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In Vitro Evaluation of *Lactobacillus* sp. as Biological Control against Crown Rot Pathogens in Cavendish Banana (*Musa acuminata*)

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Abstract. Cavendish banana (*Musa acuminata*) is one of the most globally traded fruits; however, postharvest losses due to crown rot, primarily caused by *Fusarium* spp. and *Colletotrichum musae*, pose significant challenges. This study evaluated the efficacy of *Lactobacillus* sp. as a biological control agent against these fungal pathogens in vitro. Gram staining confirmed that *Lactobacillus* sp. is Gram-positive, as its cells stained purple under the microscope. A catalase test further revealed that *Lactobacillus* sp. is catalase-negative, as no bubbles formed upon exposure to hydrogen peroxide, in contrast to the catalase-positive *Ralstonia solanacearum*. The antagonistic potential of *Lactobacillus* sp. was tested against *Fusarium* spp. and *C. musae* using different concentrations (5, 10, and 15 ml/L), compared to a synthetic fungicide (Prochloraz) and a control (PDA only). Growth of *Fusarium* spp. was significantly suppressed at concentrations of 5 and 15 ml/L, with complete inhibition observed at 10 ml/L. Similarly, *C. musae* growth was reduced by 94.1% at 10 ml/L and 83.1% at 15 ml/L, while 5 ml/L resulted in only 36.5% inhibition. These results were analyzed using ANOVA followed by a post-hoc test at the 5% significance level ($p < 0.05$), indicating that higher concentrations of *Lactobacillus* sp. are more effective. *Lactobacillus* sp. significantly inhibited fungal growth, showing comparable efficacy to synthetic fungicides. These findings highlight the potential of *Lactobacillus* sp. as an eco-friendly alternative for managing crown rot in bananas.

Keywords: Banana postharvest diseases; Biological control.

1.0 Introduction

Bananas (*Musa sapientum*) are the fourth most important agricultural commodity in developing countries and among the most widely consumed fruits globally, serving as a staple food and a vital economic commodity in many tropical and subtropical regions. They are rich in essential nutrients, including potassium, vitamin C, and dietary fiber, making them an integral component of diets worldwide.

The Food and Agriculture Organization (FAO) (2023) reported that global banana production reached around 135 million tonnes in 2022, an 8% increase from the previous year. This rise highlights growing consumer demand and the fruit's crucial role in global agriculture. Bananas remain the most exported fresh fruit worldwide, with annual exports averaging about 20 million tonnes in recent years. 2023 the global banana export market was valued at roughly $14.4 billion, up 6.7% from 2022. Ecuador topped the list with $3.79 billion in export value, followed by the Philippines at $1.22 billion and Costa Rica at $1.19 billion.

The Cavendish banana (*Musa acuminata*) continues to dominate the global market, making up about 47% of the world's total banana production. Its popularity has made it the most commercially important banana variety worldwide. In 2023, global banana exports excluding plantains reached 19.3 million metric tons, with the Cavendish variety accounting for the bulk of this trade. Ecuador was the leading exporter, shipping around 5.76 million metric tons in 2024. It was followed by Guatemala and Colombia, with exports of 2.59 million and 2.31 million metric tons, respectively. Meanwhile, once the world's second-largest banana exporter, the Philippines fell to fourth place in 2024, mainly due to ongoing production setbacks (FAO, 2023).

In the Philippines, Cavendish bananas continue to be the primary export variety. In 2023, the country produced approximately 9.02 million metric tons of bananas, with Cavendish making up about half of that. The key production areas include the Davao Region, Northern Mindanao, and SOCCSKSARGEN, with Panabo City in Davao del Norte housing the world's largest banana plantation, making it a central hub. Philippine banana exports increased slightly in 2023 to 2.354 million metric tons, generating $1.22 billion, but saw a 2.97% decline in 2024 due to the spread of Fusarium wilt Tropical Race 4 (TR4), lower yields, and higher production costs. These challenges, geopolitical tensions, and logistical hurdles, particularly in markets like China and Japan, have made it harder for the Philippines to remain competitive. The Philippine Department of Agriculture has implemented initiatives to revive the industry, such as promoting disease-resistant varieties, offering financial aid, and enhancing trade strategies. Despite these challenges, the Philippines remains a major player in the global Cavendish banana market, with significant efforts underway to ensure the industry's long-term viability and competitiveness (FAO, 2024).

