae in albino mice using autogenous bacterin. *Advances in Life Science and Technology* 58:34–42
- Iheukwumere, I. H., Uneze, B. C., & Ejike, C. E. (2017e). Efficacy of some selected antimicrobial substances in prevention of enteric bacterial infection in broiler chicks. *J. Biol. Agriculture. Healthcare*, 7, 58-66.
- Iheukwumere, I.H. , Iheukwumere, C.M. , Nnadozie, H. C. ,Unaeze, C.B. , Obiefuna, O.H. Obianom, A.O. and Ejike, C. E. (2024). Hematotoxicological and mosquito larvicidal studies of crystal proteins secreted by Bacillus thuringiensis and Bacillus sphaericus. *Tropical Journal of Applied Natural Sciences* 2(2): 61 – 92.
- Iheukwumere, I.H. and Iheukwumere, M.C. (2022c). Streptococcus suis in Pigs and Environs: A Cross-sectional Study. *IPS Journal of Public Health*, 1(2), 9-12. <https://doi.org/10.54117/ijph.v1i2.4>.
- Iheukwumere, I.H. and Iheukwumere, M.C. (2022g). Cross-sectional Study of Multiple Antibiotic-resistant Streptococcus suis in Pigs and Environments. *IPS Interdisciplinary Journal of Biological Sciences*, 1(1), 19–21. <https://doi.org/10.54117/ijjbs.v1i1.4>
- 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 soil samples. *International Journal of Research Publication* 50(1); 1047 -1062.
- Iheukwumere, I.H., Iheukwumere, M.C. and Nwakoby, N.E. (2022b). Synergistic Effects of Probiotics and Autogenous Bacterin against Salmonella enterica Serovar Typhimurium Strain U288. *IPS Journal of Nutrition and Food Science*, 1(1), 1–5. <https://doi.org/10.54117/ijnfs.v1i1.3>.
- Iheukwumere, I.H., Nwike, M. I., Iheukwumere, C.M., Ike, V.E., Obianom, A.O., Ihenatuoha, U.A., Igboanugo, E.U., Ekesiobi, A.O., Okereke, F.O., Obiefuna, O. H. Nnadozie, C.H., Agbaugo, C.F., Oduoye, O.T., Nwakoby, N.E., Ilechukwu, C. C., Ochibulu, S. C. and Ejike, C. E. (2025l). Extraction and Elucidation of Antibiotics from the Mycelia of Aspergillus niger Isolated from Poultry Farm against Enteric Bacterial Pathogens. *IPS Journal of Advanced and Applied Biochemistry*, 1(1), 1–10. <https://doi.org/10.54117/ijaab.v1i1.58>.
- Iheukwumere, I.H., Iheukwumere, C.M., Chude, C.O., Nwaolisa, C.N. and Egbe, P.A. (2020a). Comparative study of different clinical samples used for the diagnosis of staphylococcal systemic infections in apparent healthy students. *International Journal of Research Publications* 49(1): 1 – 10
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025a). Prevalence of Bacillus cereus in Powdered Soybean Sold in Uli Community, Anambra State: A Cross-Sectional Study. *IPS Journal of Basic and Clinical Medicine*, 2(3), 108–114. <https://doi.org/10.54117/ijbcm.v2i3.18>
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025b). Bacillus cereus in Uli's cornflour: A prevalence study. *IPS Journal of Nutrition and Food Science*, 4(3), 544–548. <https://doi.org/10.54117/8bte840>
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025c). Pathogenic Profile Analysis: In Vitro Screening of Enteric Bacteria from University Dusters. *IPS Journal of Applied Microbiology and Biotechnology*, 4(3), 187–191. <https://doi.org/10.54117/ijamb.v4i3.76>
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025d). Frozen Fish Pathogens: Antimicrobial Resistance and Public Health Implications. *IPS Interdisciplinary Journal of Biological Sciences*, 4(4), 138–143. <https://doi.org/10.54117/ijjbs.v4i4.77>
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., & Ochibulu, S. C. (2025e). Stream water quality assessment: Antibiotic resistance of Lac-positive enteric bacterial isolates. *Journal of Pollution Monitoring, Evaluation Studies and Control*, 4(2), 120–125. <https://doi.org/10.54117/jpmesc.v4i2.21.2025>
- 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.
- 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., Zhang, 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.
