



# Microbial Quality and Sensory Assessment of Vinegar from Date Palm and Grape Fruits: Implications for Consumer Preference

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Abstract	Article History
<p>The microbial safety and sensory appeal of fruit vinegar are critical determinants of product quality and consumer acceptance, yet these attributes remain underexplored for vinegar produced from many fruit substrates. This study aimed to evaluate the microbial quality and sensory profile of vinegar derived from <i>Phoenix dactylifera</i> (date palm) and <i>Vitis vinifera</i> (grape) and to assess its implications for consumer preference. Using standard microbiological techniques, fermentative microorganisms, including <i>Saccharomyces cerevisiae</i> strain SR 128 and <i>Acetobacter aceti</i> strain WI were isolated from spoiled fruits and employed in the submerged fermentation of fruit musts. The microbial load of the final vinegar was quantified via standard plate counts, and sensory evaluation was conducted with validated panelists using a 9-point hedonic scale to assess attributes such as colour, aroma, taste, and overall acceptability. Statistical analysis was performed using Analysis of Variance (ANOVA) and Tukey's post-hoc test. Results indicated that both vinegars contained microbial counts within permissible regulatory limits, with no statistically significant differences (<math>p &gt; 0.05</math>) in total aerobic mesophilic, acetic acid bacterial, or yeast counts between the two samples. Sensory analysis revealed favourable ratings across all evaluated attributes, confirming the products' general acceptability among consumers. In conclusion, vinegar produced from <i>Phoenix dactylifera</i> and <i>Vitis vinifera</i> exhibits compliant microbial quality and favourable sensory characteristics, supporting its potential for market introduction. The date palm vinegar received marginally higher preference scores, indicating subtle yet notable advantages in consumer appeal.</p> <p><b>Keywords:</b> Vinegar, Microbial, Sensory, <i>Saccharomyces</i>, <i>Acetobacter</i></p>	<p>Received: 05 Jan 2026 Accepted: 14 Feb 2026 Published: 20 Feb 2026</p>  <p>Scan QR code to view*</p> <p>License: CC BY 4.0*</p>  <p>Open Access article.</p>
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## Introduction

Vinegar is a globally recognized fermented condiment produced through a sequential two-stage microbial process: an initial alcoholic fermentation of fermentable carbohydrates, followed by the acetous fermentation of ethanol into acetic acid (Budak *et al.*, 2014; Iheukwumere *et al.*, 2025a; Dim *et al.*, 2025a). This biochemical conversion, typically facilitated by *Saccharomyces cerevisiae* yeasts and *Acetobacter* species bacteria, can utilize a diverse array of carbohydrate-rich fruits, including grapes (*Vitis vinifera*) and dates (*Phoenix*

*dactylifera*) (Hutchinson *et al.*, 2019; Iheukwumere *et al.*, 2025b; Dim *et al.*, 2025b). The final product's quality, stability, and consumer appeal are fundamentally determined by its microbial composition and sensory characteristics.

In contemporary food systems, vinegar is indispensable as a flavouring agent, preservative, and base for condiments (Saha and Banerjee, 2013; Ejike *et al.*, 2017; Ekechukwu *et al.*, 2025a). While its functional properties are largely governed by its acetic acid content and low pH (Alboronoz, 2012; Amadi *et*

al., 2017; Nwike *et al.*, 2017), consumer preference and market success are directly tied to its sensory profile, encompassing attributes like aroma, taste, colour, and clarity. Furthermore, the product's safety and shelf-life are intrinsically linked to its microbial quality. Given the antimicrobial nature of acetic acid, properly fermented vinegar typically hosts a specialized microflora dominated by acetic acid bacteria (AAB), which require specific media for isolation and analysis (Sharma *et al.*, 2018; Obianom *et al.*, 2024).

While extensive research details the sensory and microbial profiles of established commercial vinegars, such as those from apples or grapes (Chen *et al.*, 2016; Sharma *et al.*, 2018; Iheukwumere *et al.*, 2022a), comprehensive data on vinegars from alternative fruits like date palm remains limited. The distinct biochemical composition of date fruit suggests the potential for a vinegar with unique sensory attributes and microbial dynamics compared to the well-characterized grape vinegar. A direct comparative assessment is necessary to understand how these substrates influence final product quality. Therefore, this study aims to conduct a comprehensive comparative assessment of vinegar produced from *Phoenix dactylifera* (date palm) and *Vitis vinifera* (grape) fruits.

## Materials and Methods

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

#### Sample collection

Spoilt *Phoenix dactylifera* (date palm) and *Vitis vinifera* (grape) 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 polyethylene 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%), CaCO<sub>3</sub> (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 *Vitis vinifera* (commonly known as Grape) 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; 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±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).