Numerous fungi, including crown rot postharvest disease, harm Cavendish bananas, causing a significant decline in their commercial volume and quality. Considerable losses in banana fruit are caused by crown rot. Predominantly*, Colletotrichum musae* and *Fusarium* spp. are its causative agents. Without suitable postharvest management practices, all these may lead to substantial economic losses (Mohapatra et al., 2010). Most of the inoculum comes from diseased flowers. Still, there are also decaying leaves and the possibility of fungal transfer from banana stalks onto the crown surface when chopping banana bunches (knife-induced) or washing the bunches in tainted water. The fungus infects the crop at harvest, but the first signs of crown rot do not show up until the crop has been packaged and shipped from the producer to the consumer country. Mycelium develops on the crown surface to start crown rot, which is followed by interior growth. The result is a weakening and blackening of the fruit tissue as the fungus spreads throughout the peduncle and the entire fruit (Triest & Hendrickx, 2016).

The common pathogens associated with the crown rot disease include *Colletotrichum musae, Fusarium roseum, Fusarium semitectum,* and *Botryodiplodia theobromae* (Hailu et al., 2013). Crown rot is typically a disease complex caused by several fungi and the association with other organisms, like bacteria, that help induce the rotting. Although complex fungi generally have lower virulence and variability than simple fungi, *Colletotrichum musae* demonstrates strong pathogenicity. Unlike other pathogens that require higher concentrations to induce crown rot symptoms, *C. musae* can cause infection with only a minimal amount of inoculum (Greene & Doos, 1963; Lukezic et al., 1967; Griffee, 1976; Krauss, 1996; Krauss et al., 2000; Lassois et al., 2008).

Once the banana hands are cut or separated from the bunch, viruses can enter and flourish there. As a result, fungus spores on the fruit and in the surrounding region can be transported straight to the processing area. Spores follow the fruit directly into the wash tanks used for delatexing. Softening and blackening of tissues at the crown rot surface are signs of rot. White, grey, or pink mold may develop on the crown's surface, and diseased tissue rot may spread into the finger stalk (Hailu et al., 2013).

Bananas are the most traded fruit globally, with the Philippines ranking as one of the leading exporters. However, postharvest diseases, particularly crown rot, caused by a complex of fungal pathogens, remain a significant challenge. *Fusarium pallidoroseum* and *Verticillium theobromae* have been identified as primary causal agents, with chemical fungicides such as Prochloraz providing variable control. Due to their shared physiological and metabolic traits, gram-positive, acid-tolerant, non-sporulating, non-respiring rod-shaped bacilli or coccus bacteria are known as lactic acid bacteria (LAB). They are typically found in decaying plants, and the primary metabolic byproduct of carbohydrate fermentation is lactic acid. Since acidity prevents the growth of spoilage organisms, this characteristic has historically connected LAB with food fermentations.

LAB has been used in food fermentation and culture for nearly 4000 years. Yogurt, cheese, buttermilk, kefir, and koumiss are the most popular fermented milk products worldwide (Bintsis, 2018). A number of LAB strains produce proteinaceous bacteriocins, which act as an additional barrier to spoilage and harmful microorganisms. Due to their widespread presence in food and their contribution to the healthy microflora of human mucosal surfaces, the LAB is widely regarded as safe (GRAS), demonstrating their industrial significance (McGrath & Van Sinderen, 2007). Albuquerque et al. (2017) demonstrated and evaluated the efficacy of lactic acid bacteria (LAB) isolated from fresh fruits and vegetables as biocontrol agents against several phytopathogenic and spoilage microorganisms, including *Xanthomonas campestris*, *Erwinia carotovora*, *Penicillium expansum*, *Monilinia laxa*, and *Botrytis cinerea*. In vitro testing of the antagonistic activity of 496 LAB strains revealed that, except *P. expansum*, all tested pathogens were inhibited by at least one LAB isolate. Furthermore, the 496 LAB strains were assessed for their ability to suppress *P. expansum* infections in wounds on Golden Delicious apples. Among them, *Weissella cibaria* strain TM128 was the most effective, reducing infection levels by 50%, while four other strains (TC97, AC318, TM319, and FF441) reduced the fungal rot diameter by approximately 20%. Cell-free supernatants from selected antagonistic strains were also analyzed to determine the nature of the antimicrobial compounds produced.