- Jia, J., Wuc, Y., Kun, M., Fen, F., Zhang, 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
- Khin, H.A. and Thwe, L.K. (2016). Utilization of Fruit Waste (Pineapple peel) For Vinegar production. *Yadanabon University Research Journal* 7 (1): 1-11
- Kim, 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
- Klawpylapamornkun, T., Bovonsombut, S. and Bovonsombut, S. (2015). Isolation and characterization of acetic acid bacteria from fruits and fermented fruit juice for vinegar production. *Food and Applied Bioscience Journal* 3(1): 30 – 38
- Kumari, 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
- Maal, K.B., Shafie, R. and Kabiri, N. (2010). Production of apricot vinegar using an isolated *Acetobacter* strain from Iranian apricot. *International Journal of Biological Life Science* 6:230 – 233.
- Madrera, R.R.; Bedriñana, R.P. and Valles, B.S. (2017). Enhancement of the nutritional properties of apple pomace by fermentation with autochthonous yeasts. *Food Science Technology* 79: 27–33.
- Magalhaes, K.T., Dias, D. and Pereira, G.V.M. (2011). Chemical composition and sensory analysis of cheese whey-based beverage using kefir grains as starter culture. *International Journal of Food Science and Technology* 46: 871 – 878.
- Manasseh, C.O., Logan, C.S.P., Ikeyi, A.P., Ede, K.K., Iheukwumere, I.H., Iheukwumere, C.M. and Ejike, C.E. (2025). Investigating the Effects of the Covid-19 Pandemic and Climate Risks on Trade Balance in Emerging Markets. *The Nigerian Health Journal* 25(2): 1-27. <https://doi.org/10.71637/tmh.v25i2.914>
- Mathew, 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.
- Mathew, 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 microbiology* 9:556-569: microbiological, chemical composition and sensory analysis. *Food Research International Journal* 48: 634 – 640.
- Mokhtar, S.I., Zakaria, F., Mohammad, A.A., Soon, S.W., Nuvshahida, A.S. and Latiff, Z.A.A. (2016). Study 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
- Nwike, M.I., Iheukwumere, I.H. and Uneze, B.C. (2017). Effect of Spices, pH and Temperature on the Survival and Multiplication of *Staphylococcus aureus* in Locally Made Soya Milk Drink. *Journal of Natural Sciences Research* 7(4).
- Obianom, A.O., Iheukwumere, I.H., Iheukwumere, C.M., Ochibulu, S.C., Nnadozie, H. C. and Ifenetu, F. C. (2024). Supersizing the inhibitory activity of *Xylopi aethiopica* extract against *Vibrio cholerae* using doxycycline. *Tropical Journal of Applied Natural Sciences* 2(2).
- Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025a). Assessing the Impact of Glycemic Index on Microbial Quality and Storage Stability of Tomato Jam. *IPS Journal of Applied Microbiology and Biotechnology*, 4(3), 192–202. <https://doi.org/10.54117/ijamb.v4i3.81>
- Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025b). Physicochemical and nutritional properties of tomato jam: Influence of sweetener type and glycemic index. *IPS Journal of Nutrition and Food Science*, 4(3), 561–568. <https://doi.org/10.54117/yazv0114>
- Obiefuna, U. G., Umeh, S. O., & Iheukwumere, I. H. (2025c). Micronutrient profile and acceptability of tomato jam: A comparison of high and low glycemic carbohydrate index sweeteners. *IPS Applied Journal of Nutrition, Food and Metabolism Science*, 3(2), 67–74. <https://doi.org/10.54117/pr4r6c73>
- Okeke, C. E. Iheukwumere, I. H. Ejike, C.E. (2017). Pathogenicity Study of Dematiaceous Fungi Isolated from Chicken Feeds on Immunoincompetent Chickens. *J. Biol. Agriculture. Healthcare* 7(4).
- Onuorah, S., Joson, L. and Obika, I. (2016). Production of vinegar from oil palm wine using *Acetobacter aceti* isolated from rotten banana fruits. *Universal Journal of Biomedical Engineering* 4(1): 1 – 5
- Ouattara, A., Somba, 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
- Petruzzello, E., Blaiotta, G., Pittari, E., Piombino, P. and Aponte, M. (2023). Isolation and characterization of cytotolerant yeast from Fianodi Avellionio grapes fermented at low temperatures. *Foods* 12 (3): 526 – 537
- Puerari, C., Magalhaes, K.T. and Schwan, R.F. (2012). New cocoa pulp based kefir beverages: microbiology, chemical composition, and sensory analysis. *Food Research International Journal* 48: 634 – 640.
