ANTIBACTERIAL EFFECTS OF NEGRO PEPPER EXTRACT ON MEATS IN MILE 1 MARKET, PORT -HARCOURT

ABSTRACT

Negro pepper (*Xylopia aethiopica*) is gaining attention as a natural alternative to synthetic preservatives like sodium benzoate and potassium sorbate. This study aims to evaluate the antibacterial activity, sensory attributes, and potential for extending meat shelf life using Negro pepper extract in Port Harcourt, Nigeria. The extract was tested at concentrations of 25, 50, 75, and 100 mg/mL against *Escherichia coli, Salmonella typhi, Staphylococcus aureus, Shigella spp., Bacillus spp., Campylobacter jejuni*, and *Pseudomonas aeruginosa*. Ethanol served as a control, with sodium benzoate and potassium sorbate as benchmarks. Results revealed that Negro pepper extract exhibited increasing antibacterial activity with concentration, showing the highest inhibition at 100 mg/mL, comparable to or exceeding synthetic preservatives. ANOVA confirmed significant differences among treatments ($p < 0.0001$). Sensory evaluation demonstrated that Negro pepper scored highest for taste, aroma, color, and texture, with an overall acceptability score of 8.1 ± 0.51, significantly surpassing that of sodium benzoate, potassium sorbate, and the untreated control. In terms of shelf life, the microbial load in meat treated with Negro pepper extract was substantially lower at 1.1 x 10^6 CFU/g by Day 14, compared to 3.5 x 10^7 CFU/g in the untreated control. ANOVA indicated significant differences in microbial load over time ($p < 0.0001$).The findings suggest that Negro pepper extract is a potent natural preservative with significant antibacterial effects, excellent sensory qualities, and efficacy in extending meat shelf life.

Keywords: synthetic preservative, antibacterial activity, *xylopia aethiopica*

INTRODUCTION

The study of the antibacterial effects of Negro pepper extract, derived from *Xylopia aethiopica*, on meats sold at Mile 1 Market in Port Harcourt, explores a vital intersection of food safety, public health, and traditional knowledge. Negro pepper, also known as Uda, is a spice deeply embedded in the culinary and medicinal traditions of West Africa. This plant is renowned not only for its strong, distinctive flavor but also for its rich composition of bioactive compounds, including alkaloids, flavonoids, tannins, and essential oils. These compounds have attracted significant scientific attention due to their potential antimicrobial properties, making Negro pepper a promising candidate for natural food preservation, especially in markets where meat products are prone to bacterial contamination.

Mile 1 Market in Port Harcourt is a major commercial center, serving as a primary source of fresh meat and other food products for the local population. Like many traditional open-air markets in developing regions, Mile 1 Market faces significant challenges in maintaining food hygiene and safety. The conditions, under which meats are sold, often involving prolonged exposure to ambient temperatures and high humidity, provide an ideal environment for the proliferation of harmful microorganisms. These microorganisms, including *Escherichia coli*, *Salmonella spp.*, and *Staphylococcus aureus*, are common contaminants in such settings and are known to cause severe foodborne illnesses, posing serious public health risks (Brown et al., 2015). .

The reliance on natural preservatives like Negro pepper extract is rooted in the need for effective and affordable methods to curb microbial contamination in meat products, particularly in regions where modern refrigeration and preservation technologies are either unavailable or unreliable. The antimicrobial properties of Negro pepper have been attributed to its phytochemical constituents, which are believed to exert their effects through multiple mechanisms. These mechanisms include the disruption of bacterial cell membranes, inhibition of nucleic acid synthesis, and interference with enzymatic activities vital to bacterial survival and replication(Ogbonna et al., 2013) . By exploring these properties in the context of Mile 1 Market, this study seeks to provide a scientific basis for the use of Negro pepper as a natural preservative, potentially reducing the incidence of foodborne diseases associated with meat consumption in this region.

Several studies have demonstrated the effectiveness of *Xylopia aethiopica* in inhibiting the growth of common foodborne pathogens. For instance, research has shown that Negro pepper extract can significantly reduce the bacterial load on meat surfaces, thereby extending shelf life and improving the overall safety of meat products (Nwosu et al., 2019). This is particularly important in markets like Mile 1, where meats are often stored and displayed under conditions that do not meet standard food safety protocols. The application of Negro pepper extract could offer a low-cost, culturally acceptable method to mitigate the risks associated with meat spoilage and contamination.