The widespread use of synthetic pesticides in agriculture has raised critical concerns about environmental sustainability, human health, and international trade compliance. In Cavendish banana production, chemical pesticides are routinely applied to control pests and diseases that compromise yield and fruit quality. However, excessive or improper application of these chemicals can result in pesticide residues on harvested bananas, potentially exceeding the Maximum Residue Limits (MRLs) established by importing countries. MRLs are regulatory benchmarks that ensure food safety and facilitate international trade by preventing excessive pesticide contamination. When Cavendish bananas surpass these limits, they face rejection in global markets, leading to economic losses for producers and exporters. Additionally, the prolonged exposure to pesticide residues risks consumer health and disrupts ecological balance. Addressing these issues requires adopting integrated pest management (IPM) strategies and adherence to responsible pesticide use to ensure sustainable banana production while meeting food safety standards. With increasing restrictions on synthetic fungicides due to maximum residue limits (MRL) imposed by importing countries, there is growing interest in alternative disease management strategies such as biological control. This study explores the potential of *Lactobacillus* sp. as a biological control agent against crown rot pathogens, specifically *Fusarium* spp. and *Colletotrichum musae*, by evaluating its efficacy at varying concentrations in vitro. The aim is to reduce reliance on synthetic fungicides while promoting safer and more sustainable postharvest disease control.

2.0 Methodology

The study was conducted at a laboratory to evaluate Lactobacillus sp.'s *in vitro* antagonistic activity against selected fungal pathogens. Potato Dextrose Agar (PDA) was used as the culture medium for the fungal pathogens and *Lactobacillus* sp. The medium was prepared by dissolving 39 grams of PDA powder in 1,000 mL of purified or distilled water. It was then sterilized by autoclaving at 15 psi for 15 minutes.

The fungal pathogens *Fusarium* spp. and *Colletotrichum musae* were isolated from crown rot-infected tissues of Cavendish banana fruit. About 2- 3 mm2 was cut from the advancing portion of the infected tissues and disinfected in 10% sodium hypochlorite for 10 minutes. After being washed three times with sterile distilled water, the tissues were blot-dried using sterile tissue paper. The aseptically prepared tissues were then evenly placed on Potato Dextrose Agar (PDA) plates. The cultures were incubated at room temperature in an inverted position until fungal growth appeared. Emerging fungal colonies were examined under a microscope to identify the target organisms. The isolated pathogens were purified by transferring a disc of mycelial growth onto fresh nutrient agar plates and incubating them for an additional 7 days. Different procedures were then applied to the pure culture in the in vitro test.

Lactobacillus sp. was isolated from a commercial probiotic product (Lacto PAFI), a drink and supplement formulated with *Lactobacillus* strains, particularly *L. Plantarum is* known for promoting gut health and enhancing immunity. A 200 µL aliquot of the product solution was streaked onto Potato Dextrose Agar (PDA) plates using an L-Rod and incubated at 37°C for 24–48 hours. A microbial viability test was conducted to determine the colony-forming units (CFU) of *Lactobacillus* sp. The resulting colonies exhibited morphological characteristics

typical of *Lactobacillus*. A single colony was then transferred to a fresh PDA plate for sub-culturing. The culture was stored at 4°C for long-term preservation.

