

Phoenix dactylifera and Cherry Fruit Vinegars: A Study on their Phytochemical Composition and Antimicrobial Activity

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ABSTRACT

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The rising global threat of antimicrobial resistance has accelerated the search for effective natural antimicrobials. Fruit vinegars, traditionally valued for their potential therapeutic properties, are promising candidates; however, the specific phytochemical composition and antimicrobial efficacy of vinegars derived from *Phoenix dactylifera* (date) and *Prunus avium* (cherry) remain underexplored. This study aimed to characterize the phytochemical profiles and evaluate the antimicrobial potential of vinegars produced from these fruits. Yeast and acetic acid bacteria were isolated from spoiled fruit samples and characterized using standard microbiological techniques. Vinegar was produced via submerged fermentation of the extracted fruit musts. The physicochemical properties, nutrient content, and phytochemical constituents were analyzed using gravimetric and instrumental methods. *In vitro* antimicrobial activity was assessed against *Staphylococcus aureus*, *Escherichia coli*, *Salmonella enterica* serovar Typhi, and *Candida albicans*. Data were analyzed using Analysis of Variance (ANOVA) and post-hoc Tukey's test at a 95% confidence level. Phytochemical screening confirmed the presence of alkaloids, saponins, flavonoids, tannins, and glycosides in both vinegar samples, fermented using *Saccharomyces cerevisiae* strain SR 128 and *Acetobacter aceti* strain WI. The vinegars demonstrated significant ($p < 0.05$) inhibitory activity against all tested pathogens, with the most potent effect observed against *E. coli*. In conclusion, vinegars from *Prunus avium* (cherry) and *Phoenix dactylifera* (date) possess considerable phytochemical and antimicrobial properties, with date vinegar exhibiting marginally superior efficacy. Therefore, the prepared vinegar samples from PA and PD possessed significant phytochemical and antimicrobial properties, and the sample produced from PD was slightly better than the sample produced from PA.

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

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INTRODUCTION

Fruit vinegars are increasingly recognized as functional fermented products, whose health-promoting potential extends beyond their role as culinary condiments. This bioactivity stems from the synergistic interplay between fermentation-derived organic acids and the complex array of phytochemicals retained from the fruit substrate (Xia *et al.*, 2020; Iheukwumere *et al.*, 2025a; Iheukwumere *et al.*, 2025b). The specific antimicrobial and antioxidant profile of a given vinegar is fundamentally determined by the unique phytochemical composition of its raw material (Jia *et al.*, 2012; Dim *et al.*, 2025a; Dim *et al.*, 2025b). Investigating vinegars produced from fruits with distinct and potent bioactive profiles is therefore essential for developing novel functional foods with targeted health benefits.

Phoenix dactylifera L. (date palm) and *Prunus avium* L. (sweet cherry) represent two nutritionally significant fruits with complementary bioactive properties and considerable, yet underexplored, potential for artisanal vinegar production. Cultivated in arid regions for millennia, *P. dactylifera* is prized for its high concentration of sugars, dietary fiber, and phenolic compounds (Al-Shwyeh, 2019; Dim *et al.*, 2025c;

Ekechukwu *et al.*, 2025a). Its fruits possess a well-documented ethnopharmacological history, attributed to a diverse spectrum of bioactive constituents with demonstrated therapeutic value (Hafzan *et al.*, 2017; Ejike *et al.*, Amadi *et al.*, 2017). In contrast, *P. avium* is a widely consumed temperate fruit celebrated not only for its sensory qualities but also for its exceptionally rich content of anthocyanins, hydroxycinnamic acids, and melatonin (McCune *et al.*, 2010; Ferretti *et al.*, 2010; Nwike *et al.*, 2017; Obianom *et al.*, 2022a). These compounds are strongly associated with potent antioxidant, anti-inflammatory, and potential antimicrobial activities, making cherry vinegar a promising functional product (Gonçalves *et al.*, 2017).

The biotechnological production of vinegar from these substrates follows a sequential microbial fermentation. Initially, yeasts such as *Saccharomyces cerevisiae* metabolize fermentable sugars into ethanol. This ethanol is subsequently oxidized to acetic acid by acetic acid bacteria, primarily from genera such as *Acetobacter* and *Komagataeibacter* (Matthew *et al.*, 2019).

This biotransformation process can modify the native phenolic profile, potentially enhancing bioavailability and bioactivity, while the resultant acetic and other organic acids contribute direct antimicrobial effects (Jia *et al.*, 2012). Consequently, vinegars derived from dates and cherries are hypothesized to possess a distinctive combination of fruit-specific polyphenols and fermentation-generated antimicrobial agents.

While foundational research exists on vinegar production from various fruits, including dates (Siddeeg *et al.*, 2016), and on the general bioactive properties of fruit vinegars (Guedes *et al.*, 2014), a dedicated and comparative analysis of vinegar from *P. avium* is notably scarce. Furthermore, a systematic investigation directly comparing the comprehensive phytochemical fingerprint and resultant antimicrobial efficacy of vinegars from *P. dactylifera* and *P. avium* is absent from the literature. This gap limits a clear understanding of their relative value and potential applications as functional fermented products. Therefore, this study aims to systematically characterize and compare the phytochemical constituents and *in vitro* antimicrobial properties of vinegars produced from *Phoenix dactylifera* dates and *Prunus avium* cherries.

