

Exploring the Phytochemical and Antimicrobial Properties of Fruit Vinegars: A Study on *Phoenix dactylifera* and Mango 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, Umunya, 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

The escalating challenge of antimicrobial resistance necessitates the investigation of novel, natural therapeutic agents. Fruit vinegars, traditionally valued for their health-promoting properties, represent a promising yet underexplored source of bioactive compounds. This study provides a comprehensive analysis of the phytochemical composition and *in vitro* antimicrobial efficacy of vinegars produced from *Phoenix dactylifera* (date) and *Mangifera indica* (mango) fruits. The fermentation process utilized *Saccharomyces cerevisiae* strain SR 128 and *Acetobacter aceti* strain WI, isolated and characterized from indigenous spoiled fruits. Following submerged fermentation, the resultant vinegars were subjected to detailed physicochemical, nutritional, and phytochemical profiling employing gravimetric and spectroscopic techniques. Antimicrobial potency was evaluated against a panel of clinically relevant pathogens. Statistical analysis was performed using one-way Analysis of Variance (ANOVA) and Tukey's test at a 95% confidence interval ($\alpha = 0.05$). Phytochemical analysis confirmed the presence of significant levels of alkaloids, saponins, flavonoids, tannins, and glycosides. The vinegar samples exhibited statistically significant ($P < 0.05$) antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli*, *Salmonella enterica* serovar Typhi, and *Candida albicans*. The most potent inhibitory effect was consistently observed against *E. coli*. Comparative assessment indicated that while both vinegars possessed considerable bioactivity, the vinegar derived from *P. dactylifera* demonstrated marginally superior antimicrobial potency, which is attributed to its distinct phytochemical profile and higher acetic acid yield. The study concluded that the vinegars produced from date and mango possessed significant phytochemical and antimicrobial properties, and the sample produced from PD was slightly better than the sample produced from MI, mostly against *Escherichia coli*.

Keywords: Vinegar, Phytochemical, Antimicrobial, *Saccharomyces*, *Acetobacter*, *Staphylococcus*, *Escherichia*, *Candida*.

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Introduction

Fruit vinegars are functional fermented beverages valued not only as culinary condiments but also for their potential health-promoting properties, which are derived from the synergistic action of fermentation metabolites and residual phytochemicals from the fruit substrate (Guedes *et al.*, 2014; Xia *et al.*, 2020; Iheukwumere *et al.*, 2025a). The specific bioactivity profile of a vinegar, including its antioxidant and antimicrobial capacity, is intrinsically linked to the phytochemical composition of the raw fruit material used in its production (Jia *et al.*, 2012; Iheukwumere *et al.*, 2025b; Dim *et al.*, 2025a). Consequently,

exploring underutilized or highly nutritious fruits as substrates presents a significant opportunity to develop novel vinegars with enhanced functional characteristics.

Phoenix dactylifera L. (date palm) and *Mangifera indica* L. (mango) represent two such fruits with profound nutritional and ethnopharmacological significance. *P. dactylifera*, a cornerstone crop cultivated in arid regions for over six millennia, is renowned for its high concentration of sugars, dietary fibers, and phenolic compounds (Al-Shwyeh, 2019; Dim *et al.*, 2025b; Ekechukwu *et al.*, 2025a). Its fruits have a long history of use in traditional medicine systems for alleviating various ailments, a practice attributed to their rich content of bioactive phytochemicals (Hafzan *et al.*, 2017; Ejike *et al.*, 2017; Amadi *et al.*, 2017). Similarly, *M. indica* is one of the world's most important tropical fruits, celebrated for its flavour, vibrant colour, and impressive array of nutrients and bioactive compounds, including mangiferin, carotenoids, and ascorbic acid (Sivakumar *et al.*, 2011; Lauricella *et al.*, 2017; Obianom *et al.*, 2024). Both fruits are major dietary sources of polyphenols, compounds extensively studied for their antioxidant, anti-inflammatory, and antimicrobial effects (Duarte *et al.*, 2010; Lauricella *et al.*, 2017; Iheukeumere *et al.*, 2022a).