The Gram stain procedure was performed following the methods described by Schaad (1980) and Chaudhry and Rashid (2011). This differential staining technique classifies bacteria as either Gram-positive or Gram-negative by sequentially adding crystal violet as the primary stain, fixing it with iodine solution, decolorizing with alcohol, and counterstaining with safranin. A 48-hour-old pure culture of *Lactobacillus sp.* was used for the Gram staining test, while *Ralstonia solanacearum* served as a control for the Gram reaction. The bacterial sample was aseptically transferred from the Petri plates to a microscope slide using a sterilized wire loop, and the slide was gently heated with a low flame to fix the cells. The smear was then covered with a 0.5% crystal violet solution for 1 minute, then rinsed with stream water to remove any unbound stain. To fix the stain to the bacterial cell wall, Gram's iodine was applied for 1 minute, then rinsed with water. The smear was decolorized with 95% ethanol until the runoff was colorless. After washing, the smear was counter-stained with safranin for 10 seconds, then washed again with water. The slide was air-dried to remove excess water. The bacterial cells were examined using an oil immersion objective. Gram-positive bacteria with thick peptidoglycan layers retained the crystal violet stain, appearing purple under the microscope. In contrast, Gram-negative bacteria, with thinner peptidoglycan walls, retained the safranin stain, making them appear red after decolorization, during which the crystal violet-iodine complex was washed out.

To distinguish between catalase-positive and catalase-negative bacteria, the presence of catalase must be detected in the bacterium. The laboratory performed a catalase test on a sample using slides or drops. A 48- hour-old pure culture of *Lactobacillus* sp. and *Ralstonia solanacearum* was used as a control, and a catalase test was performed on the sample. The bacterium was aseptically removed from the Petri plates with the sterilized wire loop and gently placed in the center of the slide. Placed one drop of 3% hydrogen peroxide into the colony. The presence of bubbles on the bacterial colony is indicative of catalase positivity.

The efficacy of *Lactobacillus sp.* against selected crown rot pathogens was assessed using the poisoned food technique with potato dextrose agar (PDA). A 48-hour-old culture of *Lactobacillus sp.* was prepared, and the bacterial suspension was standardized to 107 cfu/ml using sterile distilled water. The efficacy test was conducted by adding three different volumes of the *Lactobacillus sp.* suspension at 5, 10, and 15 ml per liter of water to the culture medium. After cooling the PDA, 200 µl of the *Lactobacillus sp.* suspension was added to the medium and thoroughly mixed. The treatments were evenly distributed using an L-Rod spreader. Approximately 16 ml of the mixture was poured onto each plate. A mycelial disc from the margin of a 7-day-old pure culture of the test fungi was inoculated at the center of the PDA plates amended with the treatments. After an incubation period of 7 days, the radial growth of the test organism was measured to determine the efficacy of *Lactobacillus sp.*.

The experiment involved 15 samples (plates) per treatment: T1—Control (PDA only), T2—Synthetic Chemical (Prochloraz), T3—*Lactobacillus sp.* (5 ml/l water), T4—*Lactobacillus sp.* (10 ml/l water), and T5—*Lactobacillus sp.* (15 ml/l water). Two crown rot pathogens, *Fusarium spp.* and *Colletotrichum musae*, were tested using the aforementioned treatments. These treatments align with studies by Cedeno and Ugay (2006), who found *L. plantarum* and *L. bulgaricus* effective against soft rot and several plant pathogens. Venida and Ugay (2006) also observed strong antagonism of *L. plantarum* against various *Xanthomonas* spp. Similarly, Jose and Ugay (2004) showed that *L. plantarum* and *B. subtilis* effectively controlled soft rot in potatoes caused *by Pectobacterium carotovorum*.

3.0 Results and Discussion

3.1 Isolation of *Fusarium* spp. and *Colletotrichum musae*

During the isolation of the causal organisms for crown rot from infected Cavendish banana tissues, two dominant fungal pathogens were identified: *Fusarium spp.* and *Colletotrichum musae*. Several studies have highlighted these two pathogens as the primary causal agents of crown rot due to their strong pathogenicity and ability to cause infection with a minimal amount of inoculum (Greene & Goos, 1963; Lukezic et al., 1967; Griffee, 1976; Krauss, 1996; Kraus et al., 2000; Laoiss et al., 2008). These pathogens were utilized in the in vitro test experiment.