The use of natural preservatives like Negro pepper aligns with the growing global demand for food products free from synthetic chemicals. Consumers are increasingly concerned about the potential health risks posed by artificial preservatives, driving interest in natural alternatives. In this context, Negro pepper not only serves as an antimicrobial agent but also as a source of beneficial phytochemicals that may contribute to the nutritional and therapeutic value of the meat (Urugo et al., 2024).. These additional benefits highlight the multifaceted role that Negro pepper could play in enhancing food quality and safety.

The antibacterial activity of Negro pepper extract in meat preservation has been supported by empirical evidence from both in vitro and in vivo studies. Laboratory experiments have demonstrated that meats treated with Negro pepper extract exhibit significantly lower bacterial counts compared to untreated controls. These findings suggest that Negro pepper could be effectively used as a preservative in traditional markets, where modern preservation methods are not feasible (Ezeokeke et al., 2021). Furthermore, field studies conducted in similar market environments have shown that the regular use of Negro pepper extract can lead to a reduction in the incidence of foodborne illnesses among consumers, underscoring its potential public health benefits.

Despite these promising findings, there remain challenges and areas for further research. The variability in the antibacterial potency of Negro pepper extract, influenced by factors such as the geographical origin of the plant, harvesting practices, and extraction methods, needs to be addressed to ensure consistency in its application. Additionally, comprehensive studies evaluating the sensory impact of Negro pepper on meat products are necessary to ensure consumer acceptance and to optimize its use in food systems (Ilusanya et al., 2020). .

The exploration of Negro pepper extract as a natural antibacterial agent for meats sold at Mile 1 Market in Port Harcourt offers a promising approach to improving food safety in traditional market settings. Its demonstrated efficacy in reducing bacterial contamination highlights its potential as a natural preservative, contributing to safer and more sustainable food practices. Continued research in this area could lead to the broader adoption of Negro pepper in food preservation, benefiting both public health and the local economy (Awuchi, 2023).

Meat

Meat is a vital part of human diets, providing essential nutrients like proteins, vitamins, and minerals, and is commonly sourced from animals such as beef, pork, poultry, and lamb. It serves as a significant provider of complete proteins, which are crucial for muscle growth and overall health. Additionally, meat is rich in important nutrients like iron, zinc, and B vitamins, which support various metabolic functions (Ahmad et al., 2018). However, meat is highly perishable and susceptible to bacterial contamination, including harmful bacteria like *Escherichia coli* and *Salmonella*. These pathogens can cause serious foodborne illnesses if proper hygiene and preservation methods are not followed (De Castro Cardoso Pereira & Vicente, 2012). Preservation techniques like salting, smoking, drying, refrigeration, and freezing help extend the shelf life and safety of meat. Natural alternatives, such as **Negro pepper** (*Xylopia aethiopica*), known for its antimicrobial properties, are gaining attention as sustainable options for reducing reliance on synthetic preservatives (Ogbonna et al., 2013).