The biological production of vinegar from these substrates involves a two-stage microbial fermentation. Initially, yeasts (e.g., *Saccharomyces cerevisiae*) convert fermentable sugars into ethanol, which is subsequently oxidized to acetic acid by acetic acid bacteria (e.g., *Acetobacter* spp.) (Matthew *et al.*, 2019). This biotransformation process can modify the native fruit phytochemicals, potentially generating new bioactive compounds or altering their bioavailability, while the resultant acetic acid and other organic acids contribute directly to microbial inhibition (Jia *et al.*, 2012). Thus, vinegars produced from dates and mangoes are hypothesized to possess a potent combination of intrinsic fruit-derived bioactive and fermentation-derived antimicrobial agents.

Although foundational research exists on vinegar production from various fruits, including dates (Siddieg *et al.*, 2016) and mangoes (Ubeda *et al.*, 2013), and on the general bioactivity of such products (Jia *et al.*, 2012; Guedes *et al.*, 2014), a direct comparative analysis of the comprehensive phytochemical profiles and targeted antimicrobial efficacy of vinegars from *P. dactylifera* and *M. indica* remains underexplored. This gap limits a clear understanding of their relative potential as functional foods. Therefore, this study aims to systematically explore, characterize, and compare the phytochemical constituents and *in vitro* antimicrobial properties of vinegars produced from *Phoenix dactylifera* and *Mangifera indica* fruits.

Materials and Methods

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

Sample collection

Spoilt *Phoenix dactylifera* L. (date palm) and *Mangifera indica* L. (mango) 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 15 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 ($30\pm 2^{\circ}\text{C}$) for 48 h. Colonies with large clear zones around them were subcultured (Chude *et al.*, 2020; Ekechukwu *et al.*, 2025c; Ezedianafo *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), Ezedianafo *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 L. (date palm) and *Mangifera indica* L. (mango) 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 $30\pm 2^{\circ}\text{C}$. 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; Ezedianafo *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 ($30\pm 2^{\circ}\text{C}$). 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).

Phytochemical Analysis of the Vinegar Samples

The phytochemical components (alkaloids, glycosides, flavonoids, phenolics, tannins, steroids and saponins) of the samples were determined quantitatively using the methods described in the study published by Iheukwumere *et al.* (2025h), Idigo *et al.* (2025c), Idigo *et al.* (2025d), Ike *et al.* (2025d).

Alkaloids: Five milliliters of the sample was mixed with 96% ethanol and 20% tetraoxosulphate (VI) acid (1:1). One milliliter of the filtrate from the mixture was added to 5 ml of 60% tetraoxosulphate (VI) acid and allowed to stand for 5 minutes. Then 5 ml of 0.5% formaldehyde was added and allowed to stand for 3 h. The reading was taken at absorbance of 550nm (Ezedianafo *et al.*, 2025d; Idigo *et al.*, 2025d; Idigo *et al.*, 2025e).

Glycosides: This was carried out using Buljet's reagent. One millimeter of the sample was added in 9 ml of 70% alcohol for 2 h and then filtered with Whatman No. 1 filter paper. The extract was then purified using lead acetate solution and disodium

hydrogen tetraoxosulphate (VI) solution before the addition of freshly prepared Buljet's reagent. The absorbance was taken at 550nm (Obiefuna *et al.*, 2025b; Ike *et al.*, 2025d; Idigo *et al.*, 2025f).

Flavonoids: Five milliliters of the sample was mixed with 5 ml of dilute hydrochloric acid and boiled for 30 minutes. The boiled mixture was allowed to cool and then filtered with Whatman No. 1 filter paper. One milliliter of the filtrate was added to 5 ml of ethyl acetate and 5 ml of 1% ammonia solution. The absorbance was taken at 420nm (Idigo *et al.*, 2025g; Idigo *et al.*, 2025h).

Phenolics: Ten milliliters of the sample was boiled with 50 ml acetone for 15 minutes. Five milliliters of the solution was pipetted into 50 ml flask. The 10 ml of distilled water was added. This was followed by addition of 2 M ammonium hydroxide solution and 5 ml of concentrated amyl alcohol solution. The mixture was left for 30 minutes and absorbance was taken at 550nm (Idigo *et al.*, 2025i; Idigo *et al.*, 2025j).