3.2 Gram Staining and Catalase Test of *Lactobacillus* sp.

Two tests were conducted to further identify the characteristics of *Lactobacillus sp.*: Gram staining and the catalase test. A 48-hour-old pure culture of *Lactobacillus sp.* was used, with *Ralstonia solanacearum* as the control check to observe any differences or similarities in the test results. The Gram staining test revealed that the bacterial cells of *Lactobacillus sp.* stained purple under the microscope, indicating that it is a Gram-positive bacterium. This result aligns with the findings of Febria and Hartanto (2019), who characterized lactic acid bacteria through Sauerkraut, where bacterial cells also stained purple. This suggests that the isolate is likely from the genus *Lactobacillus*. A Gram-positive bacterium lacks an outer membrane and has a complex cell wall surrounded by a thick peptidoglycan layer, which retains the crystal violet stain (Silhavy et al., 2010). In contrast, the control bacterium *Ralstonia solanacearum* was Gram-negative, with its cells staining pinkish to red.

The bacterium was aseptically transferred from the Petri plates to the slide using a sterilized wire loop for the catalase test. After adding 3% hydrogen peroxide, bubbles were observed in the *Lactobacillus sp.* and *Ralstonia solanacearum colony*. However, the formation of bubbles in *Lactobacillus sp.* took longer than 5 seconds, while *Ralstonia solanacearum* produced bubbles within 3 seconds. This indicated that *Lactobacillus sp.* was catalase-negative, in contrast to *Ralstonia solanacearum*, which was catalase-positive. The gas bubbles in both bacteria confirm that both are aerobic or facultative anaerobic organisms (Bannihatti, 2015). As *Lactobacillus sp.* belongs to the genus of lactic acid bacteria (LAB), it is commonly catalase-negative, a characteristic of non-spore-forming bacteria that primarily metabolize organic acids such as acetic, succinic, and lactic acids. Numerous studies have explored the antibacterial, antifungal, and probiotic activities of LAB strains (Rejiniemon et al., 2015).

3.3 Effects of *Lactobacillus* sp. against crown rot Pathogens of *Fusarium* spp. and *Colletotrichum musae* In the *In Vitro* Experiment

This study tested the potential of the biological control agent *Lactobacillus sp.* against the two major crown rot pathogens of Cavendish banana, *Fusarium spp.* and *Colletotrichum musae*. The results showed that the treatments with *Lactobacillus sp.* significantly reduced the growth of *Fusarium spp.* on PDA (Table 1). The growth of *Fusarium spp.* was suppressed to 2.4 mm at *Lactobacillus sp.* treatments of 5 ml/l and 15 ml/l water, while the fungal growth was suppressed entirely at 10 ml/l water. These results were significantly different from the untreated control (T1), indicating that *Lactobacillus sp.* effectively controlled the growth of *Fusarium spp.* by 93.9% to 100%, comparable to the synthetic chemical control (Prochloraz).

Table 1. *Mean of Radial Growth and Zone of Inhibition of the Different Treatments against Fusarium spp. was grown in PDA at 7 Days of Incubation*

Treatments	*Fusarium* spp.*	
	Radial Growth[1]	% Zone of Inhibition[2]
T1- Control (Nutrient Agar Only)	39.80[b]	
T2- Synthetic Chemical (Prochloraz)	2.00[a]	95.10
T3- *Lactobacillus* sp. (5ml/ l water)	2.40[a]	94.00
T4- *Lactobacillus* sp. (10ml/l water)	0.00[a]	100.0
T5- *Lactobacillus* sp. (15ml/l water)	2.40[a]	93.90
% CV = 5.5		

[1] values are the mean of 4 replications, followed by the same letter, which indicates that is not significantly different In the ANOVA one-way test, at a 5% level of significance.
[2] Not significant (NS). The p-value is 0.339292.