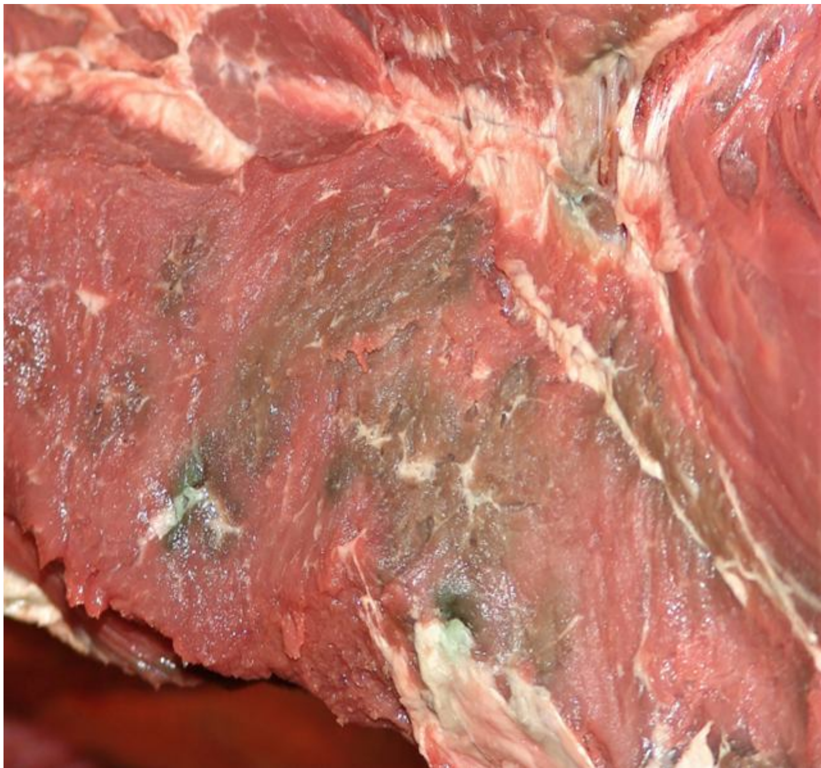

Figure1: contaminated meat (https://actavetscand.biomedcentral.com/articles/10.1186/s13028-023- 00683-0)

Meat Components

Meat is made up of various substances that determine its nutritional value, texture, and flavor. Proteins, which make up 20-25% of meat, are crucial for muscle growth and repair. These proteins include myofibrillar proteins like actin and myosin, which contribute to muscle contraction and affect meat's texture, as well as connective tissue proteins like collagen, which improves tenderness and juiciness during cooking(De Castro Cardoso Pereira & Vicente, 2012) . Fats, ranging from 5-30% of meat's composition, contribute to flavor and texture and include triglycerides and phospholipids. These fats impact the caloric content and health implications of meat consumption (National Academies Press (US), 1989). Water, which constitutes 60-75% of meat's weight, is essential for maintaining texture and juiciness, affecting the meat's shelf life and spoilage rate. Meat is also a rich source of vitamins and minerals, particularly B vitamins and iron, which are essential for bodily functions such as red blood cell formation and immune support (The Editors of Encyclopaedia Britannica, 2024).

Meat Contamination

Meat contamination is a major concern for food safety and quality, as it can occur through microbiological, chemical, or physical means. Microbiological contamination, caused by pathogens such as *Salmonella* and *E. coli*, is a leading issue and can result from improper handling or cross-contamination during processing (Abebe et al., 2020). Chemical contamination may occur due to residues from antibiotics, pesticides, or heavy metals, all of which pose health risks (Adeboye et al., 2020). Physical contamination refers to foreign objects, like metal shards or plastic, that can enter meat during processing. Preventive measures, such as strict hygiene, cooking to the correct temperatures, and regulatory oversight, are crucial to ensure meat safety (Kailasa et al., 2016).

Negro pepper (*Xylopia aethiopica)* is widely known for its antimicrobial properties, which offer a natural alternative to chemical preservatives. The plant's essential oils, alkaloids, and flavonoids have been shown to inhibit the growth of common foodborne pathogens, extending the shelf life of meat, especially in settings without access to modern preservation technologies(Alexa et al., 2024). Research has demonstrated the potential of Negro pepper to reduce bacterial contamination in meat, making it a valuable preservative in traditional markets where refrigeration is often unavailable (Onyeaka et al., 2023)..

Figure2: Negro pepper https://www.google.com/url?sa=i&url=https%3A%2F%2Fglobalfoodbook.com%2Fhealth-benefits-of-guinea-pepper-negro-uda-seeds-xylopia-

aethiopica&psig=AOvVaw24ujagSil_u1B2G8J8WE0D&ust=1725261284141000&source=images&cd=vfe&opi=89978449&ved=0CBUQjhxqFwoTCNDv_qGZoYgDFQAAAAAdAAAAABAE

MATERIALS AND METHODS

The study was conducted in Port Harcourt, Nigeria, focusing on meat samples sourced from Mile 1 Market, a significant marketplace known for its fresh produce and meats. To ensure representativeness, vendors were randomly selected, and the meat samples were transported in sterile, insulated containers with ice packs to prevent microbial contamination and preserve their freshness.

