Longan (*Dimocarpus longan*) Concentrate: Bioactive Potential Against Bacterial Strains and Stored Product Insects

Miroslava Kačániová[1], Minhang Qiao [1], Mária Babošová[2], Jana Ivanič Porhajašová[2], Ladislav Bakay[3], Ján Kollár[3]

[1]Slovak University of Agriculture, Faculty of Horticulture and Landscape Engineering, Institute of Horticulture, Nitra, Slovakia
[2]Slovak University of Agriculture, Faculty of Agrobiology and Food Resources, Institute of Plant and Environmental Sciences, Slovakia
[3]Slovak University of Agriculture, Faculty of Horticulture and Landscape Engineering, Institute of Landscape Architecture, Nitra, Slovakia

Abstract
Longan (*Dimocarpus longan* Lour.) is a tropical fruit native to southern China and Southeast Asia, traditionally used not only as a food source but also in traditional Chinese medicine. Longan concentrate is a thick yellow brown to dark brown paste with a characteristic aroma, obtained by extraction of plant material using organic solvents. It contains a wide range of bioactive compounds responsible for its antioxidant, antimicrobial, and insecticidal properties. The aim of this study was to evaluate the antimicrobial activity of longan concentrate against selected bacterial strains and its insecticidal activity against two beetle species infesting stored products. Antimicrobial activity was determined using the disc diffusion method and by assessing the minimum inhibitory concentration (MIC_{50} and MIC_{90}) against six bacterial strains: *Bacillus cereus* CCM 2010, *Enterobacter aerogenes* CCM 2531, *Klebsiella pneumoniae* CCM 2318, *Listeria innocua* CCM 4030, *Staphylococcus epidermidis* CCM 4418, and *Citrobacter koseri* CCM 2535. An antibiotic disc (ABT) was used as a positive control. Insecticidal activity was evaluated against *Callosobruchus maculatus* and *Megabruchidius dorsalis* at concentrations ranging from 3.125 % to 100 %. Disc diffusion results showed inhibition zones ranging from 7.67 to 13.67 mm, with the strongest activity observed against *S. epidermidis* (13.67 mm) and *L. innocua* (12.67 mm). MIC_{50} values ranged from 0.188 mg/mL (*S. epidermidis*) to 2.472 mg/mL (*C. koseri*), while MIC_{90} values ranged from 0.468 mg/mL (*S. epidermidis*) to 3.461 mg/mL (*C. koseri*). At the highest concentration (100 %), insecticidal activity reached 95.67 % mortality for *C. maculatus* and 88.67 % for *M. dorsalis*. Longan concentrate exhibited notable antimicrobial activity, particularly against Gram-positive bacteria, as well as significant insecticidal effects against both tested beetle species. These findings suggest its potential as a natural alternative for the protection of stored food commodities.

Keywords: *Dimocarpus longan*; antimicrobial activity; insecticidal activity; stored food protection; natural preservative.

1. Introduction

Longan (*Dimocarpus longan* Lour.) is a large evergreen tree belonging to the family Sapindaceae, widely distributed across southern China, Thailand, Vietnam, and other tropical and subtropical regions of South and Southeast Asia. In terms of annual production, China is the world's largest producer, accounting for the majority of global output [1]. The fruit is highly valued for its sweet, translucent pulp and has been consumed for centuries both fresh and in

* Corresponding author: Miroslava Kačániová, miroslava.kacaniova@gmail.com

processed forms, including dried fruit, juice, wine, and canned products. Beyond its nutritional value, longan occupies an important place in traditional Chinese medicine, where it has been used to nourish the heart, calm the mind, and strengthen the spleen, reflecting its classification as a functional medicinal food [1].