Tannins: Ten milliliters was pipetted into 50 ml plastic containing 50 ml of distilled water. This was mixed for 1 h on a sterile mechanical shaker. The solution was filtered with Whatman No. 1 filter paper, and 5 ml of the filtrate was mixed with 2 ml of iron (III) chloride solution in 0.1 N hydrochloric acid. The absorbance was taken at 550nm (Idigo *et al.*, 2025k; Idigo *et al.*, 2025l).

Steroids: The sample was mixed with normal ammonium hydroxide solution. Two milliliters of eluate was mixed with 2 ml of chloroform in a test tube. Three milliliters of ice cold acetic anhydride was added to the mixture and allowed to cool. The absorbance was taken at 420nm (Idigo *et al.*, 2025m; Idigo *et al.*, 2025n; Idigo *et al.*, 2025o).

Saponins: Five milliliters of the sample was dissolved in aqueous methanol. The 0.25 ml of aliquot was taken for spectrophotometric determination for total saponins at 544nm (Idigo *et al.*, 2025p; Idigo *et al.*, 2025q).

Antimicrobial Activity of the Vinegar Samples

Collection and preparation of test organisms: The test organisms used for this study were *Staphylococcus aureus*, *Escherichia coli*, *Salmonella enterica* serovar Typhi and *Candida albican*. The test organisms were collected from ZAHARM Analytical and Research Laboratory, Awka, Anambra State. Catalase test, indole test, citrate/hydrogen sulphide production test and germ tube test were respectively carried out to confirm the identities of the test organisms. The pure isolates were scrapped in normal saline solution, subsequently diluted to match the turbidity of 0.5 MacFarland matching standard that was prepared by mixing 0.5 mL of 1.175 % BaCl₂·2H₂O and 9.95 mL of 1 % of concentrated H₂SO₄ to form 1.50×10^8 cells/mL

Agar-welled diffusion technique: This was carried out using the method described by Iheukwumere *et al.* (2017b), Idigo *et al.* (2025r). Each labeled plate was uniformly inoculated with the test organism using pour plate method. A sterile cork borer of 5 mm diameter was used to make the wells on the medium. One tenth milliliter of test sample was dropped into each labeled wells and then incubated at 37±2°C for 24 h. Antimicrobial activity was determined by measuring the diameter of the zones of inhibition (mm) produced after incubation.

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.*, 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 ($P > 0.05$).

Phytochemical Constituents of the Vinegars

The study revealed the presence of alkaloids, saponins, flavonoids, tannins, and glycosides as shown in Table 6. Alkaloids and saponins were non-significantly ($P > 0.05$) detected most in sample VM. Tannin was significantly ($P > 0.0$) detected most in VM. Flavonoids were non-significantly ($P. 0.05$) detected most in VD, whereas glycosides were detected most in VD.

Antimicrobial Activities of the Vinegar Samples

The study revealed significant activities of the vinegar samples against *S. aureus*, *E. coli*, *S. enterica* ser. Typhi and *C. albicans* as shown in Table 11. The study showed that sample VD showed the highest zones of inhibition when compared to samples VM and VS, but the variations in their zones of inhibition were statistically non-significant ($P > 0.05$). The zones of inhibition of the vinegar samples against *S. aureus*, *E. coli*, and *S. ser. Typhi* were significantly ($P < 0.05$) lower than that of ciprofloxacin (standard antibiotic) as shown in Table 7. Ketoconazole (standard antifungal agent) was able to inhibit only *C. albicans*, and the zone of inhibition is significantly ($P < 0.05$) higher than the zones of inhibition recorded by the vinegar samples against *C. albicans*.