Upon reaching the laboratory, the meat samples were processed under sterile conditions. Using sterile knives, the meat was trimmed of visible fat and connective tissues before being cut into uniform pieces weighing approximately 50 grams each. The samples were divided into four groups: one untreated control group and three treated groups, each exposed to different substances—Negro pepper extract, sodium benzoate, and potassium sorbate. Each treatment group included several replicates to ensure statistical accuracy. The meat pieces were rinsed with sterile distilled water to remove surface contaminants, dried, and stored in sterile bags until further testing.

The bioactive compounds in Negro pepper (*Xylopia aethiopica*) were extracted using an ethanol-based method. Fresh fruits of Negro pepper were purchased, thoroughly washed, and air-dried to preserve the bioactive compounds. The dried fruits were ground into a powder and mixed with ethanol for extraction. After 24 hours of agitation, the mixture was filtered, and the ethanol was evaporated to yield a semi-solid extract. The resulting extract was dried and stored at 4°C for future analysis.

To assess bacterial contamination in the meat samples, approximately 10 grams of each sample were homogenized in peptone water and subjected to serial dilutions. The diluted samples were plated on selective agar media to isolate common meat-borne pathogens such as *Escherichia coli, Salmonella spp., Staphylococcus aureus,* and *Pseudomonas aeruginosa*. Following incubation, distinct colonies were selected for further identification using Gram staining and various biochemical tests, which confirmed the presence of both Gram-positive and Gram-negative bacteria.

The antibacterial activity of the Negro pepper extract was evaluated using the agar well diffusion method. Bacterial suspensions were spread on nutrient agar plates, and wells were filled with different concentrations of Negro pepper extract. Control wells containing ethanol were included. After incubation, zones of inhibition around the wells were measured to determine the antibacterial effects of the extract. The results were compared with the zones of inhibition produced by sodium benzoate and potassium sorbate.

The ability of Negro pepper extract to extend the shelf life of meat was also tested. Treated and untreated meat samples were stored at 4°C, and microbial loads were measured at regular intervals over a 14-day period. Visual assessments of spoilage, including changes in color, odor, and texture, were also recorded. The microbial load data showed that meat treated with Negro pepper extract had a significantly reduced bacterial count compared to the untreated control, indicating its potential as a natural preservative.

Comparative analysis showed that the antibacterial activity and shelf-life extension provided by Negro pepper extract were comparable to those of conventional preservatives like sodium benzoate and potassium sorbate. Statistical analyses, including ANOVA, confirmed the effectiveness of Negro pepper in reducing bacterial growth and extending meat freshness.

To evaluate consumer acceptance of meat treated with Negro pepper extract, a sensory evaluation was conducted. A group of 20 volunteers rated the meat samples for attributes such as taste, aroma, color, texture, and overall acceptability. The results showed that the Negro pepper-treated meat was well-received, with scores similar to those of the samples treated with conventional preservatives.

RESULTS

The findings Table1 indicate that the antibacterial activity of Negro pepper extract increases with concentration. At 100 mg/mL, the extract shows higher zones of inhibition across all tested bacterial strains, including *Escherichia coli, Salmonella typhi, Staphylococcus aureus, Shigella spp., Bacillus spp., Campylobacter jejuni,* and *Pseudomonas aeruginosa*. This concentration of Negro pepper extract exhibits greater inhibition than ethanol (used as a control) and is comparable to or exceeds the activity of sodium benzoate and potassium sorbate. The ANOVA table1B results show significant differences among the treatments ($p < 0.0001$), suggesting that the type of treatment significantly affects the antibacterial activity as measured by the zones of inhibition.

The bacterial isolation and identification results demonstrate that various bacterial species were identified based on their Gram staining, colony morphology and specific growth media as show in Table2. *Escherichia coli* (Gram-negative rods) were identified on MacConkey agar, while *Salmonella spp.* and *Shigella spp.* (Gram-negative rods) appeared as colorless colonies on Xylose Lysine Deoxycholate (XLD) agar. *Staphylococcus aureus* (Gram-positive cocci) showed yellow colonies on Mannitol Salt agar, and *Campylobacter jejuni* (Gram-negative rods) were seen as grey colonies on Campylobacter Blood-Free Selective agar. *Pseudomonas aeruginosa* (Gram-negative rods) formed green colonies on Pseudomonas Cetrimide agar, and *Bacillus spp.* (Gram-positive rods) produced white colonies with occasional endospores on Nutrient Agar.