- Purugganan, M.D. (2015). Whole Genome Re-sequencing of Date Palms Yields Insights Into Diversification of a Fruit Tree Crop. *Nature Community Journal* 6:8824.
- Safrida, F.A.U., Gholib, M.M., Raissya, A., Yelly, A.P. and Nadila, F. (2023). Phytochemical characterization 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
- Sengun, I.Y., Kilic, G. and Oturk, B. (2020). Screening physicochemical, microbiological and bioactive properties of fruit vinegars. *Food Sciences and Biotechnology* 29 (3): 401 – 408
- Sengun, I.Y., Kilic, G. and Oturk, B. (2020). Screening Physicochemical, Microbiological and Bioactive Properties of Fruit Vinegars Produced from Various Raw Materials. *Food Science Biotechnology* 29: 401–408
- Siddeeg A, Zeng XA, Rahaman A, Manzoor MF, Ahmed Z, Ammar AF (2019). Quality characteristics of the processed dates vinegar under influence of ultrasound and pulsed electric field treatments. *Journal Food Science and Technology* 56(9):4380 – 4389.
- Singh, J. and Garg, A.P. (2022). Antimicrobial activity of apple cidar vinegar treated selected vegetables against common food borne bacterial pathogens. *Bioscience Biotechnology Research Communications* 15 (2): 350 – 356.
- Srivastava, V. and Rani, R. (2019). Isolation and characterization of acetoacetic bacteria from decomposed fruits. *Journal of Biological, Chemistry and Chron* 5(1): 123 – 129
- Tharinee, K., Sakunne, B. and Sittisin, B. (2015). Isolation and characterization of acetic acid bacteria from fruits and fermented fruit juices for vinegar production. *Food and Applied Bioscience Journal* 3(1): 30-38.
- Tumane, P. M., Sarkar, S., Wasnik, D.D. and Kolte, N. A. (2018). Production of vinegar from pineapple peels using *Acetobacter* species isolated from soil sample and its antibacterial activity. *International Journal of Life Sciences* 6(4):948 – 956.
- Tumane, P. M., Sarkar, S., Wasnik, D.D. and Kolte, N. A. (2018). Production of vinegar from pineapple peels using *Acetobacter* species isolated from soil sample and its antibacterial activity. *International Journal of Life Sciences* 6(4):948 – 956.
- Ugwu, C. H., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragi, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025a). Maternal health and antibiotic resistance: *Klebsiella pneumoniae* isolates analysis. *IPS Journal of Public Health*, 5(3), 290–295. <https://doi.org/10.54117/s3tx6v26>

- Ugwu, C. H., Iheukwumere, I. H., Iheukwumere, C. M., Ike, V. E., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, O. C., Onwuasoanya, U. F., Okereke, F. O., Oduenyi, P. M., & Ochibulu, S. C. (2025b). *Ocimum gratissimum* Extract's Effectiveness against *Vibrio cholerae* from Uli Streams. *IPS Journal of Phytochemistry and Medicinal Plant Research*, 1(2), 15–19. <https://doi.org/10.54117/ijpmpr.v1i2.38>
- Vayalil, P.K. (2012). Date fruits (*Phoenix dactylifera*): An emerging medicinal food. *Critical Review in Food Science and Nutrition* 6: 70 –76.
- Viana, R.O., Magalhaes-Guedes, K.T., Braga Jr. R.A., Dias, D.R. and Schwan, R.F. (2017). Fermentation process for production of apple-based kefir vinegar: microbiological, chemical, and sensory analysis. *Brazilian Journal of Microbiology* 48: 592 – 601.
- Wang, B., Rutherford-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
- Yulianti, H., Tjandra, S.A. and Setianingsih, H. (2019). Effect of administration of apple cider vinegar (*Malus sylvestri* mill) manalagi varieties on blood triglyceride levels of white rats. *Journal of Agricultural Science, Forestry, and Agrotechnology* 20 (2): 70 – 77
- Zubaidah, E. (2015). Effects of apple cider vinegar and zalacca vinegar blood glucose reduction and pancreatic histopathology of diabetic wistar rats. *Brawijaya Medicinal Journal* 28 (4): 297 - 301

Thanks for publishing with us: <https://ipsintelligentsia.com/>