The effect of *Lactobacillus* sp. against *Colletotrichum musae* was also observed in the *in vitro* test (Table 2). At 10 and 15 ml/l water, the fungus inhibits the growth of *C. musae,* with the fungal growth of 1.1 mm and 3.1 mm, respectively. This showed a 94.1% and 83.1% reduction in fungal growth compared with the untreated control. However, at 5 ml/l water, *Lactobacillus* sp. reduced the fungal growth by 36.5%. This means that at lower concentrations of the bacterium, the fungus *C. musae* can still grow at a minimal rate. In the study, *Lactobacillus* sp. showed apparent antagonistic effects against both tested pathogens. Interestingly, at a concentration of 10 ml/L, it could completely suppress the growth of *Fusarium* spp., while its effect on *Colletotrichum musae* was less pronounced. This more potent inhibition of Fusarium may be linked to the antimicrobial compounds naturally produced by Lactobacillus, such as lactic acid, bacteriocins, and hydrogen peroxide. These substances create unfavorable conditions for fungal growth, especially for Fusarium, which is particularly sensitive to acidic environments. Beyond chemical inhibition, it is also possible that Lactobacillus competes more effectively for nutrients and space, quickly colonizing the medium and limiting the ability of Fusarium to establish itself.

Table 2. *Mean of Radial Growth and Zone of Inhibition of the Different Treatments against Colletotrichum musae was Grown in PDA at 7 Days of Incubation*

Treatments	*Colletotrichum musae*	
	Radial Growth[1]	**% Zone of Inhibition[2]**
T1- Control (Nutrient Agar Only)	18.3c	
T2- Synthetic Chemical (Prochloraz)	2.5a	86.5a
T3- *Lactobacillus* sp. (5ml/ l water)	11.6b	36.5b
T4- *Lactobacillus* sp. (10ml/l water)	1.1a	94.1a
T5- *Lactobacillus* sp. (15ml/l water)	3.1a	83.1a
% CV = 10.6		

[1,2] values are the mean of 4 replications; those followed by the same letter are not significantly different In an ANOVA one-way test, at a 5% level of significance.

Lactobacillus sp. has been effective as a biological control against the Cavendish banana's two major crown rot pathogens, ranging from 5 to 15 ml/l of water in the in vitro test experiment. This result was also validated in the study by Cedeno and Ugay (2006), which evaluated the efficacy of *L. plantarum* and *L. bulgaricus* against soft rot and found that both beneficial bacteria completely controlled the disease. *L. plantarum* and *L. bulgaricus* were found to be antagonistic in vitro to seven other plant pathogenic bacteria to varying degrees. Furthermore, a high degree of antagonism by *L. plantarum* was observed in a study by Venida and Ugay (2006), where it was effective against *Xanthomonas oryzae* pv. *Oryzae*, *Xanthomonas campestris* pv. *Vesicatoria*, and *Xanthomonas campestris* pv. *Dieffenbachia* causes bacterial leaf blight in rice, bacterial leaf spot in bell pepper, and leaf blight in anthurium, respectively. Another study by Jose and Ugay (2004) on the antagonism of *L. plantarum* and *B. subtilis* against soft rot of potato showed that both bacteria were highly antagonistic to *Pectobacterium carotovorum* subsp. *carotovorum*, with both organisms providing complete control of soft rot on potato tubers.

These results suggest that *Lactobacillus* sp. possesses antagonistic properties, allowing the organism to inhibit the growth of pathogens, likely through the secretion of antibacterial substances such as lactic acid, hydrogen peroxide, and bacteriocins. These substances affect the growth of pathogenic diseases and enhance the host's immune response (Soccol et al., 2010). Japan is one of the major markets that has recently increased demand for low-chemical Cavendish bananas and advocates for natural farming. The market prefers fruits produced with safer products, or without synthetic chemicals, while maintaining the best quality at a reasonable price. Therefore, exploring the potential of *Lactobacillus* sp. as a postharvest treatment for Cavendish bananas aligns with this market demand. Using *Lactobacillus* sp. as an effective biological control to manage crown rot offers a sustainable approach to postharvest disease management. This could create opportunities for business continuity, enabling adaptation to an ever-evolving market preference and strategy. As a safer alternative for postharvest treatment, it ensures food safety for banana consumers of all ages, promoting a consumer-friendly approach and positively impacting the environment.