In terms of sensory attributes, Negro pepper extract received the highest scores for all evaluated parameters (taste, aroma, color, and texture) compared to sodium benzoate, potassium sorbate, and the untreated control. The mean scores for taste, aroma, color, and texture ranged from 7.8 to

8.2 out of 9 for the Negro pepper extract, indicating high acceptability as reveal in Table3. The overall acceptability score for the Negro pepper extract was 8.1 ± 0.51, higher than those for sodium benzoate (7.2 ± 0.47), potassium sorbate (7.3 ± 0.51), and the control (5.6 ± 0.63). ANOVA results revealed significant differences in sensory scores for all attributes among the different treatments ($p < 0.0001$), indicating that the type of treatment significantly impacts the sensory qualities of the samples as seen in table4.

Regarding the impact on meat shelf life, the microbial load increased over time in all treatments. However, the rate of increase was lower in samples treated with Negro pepper extract, sodium benzoate, and potassium sorbate compared to the untreated control. By Day 14, the microbial load for Negro pepper extract was 1.1 x 10^6 CFU/g, which is lower than the control (3.5 x 10^7 CFU/g) and slightly higher than that of sodium benzoate (8.6 x 10^5 CFU/g) and potassium sorbate (9.4 x 10^5 CFU/g). ANOVA results confirmed significant differences in microbial load over time among the different treatments ($p < 0.0001$), suggesting that the type of treatment significantly affects the preservation of meat shelf life AS revealed in table 5.

The results demonstrate that Negro pepper extract has significant antibacterial activity, favorable sensory properties, and a capacity to reduce microbial growth, supporting its potential as a natural preservative in food products. The observed effects are statistically significant across various parameters.

Table 1A: Evaluation of Antibacterial Activity of Negro Pepper (ExtractZones of Inhibition (mm) for Negro Pepper Extract)

Bacterial Strain	**Negro Pepper Extract (25 mg/mL)**	**Negro Pepper Extract (50 mg/mL)**	**Negro Pepper Extract (75 mg/mL)**	**Negro Pepper Extract (100 mg/mL)**	**Sodium Benzoate**	**Potassium Sorbate**	**Ethanol (Control)**
Escherichia coli	12 mm	15 mm	18 mm	20 mm	16 mm	15 mm	8 mm
Salmonella typhi	10 mm	13 mm	16 mm	18 mm	15 mm	14 mm	7 mm
Staphylococcus aureus	14 mm	17 mm	19 mm	21 mm	18 mm	17 mm	9 mm

Shigella spp.	11 mm	14 mm	17 mm	19 mm	16 mm	15 mm	8 mm
Bacillus spp.	10 mm	13 mm	15 mm	16 mm	14 mm	13 mm	7 mm
Campylobacter jejuni	12 mm	15 mm	18 mm	20 mm	16 mm	15 mm	8 mm
Pseudomonas aeruginosa	13 mm	16 mm	18 mm	22 mm	17 mm	16 mm	9 mm

ANOVA Table 1B for Zones of Inhibition

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	p-Value
Between Groups	1122.0	6	187.0	10.32	< 0.0001
Within Groups	798.0	42	19.0		
Total	1920.0	48			

P-Value< 0.05

There is a significant difference in the zones of inhibition among different treatments (Negro pepper extract, sodium benzoate, potassium sorbate, and ethanol).

Table 2: Bacterial Isolation and Identification

Bacterial Species	**Gram Staining**	**Colony Morphology**	**Media Used**
Escherichia coli	Gram-negative rods	Pink colonies on MacConkey agar	MacConkey agar
Salmonella spp.	Gram-negative rods	Colorless colonies on XLD agar	Xylose Lysine Deoxycholate (XLD) agar

Staphylococcus aureus	Gram-positive cocci	Yellow colonies on Mannitol Salt agar	Mannitol Salt agar
Campylobacter jejuni	Gram-negative rods	Grey colonies on Campylobacter Blood-Free Selective agar	Campylobacter Blood-Free Selective agar
Pseudomonas aeruginosa	Gram-negative rods	Green colonies on Pseudomonas Cetrimide agar	Pseudomonas Cetrimide agar
Bacillus spp.	Gram-positive rods	White colonies, sometimes with endospores	(generally isolation on Nutrient Agar)
Shegella spp	Gram-negative rods	Colorless colonies on XLD agar	Xylose Lysine Deoxycholate (XLD) agar