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($\mu\text{g/mL}$)	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	11CC662508.1	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 Calcium Carbonate	Extract
	Count (CFU/mL)	Log CFU/mL	Count (CFU/mL)
2.0	5.10X10 ²	2.71	6.40X10 ²
4.0	4.70X10 ²	2.67	6.10X10 ²
6.0	4.30X10 ²	2.63	5.70X10 ²
8.0	4.10X10 ²	2.61	5.40X10 ²
10.0	3.80X10 ²	2.58	5.10X10 ²

Table 6: Phytochemical constituents of the vinegars

Parameter	VM (%)	VD (%)	VS (%)
Alkaloids	0.29 $\pm$ 0.01	0.17 $\pm$ 0.01	0.11 $\pm$ 0.00
Saponins	2.11 $\pm$ 0.03	1.93 $\pm$ 0.04	1.82 $\pm$ 0.13
Flavonoids	1.74 $\pm$ 0.11	2.19 $\pm$ 0.31	2.04 $\pm$ 0.07
Tannins	3.05 $\pm$ 0.17	1.86 $\pm$ 0.11	2.23 $\pm$ 0.13
Glycosides	1.04 $\pm$ 0.01	2.14 $\pm$ 0.14	2.04 $\pm$ 0.01
Steroids	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00

Table 7: Antimicrobial activities of the samples

Test organism	Diameter Zones of INHIBITION ($\bar{x}\pm\text{SD}$) mm				
	VM	VD	VS	CPX	KET
<i>S. aureus</i>	6.70 $\pm$ 0.14	7.40 $\pm$ 0.11	6.90 $\pm$ 0.21	14.10 $\pm$ 0.33	0.00 $\pm$ 0.00
<i>E. coli</i>	7.80 $\pm$ 0.42	8.50 $\pm$ 0.00	8.40 $\pm$ 0.21	28.50 $\pm$ 0.11	0.00 $\pm$ 0.00
<i>S. ser. Typhi</i>	7.10 $\pm$ 0.81	7.90 $\pm$ 0.14	7.90 $\pm$ 0.11	19.50 $\pm$ 0.14	0.00 $\pm$ 0.00
<i>C. albicans</i>	6.80 $\pm$ 0.11	7.30 $\pm$ 0.58	7.10 $\pm$ 0.22	0.00 $\pm$ 0.00	17.10 $\pm$ 0.00

CPX= Ciprofloxacin; KET= Ketoconazole

Discussion

This study systematically investigates the phytochemical profiles and *in vitro* antimicrobial properties of vinegars derived from *Phoenix dactylifera* (date) and *Mangifera indica* (mango) fruits. Vinegar is a fermented liquid containing numerous functional compounds, including organic acids, vitamins, minerals, amino acids, and phytochemicals such as phenolics, flavonoids, and tannins (Hamidalu, 2014). The present production of vinegar from these fruit sources aligns with the work of previous researchers (Tengberg, 2012; Cantadori *et al.*, 2022; Habiba *et al.*, 2024; Iheukwumere *et al.*, 2025j).

Microbial analysis revealed that the characteristic features of the yeast isolate from date fruit were consistent with established findings (Mohammed *et al.*, 2021; Chibi and El Haldi, 2019; Atitallah *et al.*, 2021; Ahmad *et al.*, 2021). Specifically, the isolation of *Saccharomyces cerevisiae* strain Ysr128 (SC 128) from spoiled *Phoenix dactylifera* samples corroborates the reports of Ahmad *et al.* (2021) and Ugobogu *et al.* (2025). Similarly, the cultural, morphological, and biochemical characteristics of the bacterial isolate from mango fruit matched descriptions by several researchers (Ceolho *et al.*, 2017; Adebayo-Oyetoro *et al.*, 2017; Boutenin *et al.*, 2021; Iheukwumere *et al.*, 2025k), with the presence of *Acetobacter aceti* strain w1 (AAWI) further supporting findings by Ndoeye *et al.* (2022).

In this study, vinegar produced from date fruits yielded 5.2% acetic acid, a concentration higher than that reported for many other fruits. This maximum acetic acid production is in agreement with research on other substrates, such as green apple (Klawpiyapamokun *et al.*, 2015; Iheukwumere *et al.*, 2025l; Iheukwumere *et al.*, 2025m) and mango juice (Ouattara *et al.*, 2018).

Phytochemical screening confirmed the presence of alkaloids, saponins, flavonoids, tannins, and glycosides in the vinegar samples, supporting the findings of Hamidatun (2014) and Zubaidah (2015). The combination of acetic acid, flavonoids, and other antioxidants in vinegar is known to prevent oxidative damage caused by free radicals (Yuliant *et al.*, 2015; Iheukwumere *et al.*, 2025n). Furthermore, the antioxidant potentials of flavonoids, tannins, and phenolics protect cells and organs from oxidative stress (Yuliant *et al.*, 2019; Han *et al.*, 2016). Saponins contribute additional biological activities, including medicinal and antimicrobial properties (Safrida *et al.*, 2023).