Different parts of the longan plant including the pulp, pericarp, seed, flower, and leaves are rich in bioactive phytochemicals. Among the most extensively studied are hydrolysable tannins such as gallic acid, ethyl gallate, corilagin, geraniin, and ellagic acid, which have been identified and quantified in pericarp and seed extracts by HPLC analysis [2,3]. Corilagin has been reported as the dominant polyphenolic compound in both pericarp and seed extracts [4]. In addition, flavonoids including epicatechin, kaempferol, quercetin, rutin, and isoquercitrin have been identified and contribute to the antioxidant, anti-inflammatory, and antimicrobial properties of longan extracts [5]. Longan seed extracts have also demonstrated antifungal activity against *Candida* spp., with polyphenolic fractions particularly ellagic acid identified as the principal active components [6]. However, most studies on longan antimicrobial activity have focused on conventional aqueous or ethanol extracts, while aromatic extraction products such as longan concentrate remain largely unexplored.

Concentrate extracts are semi-solid aromatic preparations obtained by extraction of plant material with non-polar hydrocarbon solvents (e.g., hexane), followed by solvent removal. The resulting product retains waxes, pigments, and volatile compounds in a concentrated form. Unlike essential oils, which are typically obtained by hydrodistillation and consist mainly of volatile terpenoids, concentrate s contain a broader spectrum of lipophilic and semi-volatile constituents, including fatty acid esters, sesquiterpenes, and aromatic aldehydes and esters. This complex chemical composition suggests that concentrate s may serve as multifunctional bioactive agents. Despite increasing interest in plant-derived aromatic products for food protection, the biological activity of longan concentrate has not yet been systematically investigated.

The safety of stored food commodities is compromised by two major groups of biological hazards: foodborne microorganisms and storage insects. Among bacterial pathogens, *Bacillus cereus* is a spore-forming Gram-positive organism widely distributed in food matrices such as cereals, meat products, vegetables, and dairy, and is capable of producing emetic and diarrhoeal toxins either in food or in the human intestine [7,8]. *L. innocua*, a non-pathogenic species closely related to *L. monocytogenes*, is commonly used as a surrogate organism in antimicrobial studies. Gram-negative bacteria such as *K. pneumoniae* and *E. aerogenes* are opportunistic pathogens frequently associated with contaminated food and clinical environments, while *C. koseri* is an emerging pathogen occasionally detected in food products. *S. epidermidis*, although primarily a commensal organism, is widely used as an indicator of hygiene in food processing environments.

In addition to microbial contamination, insect infestation represents a major cause of postharvest losses in stored legumes worldwide. *C. maculatus* (Fabricius) (Coleoptera: Chrysomelidae, Bruchinae), commonly known as the cowpea weevil, is one of the most destructive pests of stored pulses, capable of causing losses exceeding 90 % within a few months under favourable conditions [9]. *M. dorsalis* (Fahraeus), a species of East Asian origin, has spread to Europe and other regions, where it infests seeds of leguminous plants such as *Gleditsia triacanthos*. Control of these pests has traditionally relied on synthetic fumigants and insecticides, including phosphine and methyl bromide, whose use is increasingly restricted due to environmental concerns, residue persistence, and the development of resistance [10].

In response to these challenges, there is growing interest in natural, plant-derived alternatives to synthetic antimicrobials and pesticides. Aromatic plant extracts including essential oils, concentrate s, and absolutes represent a promising yet still underexplored source of bioactive compounds with potential applications in food protection [11]. The present study therefore aimed to evaluate, for the first time, the antimicrobial activity of longan concentrate against six bacterial strains relevant to food safety, as well as its fumigant insecticidal activity against adult *C. maculatus* and *M. dorsalis*, in order to assess its potential as a natural bioactive agent.

2. Materials and methods

2.1 Plant material

Longan concentrate was sourced from GuiLin Four Seasons Sunshine Co., Ltd. (Guilin, Guangxi, China), where it was produced by extraction of *longan* (*Dimocarpus longan* Lour.) plant material with hydrocarbon solvents, followed by complete solvent removal under reduced pressure. The product was supplied as a semi-solid, yellow–brown aromatic paste. Upon receipt, it was stored in amber glass vials at 4 °C in the dark until use to minimise volatilisation losses and oxidative degradation.