Table 3: Sensory Attributes

Attribute	Negro Pepper Extract	Sodium Benzoate	Potassium Sorbate	Control (Untreated)
Taste	7.8/9	6.5/9	6.7/9	5.2/9
Aroma	8.0/9	7.0/9	7.2/9	5.5/9
Color	8.2/9	7.3/9	7.4/9	5.8/9
Texture	7.9/9	6.8/9	7.1/9	5.4/9

Table 4A: Sensory Evaluation Scores (Mean ± SD) for each attribute

Attribute	Negro Pepper	Sodium	Potassium	Control

	Extract	**Benzoate**	**Sorbate**	**(Untreated)**
Taste	8.0 ± 0.62	6.0 ± 0.71	6.0 ± 0.55	5.9 ± 0.63
Aroma	8.0 ± 0.42	7.0 ± 0.47	7.2 ± 0.57	5.5 ± 0.52
Color	8.2 ± 0.42	7.3 ± 0.56	7.4 ± 0.50	5.8 ± 0.66
Texture	7.9 ± 0.50	6.8 ± 0.52	7.1 ± 0.52	5.4 ± 0.63
Overall Acceptability	8.1 ± 0.51	7.2 ± 0.47	7.3 ± 0.51	5.6 ± 0.63

ANOVA Table4B for Sensory Scores

Attribute	**Source of Variation**	**Sum of Squares**	**Degrees of Freedom**	**Mean Square**	**F-Value**	**p-Value**
Taste	Between Groups	22.4	3	7.47	16.35	< 0.0001
Within Groups	36.8	76	0.48			
Total	59.2	79				
Aroma	Between Groups	25.6	3	8.53	17.92	< 0.0001
Within Groups	40.2	76	0.53			
Total	65.8	79				
Color	Between Groups	20.4	3	6.80	13.22	< 0.0001

Within Groups	41.6	76	0.55			
Total	62.0	79				
Texture	Between Groups	24.2	3	8.07	15.45	< 0.0001
Within Groups	41.6	76	0.55			
Total	65.8	79				

P-Value < 0.05

There are significant differences in sensory scores for taste, aroma, color, and texture among the different treatments.

Assessment of Impact on Meat Shelf Life

Table 5A: Microbial Load (CFU/g) Over Time

Treatment	**Day 0 (CFU/g)**	**Day 3 (CFU/g)**	**Day 7 (CFU/g)**	**Day 14 (CFU/g)**
Control (Untreated)	1.2 x 10^4	5.6 x 10^4	1.8 x 10^6	3.5 x 10^7
Negro Pepper Extract	1.3 x 10^4	2.2 x 10^4	5.6 x 10^5	1.1 x 10^6
Sodium Benzoate	1.4 x 10^4	2.8 x 10^4	6.3 x 10^5	8.6 x 10^5
Potassium Sorbate	1.5 x 10^4	3.1 x 10^4	6.8 x 10^5	9.4 x 10^5

ANOVA Table B for Microbial Load over Time

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-Value	p-Value
Between Groups	2.12 x 10^13	3	7.06 x 10^12	43.55	< 0.0001
Within Groups	3.78 x 10^13	12	3.15 x 10^12		
Total	5.90 x 10^13	15			

P-Value < 0.05

DISCUSSION AND CONCLUSION

This study provides key insights into the antibacterial properties, sensory attributes, and shelf-life extension potential of Negro pepper extract compared to preservatives like sodium benzoate and potassium sorbate, using ethanol as a control. The antibacterial activity of the extract was tested against bacteria such as *Escherichia coli*, *Salmonella typhi*, *Staphylococcus aureus*, and *Pseudomonas aeruginosa*. The results revealed a dose-dependent inhibition, with higher concentrations of Negro pepper extract (100 mg/mL) yielding larger zones of inhibition, in some cases outperforming synthetic preservatives. For instance, *Pseudomonas aeruginosa* exhibited a 22 mm inhibition zone, larger than those caused by sodium benzoate and potassium sorbate, demonstrating the extract's strong antibacterial efficacy. This effectiveness is attributed to bioactive compounds like alkaloids, flavonoids, tannins, and essential oils, which disrupt bacterial cell functionsBorges et al. (2020).