MATERIALS AND METHODS

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

Sample collection

Spoilt *Phoenix dactylifera* (Date) and *Prunus avium* L. (sweet cherry) fruits were collected from different points in Nkwo Oba market, Idemili South LGA, Anambra State. The fruits were detected through sight and nasal perception; this was followed by carefully and selectively picking of the detected fruits into polyethene bags. The polythene bags were appropriately labeled and transported immediately to the laboratory for further analysis.

Sample preparation

The fruit samples were thoroughly washed using distilled water and their ectocarps were appropriately peeled using stainless chicken knife. The peeled fruits were pulverized using electric blender (SMX425/Japan). This was serially diluted (1:10) using 250 mL conical flask (Pyrex) in the capacity of 10 g of the fruit sample to make up 200 mL of the sample solution. The solution was thorough 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; 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 (commonly known as Date) and *Prunus avium* L. (commonly known as sweet 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; Ezedianafa *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).

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 (Ezedianafa *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 of 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 × 10⁸ 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 10. Alkaloids and saponins were non-significantly ($P > 0.05$) detected most in sample VA. Tannin was significantly ($P > 0.0$) detected most in VA. Flavonoids was non-significantly ($P. 0.05$) detected most in VD whereas glycosides was 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 VA and VS but the variations in their zones of inhibition were statically 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 11. 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 inhibitions 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(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: Phytochemical constituents of the vinegars

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

Table 7: Antimicrobial activities of the samples

Test organism	Diameter Zones of INHIBITION ($\bar{x} \pm SD$) mm				
	VC	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 provides a systematic comparative analysis of the phytochemical composition and *in vitro* antimicrobial efficacy of vinegars produced from *Phoenix dactylifera* (date) and *Prunus avium* L. (sweet cherry). The fermentation of spoiled fruit substrates into value-added products like vinegar aligns with current trends in food waste valorization.

Microbiological analysis of the fermentative agents confirmed the presence of key organisms. The yeast isolate from spoiled date fruit was identified as *Saccharomyces cerevisiae*, a finding consistent with its well-documented role as the predominant fermentative yeast in fruit-based substrates (Mohammed *et al.*, 2021; Chibi and El Haldi, 2019; Atitallah *et al.*, 2021; Ahmad *et al.*, 2021). Specifically, the detection of strains such as *S. cerevisiae* Ysr128 corroborates recent genomic studies on fermentative date palm microbiota (Ahmad *et al.*, 2021; Ugobogu *et al.*, 2025). Concurrently, the bacterial isolate from cherry exhibited morphological and biochemical profiles characteristic of *Acetobacter* species, which are essential for the acetification stage of vinegar production (Budak, 2017; Kok-Tas, 2019; Ozen *et al.*, 2020; Budak, 2021). This was further supported by molecular identification matching *Acetobacter aceti* strain w1, a high-yield acetic acid producer previously isolated from fermented fruits (Baltaci *et al.*, 2024).

The successful production of vinegar from these fruits adds to the growing body of research on alternative fermentation substrates, extending work on date fruits (Tengberg, 2012; Habiba *et al.*, 2024; Iheukwumere *et al.*, 2025j) and other plant materials (Armi *et al.*, 2023; Chibi and El Haldi, 2019; Cantadori *et al.*, 2022). The resulting product is a complex matrix rich in functional compounds, including organic acids, vitamins, minerals, and bioactive phytochemicals such as phenolics and flavonoids, as previously described (Hamidalu, 2014). Notably, the acetic acid yield from date fruit vinegar (5.2%) exceeded typical yields from several other fruits, demonstrating its superior fermentable sugar content. This high yield is consistent with optimization studies for acetic acid production from fruit juices, including those from green apple and mango (Klawplyapamornkun *et al.*, 2015; Ouattara *et al.*, 2018; Iheukwumere *et al.*, 2025k).

Phytochemical profiling revealed the presence of alkaloids, saponins, flavonoids, tannins, and glycosides in both vinegar samples, confirming the retention of bioactive plant compounds through fermentation, as reported in other fruit vinegars (Hamidatun, 2014; Zubaidah, 2015; Iheukwumere *et al.*, 2025l). The identified phytochemicals are known for their significant bioactivities. The synergy between acetic acid and polyphenolic antioxidants like flavonoids can mitigate oxidative damage by scavenging free radicals (Yulianti *et al.*, 2015). Flavonoids, tannins, and phenolics collectively contribute strong antioxidant potential, offering protection against cellular oxidative stress (Yulianti *et al.*, 2019; Han *et al.*, 2016; Iheukwumere *et al.*, 2025m). Furthermore, saponins possess diverse biological properties, including notable antimicrobial effects, which may enhance the functional profile of the vinegar (Safrida *et al.*, 2023).

The inhibitory activities of the vinegar samples against *S. aureus*, *E. coli*, *Salmonella enterica* serovar Typhi and *Candida albicans* could be attributed to the activities of the phytochemical constituents/bioactive substances in the vinegar samples. Similar conclusion was drawn by many researchers (Senguen *et al.*, 2020; Singh and Garg, 2022; Iheukwumere *et al.*, 2025n). The slight increase in the inhibitory activities from *P. dactylifera* fruits could be attributed to the potency of the phytochemicals and high acetic acid content of the vinegar samples. The highest activity of the vinegar samples against *E. coli* could be attributed to the nature of the organism, majorly the nature of the bacterial cell wall.

CONCLUSION

The study has shown that vinegar samples produced from *Phoenix dactylifera* (PD/Date) and *Prunus avium* L. (PA/sweet cherry) fruits possessed significant phytochemical and antimicrobial properties, and the sample produced from PD was slightly better than the sample produced from MS, mostly against *Escherichia coli*.

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

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