### Microbial Analyses of the Vinegar

The microbial analyses of the vinegar were carried out using the standard plate count technique as described in Cheesbrough (2010), Iheukwumere *et al.* (2025h), Idigo *et al.* (2025c), Idigo *et al.* (2025d), and Ike *et al.* (2025d) with slight modification in the choice of media used. The total spore counts were carried out by growing the heated samples on Nutrient Agar (BIOTECH) at 35±2°C for 24 h. The total *Bacillus cereus* counts were carried out by growing the heated samples on Mannitol Nutrient Agar (MNA) at 35±2°C for 24 – 48 h as described by Ezedianafo *et al.* (2025d), Idigo *et al.* (2025d), Idigo *et al.* (2025e). The total mesophilic aerobic

bacterial counts were carried out by growing the samples on nutrient agar (BIOTECH H) at 35±2°C for 24 h. The total acetic acid bacterial count was carried out by growing the samples at GYC agar at room temperature (30±2°C) for 24 h. The total lactic acid bacterial counts were carried out by growing the samples on Demann Rogosa Sharpe (MRS) agar at 30±2°C for 48 h. The total yeast and mold counts were carried out by growing the samples on Sabouraud Dextrose Agar (SDA) at 35±2°C and 30±2°C, respectively, for 24 hours and 5 days respectively as described by Obiefuna *et al.* (2025b); Ike *et al.* (2025d); Idigo *et al.* (2025f) Idigo *et al.* (2025g), Idigo *et al.* (2025h).

### Sensory Evaluation of the Prepared Vinegar

Sensory Evaluation: In house consumer-oriented test was conducted to determine product acceptability using scoring test with the aid of 9-points hedonic scale with little modification in the studies published by Adedokun *et al.* (2013), Piotrowska *et al.* (2015) and Enidiok *et al.* (2017), Idigo *et al.* (2025i); Idigo *et al.* (2025j), Idigo *et al.* (2025k); Idigo *et al.*, (2025l) . The sensory characteristics of the vinegar samples such as colour, odour, taste and general acceptability was examined by the team of twenty (20) validated panelists which was drawn from microbiology students of Chukwemeka Odumegwu Ojukwu University, Uli. The panelists were validated in such a way that they were able to detect little perceptible changes in the sensory attributes mentioned. Each panelist was asked to score each coded sample based on a nine point hedonic scale (like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much, dislike extremely) as described by Idigo *et al.*, 2025m; Idigo *et al.*, 2025n; Idigo *et al.*, 2025o.

### 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 ( $P > 0.05$ ).

**Microbial Qualities of the Vinegar Samples**

The study revealed count values for total mesophilic aerobic bacterial counts (TMABC), total acetic acid bacterial counts (TABC) and total yeast counts (TYC) for the three vinegar samples. The TMABC was significantly ( $P < 0.05$ ) higher in vinegar bought from the supermarket (VS) whereas the vinegar prepared from apples (VA) and dates (VD) non-significantly ( $P > 0.05$ ) showed slight variations in their TMABC as shown in Table

6. There was also slight variations in TABC of VA and VD and these were non-significantly ( $P > 0.05$ ) higher than that of VS. There were variations in TYC, and this was non-significantly ( $P > 0.05$ ) most in VA. There was no total spore counts (TSC), total *Bacillus cereus* counts (TBCC), total lactic acid bacterial counts (TLBC) and total mold counts (TMC) detected in VA and VD; TSC, TBC, TLBC, and TMB were within the stipulation limit of National Industrial Standard (NIS).

**Sensory Evaluation and Acceptability of the Vinegar Samples**

The study on the sensory evaluation and acceptability of the vinegar samples are shown in Table 7. The study revealed that the colour of the vinegar samples were like moderately in the 9-point hedonic scale. The taste of the vinegar samples were within neither like nor dislike points, and the odour was within like slightly in the point scale. The general acceptability of the vinegar samples was seen within like very much in the 9-point hedonic scale.

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 acetii</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	$5.10 \times 10^2$	2.71	$6.40 \times 10^2$	2.81
4.0	$4.70 \times 10^2$	2.67	$6.10 \times 10^2$	2.79
6.0	$4.30 \times 10^2$	2.63	$5.70 \times 10^2$	2.76
8.0	$4.10 \times 10^2$	2.61	$5.40 \times 10^2$	2.73
10.0	$3.80 \times 10^2$	2.58	$5.10 \times 10^2$	2.71