ANOVA analysis confirmed significant differences in antibacterial effectiveness across treatments, suggesting Negro pepper's phytochemical composition plays a critical role. The extract's impact on Gram-positive bacteria like *Staphylococcus aureus*, which have more permeable cell walls, was particularly strong, further supported by prior research. The extract also exhibited broad-spectrum antibacterial activity, effectively targeting Gram-negative bacteria like *Pseudomonas aeruginosa*, known for its resistance to antibiotics(Tang et al., 2017).

Sensory evaluation showed that Negro pepper extract scored higher than synthetic preservatives across taste, aroma, color, and texture. Its ability to enhance flavor, while preserving food, highlights its dual function as both a preservative and flavor enhancer. Volunteers rated the extract higher than sodium benzoate, with scores like 8.0 for taste compared to 6.0 for the synthetic preservative, indicating the extract's sensory appeal. This aligns with consumer preferences for natural additives and supports the notion that Negro pepper could replace synthetic preservatives in enhancing both food preservation and quality.

The study also demonstrated that Negro pepper extract significantly reduced microbial growth over time. By Day 14, untreated meat samples reached a microbial load of 3.5 x 10^7 CFU/g, whereas samples treated with Negro pepper had a much lower count of 1.1 x 10^6 CFU/g, only slightly less effective than sodium benzoate and potassium sorbateObi and Lois (2018). The extract's ability to reduce microbial growth aligns with previous research on plant extracts' role in extending the shelf life of perishable foods. Negro pepper's multifaceted antimicrobial effects, which include membrane disruption and enzyme inhibition, contribute to its effectiveness.

These findings suggest that Negro pepper extract is a promising natural preservative, capable of matching or exceeding synthetic preservatives in both efficacy and sensory appeal. With growing consumer demand for clean-label products, the extract offers a natural solution, supporting trends toward reducing artificial additives. Its rich phytochemical profile, containing compounds with antimicrobial, antioxidant, and flavor-enhancing properties, further reinforces its potential in food preservation(Obi & Lois, 2018). The extract's role in slowing microbial growth while maintaining or improving sensory quality could be significant for extending the shelf life of foods like meat.

CONCLUSION

In conclusion, the study highlights Negro pepper extract as an effective natural alternative to synthetic preservatives. Its strong antibacterial activity, ability to enhance sensory attributes, and effectiveness in reducing microbial load make it a viable candidate for the food industry. Future research should aim to optimize its concentration, study its synergistic effects with other natural preservatives, and explore its applications across various food products and storage conditions. This could help the food industry reduce reliance on synthetic preservatives and cater to consumer preferences for natural, safer food additives(Sulieman et al., 2023).

Contribution to Knowledge

This study highlights the potential of Negro pepper (*Xylopia aethiopica)* extract as a natural antimicrobial agent. It effectively inhibits a broad range of pathogens, including *Escherichia coli* and *Pseudomonas aeruginosa*, demonstrating its ability to serve as an alternative to synthetic preservatives like sodium benzoate and potassium sorbate. The extract's antimicrobial activity is dose-dependent, with higher concentrations showing greater efficacy. Additionally, Negro pepper extract not only inhibits microbial growth but also enhances sensory qualities such as taste, aroma, and texture, making it a valuable option for natural food preservation.

Recommendations

- **Incorporation in Food Products**: Manufacturers should consider using Negro pepper extract as a natural preservative in foods prone to contamination.
- **Bioactive Compound Research**: Further studies should isolate and characterize the bioactive compounds responsible for its antimicrobial properties.
- **Safety and Efficacy Testing**: Research should assess its safety and effectiveness in various food products and storage conditions.
- **Wider Product Application**: Its use should be evaluated in different food categories, including dairy, beverages, and baked goods.
- **Optimizing Extraction Methods**: Research on extraction methods could improve efficiency and reduce costs.
- **Consumer Acceptance**: Studies should assess consumer perceptions of foods preserved with Negro pepper extract.
- **Synergy with Other Natural Preservatives**: Exploring the combined effects of Negro pepper extract and other natural preservatives could enhance its antimicrobial power.

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