4.0 Conclusion

The potential of *Lactobacillus* sp. as a biological control was evaluated as a postharvest treatment against the two central crown rot pathogens of Cavendish banana (*Musa acuminata*) vitro. *Lactobacillus* sp. was tested at concentrations of 5, 10, and 15 ml/l of water. This experiment determined which concentration exhibited the best antagonistic effect and control over Cavendish banana's two major crown rot pathogens. *Lactobacillus* sp. treatments effectively suppressed fungal growth, with *Fusarium* spp. This shows only 2.4 mm growth at 5 and 15 ml/L water, and complete suppression at 10 ml/L, significantly different from the untreated control (T1). This demonstrated 93.9% to 100% control, comparable to the synthetic fungicide Prochloraz. Similarly, in vitro tests against *Colletotrichum musae* showed fungal growth reductions of 94.1% and 83.1% at 10 and 15 ml/L (1.1 mm and 3.1 mm growth, respectively), while 5 ml/L resulted in only 36.5% reduction, indicating minimal fungal growth at lower concentrations.

Conducting an *In Vivo* evaluation of the application of *Lactobacillus* sp. on Cavendish bananas is highly recommended. This study aims to assess the effects of *Lactobacillus* sp. on key fruit quality indicators, including organoleptic properties such as taste, texture, aroma, and color, as well as total soluble solids (TSS), which directly relate to sweetness and overall fruit acceptability. While previous studies may have explored microbial applications under controlled conditions, evaluating the performance of *Lactobacillus* sp. in real- world settings can provide more meaningful insights into its practical benefits. This research could contribute significantly to developing eco-friendly postharvest treatments, reducing reliance on chemical preservatives,

and supporting efforts to improve fruit quality and shelf life through natural means. Ultimately, it aims to strengthen the potential of microbial-based technologies in commercial banana production and postharvest management.

5.0 Contributions of Authors

The author solely conducted this work.

6.0 Funding

No funding is sought for this research.

7.0 Conflict of Interests

The author declares no conflict of interest.

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9.0 References

Albuquerque, M. A. C., Bedani, R., LeBlanc, J. G., & Saad, S. M. I. (2017). Passion fruit by-product and fructooligosaccharides stimulate the growth and folate production by starter and probiotic cultures in fermented soymilk. International Journal of Food Microbiology, 261, 35–41. https://doi.org/10.1016/j.ijfoodmicro.2017.09.001

Bintsis, T. (2018). Lactic acid bacteria: Their applications in foods. Journal of Bacteriology & Mycology: Open Access in 2018, 6(2), 89–94. https://doi.org/10.15406/jbmoa.2018.06.00182

Chaudhry, Z., & Rashid, H. (2011). Isolation and characterization of *Ralstonia solanacearum* from infected tomato plants of Soan Skesar Valley of Punjab. Pakistan Journal of Botany, 43(6), 2979–2985. https://www.pakbs.org/pjbot/abstracts/43(6)/55.html

Fevria, R., & Hartanto, I. (2020). Isolation and characterization of lactic acid bacteria (Lactobacillus sp.) from sauerkraut. Proceedings of the International Conference on Biology, Sciences and Education (ICoBioSE, 2019). International Conference on Biology, Sciences and Education (ICoBioSE, 2019), Padang, Indonesia. https://doi.org/10.2991/absr.k.200807.018

Food and Agriculture Organization of the United Nations (FAO). (2023). Bananas | Markets and trade. Retrieved from https://www.fao.org/markets-and-trade/commodities/bananas/en

Food and Agriculture Organization of the United Nations (FAO). (2023). Banana market review 2023. Retrieved from https://www.fao.org/3/cc0582en/cc0582en.pdf

Food and Agriculture Organization of the United Nations (FAO). (2024). Banana market review–Preliminary results 2024. Retrieved from https://openknowledge.fao.org/server/api/core/bitstreams/a2c47975-b6eb-4088-acdb-b2b7415b076a/content

Greene, G. L., & Goos, R. D. (1963). Fungi associated with crown rot of boxes bananas. Phytopathology, 53, 271–275. https://www.sciencedirect.com/science/article/abs/pii/S0007153681801052