Table 6: Microbial qualities of the vinegar samples

Count	VG	VD	VS
TMABC (CFU/mL/LogCFU/mL)	$5.40 \times 10^2$ (2.73)	$5.10 \times 10^2$ (2.71)	$9.20 \times 10^2$ (2.96)
TBCC(CFU/mL/LogCFU/mL)	0(0)	(0)	$0.60 \times 10^2$ (1.78)
TSC (CFU/mL/LogCFU/mL)	0(0)	0(0)	$2.20 \times 10^2$
TABC(CFU/mL/LogCFU/mL)	$7.60 \times 10^2$ (2.88)	$7.90 \times 10^2$ (2.90)	$6.80 \times 10^2$ (2.83)
TLBC(CFU/mL/LogCFU/mL)	0(0)	0(0)	$1.20 \times 10^2$ (2.08)
TYC(CFU/mL/LogCFU/mL)	$2.60 \times 10^2$ (2.41)	$2.10 \times 10^2$ (2.32)	$6.80 \times 10^2$ (2.226)
TMC(CFU/mL/LogCFU/mL)	0(0)	0(0)	$0.30 \times 10^2$ (1.48)

Table 7: Sensory parameters and acceptability of the vinegar samples

Parameter	VG	VD	VS
Colour	$0.74 \pm 0.01$	$0.71 \pm 0.01$	$0.76 \pm 0.01$
Taste	$0.51 \pm 0.001$	$0.52 \pm 0.01$	$0.56 \pm 0.01$
Odour	$0.64 \pm 0.01$	$0.62 \pm 0.01$	$0.61 \pm 0.01$
General Acceptability	$0.82 \pm 0.01$	$0.84 \pm 0.01$	$0.84 \pm 0.1$

## Discussion

Fruit vinegars, recognized as functional foods with both culinary and ethnomedicinal value, are produced through a sequential fermentation process involving alcoholic and acetic

fermentation (Hamidalu, 2014; Iheukwumere *et al.*, 2025j). This study assessed the microbial quality and sensory attributes of vinegar produced from *Phoenix dactylifera* (date)

and *Vitis vinifera* (grape), with implications for consumer preference and product safety.

The microbial isolates obtained in this study align with established literature on fruit fermentation. Yeast isolated from date fruit exhibited characteristics consistent with *Saccharomyces cerevisiae*, as previously documented by Mohammed *et al.* (2021), Chibi and El Haldi (2019), Atitallah *et al.* (2021), and Ahmad *et al.* (2021). Also, the identification of *Saccharomyces cerevisiae* strain Ysr128 (SC 128) from spoiled date samples corroborates with the findings of Ahmad *et al.* (2021) and Ugobogu *et al.* (2025). Similarly, bacterial isolates from grape fruit displayed cultural, morphological, and biochemical profiles matching those described for *Acetobacter* species by Navarro *et al.* (2013), Arifuzzman *et al.* (2014), and Klawpiyapamokun *et al.* (2015). The presence of *Acetobacter acetii* strain w1 (AAWI) in spoiled grape samples further supports the work of Rahman *et al.* (2024). The successful acetic acid fermentation of both substrates is consistent with established protocols for fruit vinegar production (Tengberg, 2012; Mohammed *et al.*, 2018; Cantadori *et al.*, 2022), paralleling studies on diverse plant sources (Klawpiyapamokun *et al.*, 2015; Atitallah *et al.*, 2021; Ahmad *et al.*, 2018; Iheukwumere *et al.*, 2025k). The microbial counts in the vinegar samples were in accordance with the National Industrial Standard (NIS). Total mesophilic aerobic bacterial counts (TMABC), total acetic acid bacterial counts (TABAC), and total yeast counts (TYC) all fell within acceptable limits. Notably, no detectable counts of *Bacillus cereus* (TBCC), lactic acid bacteria (TLBC), or molds (TMC) were recorded. This absence contrasts with some previous studies, which reported the presence of these microorganisms in vinegar samples (Ruth *et al.*, 2014; Li *et al.*, 2015; Jones *et al.*, 2019; Iheukwumere *et al.*, 2025l), and may reflect differences in raw material handling, fermentation conditions, or hygiene practices during production. Sensory quality is a critical determinant of overall product acceptability and an indirect indicator of safety. In this study, the sensory profiles of both vinegars were favourable, suggesting good quality and safety. These findings are consistent with prior sensory evaluations of fruit-derived vinegars (Adebayo-Oyetero *et al.*, 2017; Chen *et al.*, 2025; Iheukwumere *et al.*, 2025m; Iheukwumere *et al.*, 2025n), supporting their potential for consumer acceptance.

## Conclusion

The study has shown that the prepared vinegar samples from *Vitis vinifera* (VV/Grape) and *Phoenix dactylifera* (PD/Date) fruits had microbial qualities that conformed to the stipulated standard, preferred and acceptable, and the sample prepared from PD was slightly better.

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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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