The vinegar samples exhibited inhibitory activity against *Staphylococcus aureus*, *Escherichia coli*, *Salmonella enterica* serovar Typhi, and *Candida albicans*. This antimicrobial effect can be attributed to the bioactive phytochemical constituents present, a conclusion supported by other researchers (Senguen *et al.*, 2020; Singh and Garg, 2022; Iheukwumere *et al.*, 2025n). The slightly greater inhibitory activity observed in vinegar from *P. dactylifera* may be due to the potency of its phytochemicals and its higher acetic acid content. The highest activity recorded against *E. coli* is likely attributable to the specific nature of this organism's cell wall.

Conclusion

The study has shown that vinegar samples produced from *Mangifera indica* (MI/Mango) and *Phoenix dactylifera* (PD/Date) fruits possessed significant phytochemical and antimicrobial properties, and the sample produced from PD was slightly better than the sample produced from MI, mostly against *Escherichia coli*.

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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

- Adebayo-Oyetoro, A. O., Adenubi, E., Ogundipe, O. O., Bankole, B. O., & Adeyeye, S. A. O. (2017). Production and quality evaluation of vinegar from mango. *Cogent Food & Agriculture*, 3(1), 1278193.
- 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.
- 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.
- Coelho, E., Genisheva, Z., Oliveira, J. M., Teixeira, J. A., & Domingues, L. (2017). Vinegar production from fruit concentrates: Effect on volatile composition and antioxidant activity. *Journal of food science and technology*, 54(12), 4112-4122.
- 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.
- 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., Ogbonnaya, 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., Ogbonnaya, 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., Ogbonnaya, 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/iajnfs.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., Ihechukwu, C. C., Ike, V. E., Okereke, F. O., & Ochibulu, S. C. (2025). Hying the Inhibitory Activity of *Xylopiia 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/10.54117/3vwg0p36>
- 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/wjmnvy91>
- Ezendianefor, 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>
- Ezendianefor, 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>
- Ezendianefor, 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>
- 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.
- Habiba, U., Alam, A. I., Aunsary, L., Jubayer, M. F., Karmoker, P., Alim, M. A., & Mazumder, M. A. R. (2024). Exploring the potential of wild date palm (*Phoenix Sylvestris* L. Roxb) fruits for vinegar production in Bangladesh. *Applied Food Research*, 4(2), 100628.
- 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
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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., Ezendianefor, 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/10.54117/2k0d9r18>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, 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., Ezendianefor, 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., Ezendianefor, 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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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., Ezendianefor, 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. (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/ijjbs.v5i1.106>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, 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. (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/ijjbs.v5i1.105>
- Idigo, M. A., Iheukwumere, I. H., Iheukwumere, C. M., Nnaeze, B. C., Akulue, C. J., Nwakoby, N. E., Ezendianefor, 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. (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., Ezendianefor, 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. (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/iimj.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/qbwbbp15>
- 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., Nnadozie, 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., Nnadozie, 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., Ajeh, J. C., Iheukwumere, C. M., Ike, V. E., Obianom, A. O., Ihenatuoha, U. A., ... & Ilechukwu, C. C. (2025). 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.
- 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 Intelligentsia 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/ijbs.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., Ogbonnaya, 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., Ogbonnaya, 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/10.54117/8bttte840>
- Ike, V. E., Iheukwumere, I. H., Iheukwumere, C. M., Dim, C. N., Ezendianefo, J. N., Egbe, P. A., Oragwu, I. P., Orji, C. C., Ogbonnaya, 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., Ogbonnaya, 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., Ogbonnaya, 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>
- 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.
- 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 *Xylopiia 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., 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

- 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
- 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 cider vinegar treated selected vegetables against common food borne bacterial pathogens. *Bioscience Biotechnology Research Communications* 15 (2): 350 – 356.
- 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.
- 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. (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>
- 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

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