Griffee, P. J. (1976). Pathogenicity of some fungi isolated from diseased crowns of banana hands. Journal of Phytopathology, 85, 206-2016. https://doi.org/10.1111/j.1439-0434.1976.tb01665.x

Hailu, M., Worneh, T. S., & Belew, D. (2013). Review on postharvest technology of banana fruit. African Journal of Biotechnology, 12(7), 635-647. https://www.ajol.info/index.php/ajb/article/view/126652

Krauss, U. (1996). Establishment of a bioassay for testing control measures against crown rot of banana. Crop Protection, 15, 269–274. https://doi.org/10.1016/0261-2194(95)00132-8

Krauss, U., & Johanson, A. (2000). Recent advances in the control of crown rot of banana in the Windward Islands. Crop Protection, 19, 151–160. https://doi.org/10.1016/S0261-2194(99)00097-6

Lassois, L., de Lapeyre de Bellaire, L., & Jijakli, M. H. (2008). Biological control of crown rot of bananas with Pichia anomala strain and Candida oleophila strain O. Biological Control, 45, 410-418. https://doi.org/10.1016/j.biocontrol.2008.01.013

Lukezic, F. L, Kaiser, W. J., & Marinez, M. M. (1967). The incidence of crown rot of boxes bananas in relation to microbial populations of the crown tissues. Canadian Journal Botany, 45, 413–421. https://ui.adsabs.harvard.edu/abs/1967CaJB...45..413L/abstract

McGrath, S., & Van Sinderen, D. (2007). Bacteriophage: Genetics and molecular biology (1st ed.). Caister Academic Press. https://www.caister.com/phage

Mohapatra, D., Mishra S., & Sutar N. (2010). Banana postharvest practices: Current status and future prospects – A review. Agricultural Review, 31(1). https://arccjournals.com/journal/agricultural-reviews/ARCC1337

Phondekar, U. R, Bhagwat, R. G., Rathod, R. R., Gadhave, A. D., Nirgude, Y. R., Nalawade, R. R., & Josiya, J. (2020). Isolation and characterization of Ralstonia solanacearum causing bacterial wilt of potato in Konkan Region of Maharashtra. International Journal of Current Microbiology and Applied Sciences, 9(10), 136–142. https://doi.org/10.20546/ijcmas.2020.910.018

Rejiniemon, T. S., Kadaikunnan, S., Khaled, J. M., Alharbi, N. S., & Mothana, R. (2015). In-vitro antibacterial, antifungal, antioxidant and functional properties of Bacillus amyloliquefaciens. Annals of Clinical Microbiology and Antimicrobials, 14(1), 9. https://doi.org/10.1186/s12941-015-0069-1

Schaad, N. W. (1980). Laboratory guide for identification of plant pathogenic bacteria. Retrieved from https://tinyurl.com/sa9t9k3y

Silhavy, T. J., Kahne, D., & Walker, S. (2010). The bacterial cell envelope. Cold Spring Harbor Perspectives in Biology, 2(5), a000414–a000414. https://doi.org/10.1101/cshperspect.a000414

Soccol, C. R., Vandenberghe, L. P. de S., Spier, M. R., Medeiros, A. B. P., Yamaguishi, C. T., Lindner, J. D. D., Pandey, A., & Thomaz-Soccol, V. (2010). The potential of probiotics: A review. Food Technology and Biotechnology, 48(4), 413–434. https://hrcak.srce.hr/61713

Triest, D., Piérard, D., De Cremer, K., & Hendrickx, M. (2016). Fusarium musae infected banana fruits as potential source of human fusariosis: May occur more frequently than we might think and hypotheses about infection. Communicative & Integrative Biology, 9(2), e1162934. https://www.tandfonline.com/doi/full/10.1080/19420889.2016.1162934

Venida, N. K., & Ugay, V. P. (2006). Screening for antagonism of Lactobacillus bulgaricus and Lactobacillus plantarum against selected bacterial plant pathogens.

Vicente, R. B., & Ugay, V. P. (2006). Growth of Lactobacillus bulgaricus and Lactobacillus plantarum on enriched coconut coir substrate.