2.2 Bacterial strains and culture conditions

Six bacterial strains obtained from the Czech Collection of Microorganisms (CCM, Brno, Czech Republic) were used in this study: *Bacillus cereus* CCM 2010, *Enterobacter aerogenes* CCM 2531, *Klebsiella pneumoniae* CCM 2318, *Listeria innocua* CCM 4030, *Staphylococcus epidermidis* CCM 4418, and *Citrobacter koseri* CCM 2535.

Prior to testing, each strain was subcultured twice in Mueller–Hinton broth (MHB; Oxoid, Basingstoke, UK) at 37 °C for 24 h to ensure viability and purity. Working suspensions were prepared by adjusting turbidity to the 0.5 McFarland standard (approximately 1.5×10^8 CFU/mL) using a densitometer. All manipulations were performed under sterile conditions in a laminar flow cabinet [12].

2.3 Agar disc diffusion assay

Preliminary antimicrobial activity of longan concentrate was evaluated using the agar disc diffusion method following Kačániová et al. [13]. Mueller–Hinton agar (MHA; Oxoid) plates were inoculated by uniform swabbing with bacterial suspensions adjusted to 0.5 McFarland turbidity.

Sterile filter paper discs (6 mm diameter; Whatman, Maidstone, UK) were impregnated with 10 µL of longan concentrate solution prepared in dimethyl sulfoxide (DMSO; Sigma-Aldrich, St. Louis, MO, USA) to ensure adequate solubilisation. The discs were placed on the surface of inoculated agar plates and allowed to pre-diffuse for 10 min at room temperature before incubation. Plates were incubated aerobically at 37 °C for 24 h.

Following incubation, inhibition zone diameters (including the disc) were measured in millimetres using a digital calliper. Antibiotic discs (ABT; Oxoid) were used as positive controls, while discs containing DMSO alone served as negative controls. Each strain was tested in triplicate on independently prepared plates, and results are expressed as mean ± standard deviation (SD).

2.4 Determination of minimum inhibitory concentrations (MIC_{50} and MIC_{90})

Minimum inhibitory concentrations were determined using the broth microdilution method in sterile 96-well flat-bottom microplates (Nunc, Roskilde, Denmark), following Kačániová et al. [12]. A stock solution of longan concentrate was prepared in DMSO at 20 mg/mL and serially diluted two-fold in Mueller–Hinton broth to obtain a concentration range from 10 mg/mL to 0.0098 mg/mL.

Each well contained 50 µL of diluted extract and 50 µL of bacterial suspension adjusted to the 0.5 McFarland standard, resulting in a final volume of 100 µL. Positive controls (inoculated broth without extract) and negative controls (broth with extract but without inoculum) were included. Plates were sealed with adhesive film to prevent evaporation and incubated at 37 °C for 24 h.

Bacterial growth was assessed by measuring optical density at 600 nm using a GloMax® microplate reader (Promega, Madison, WI, USA). MIC_{50} and MIC_{90} values, defined as concentrations inhibiting 50 % and 90 % of bacterial growth relative to the control, were calculated by probit regression analysis using JMP Student Edition 18.0 (SAS Institute, Cary, NC, USA). All experiments were performed in triplicate.

2.5 Fumigant insecticidal bioassay

Fumigant insecticidal activity of longan concentrate was evaluated against adult *Callosobruchus maculatus* and *Megabruchidius dorsalis* using a closed-system vapour-phase bioassay. Both species were reared on mung bean (*Vigna radiata*) seeds under controlled conditions (27 ± 1 °C, 65 ± 5% relative humidity, 16:8 h light:dark photoperiod), and adults aged 1-7 days were used for testing.

Six concentrations of longan concentrate (100 %, 50 %, 25 %, 12.5 %, 6.25 %, and 3.125 %; v/v in acetone) were prepared. A 10 µL aliquot of each dilution was applied to a filter paper disc (3 cm diameter; Whatman No. 1) attached to the inner

side of a Petri dish lid, ensuring exposure exclusively to the vapour phase without direct contact.

Ten adult insects were introduced into each 9 cm Petri dish, which was immediately sealed with Parafilm. Dishes were maintained at 27 ± 1 °C for 24 h. After exposure, insects were examined under a stereomicroscope, and individuals not responding to gentle stimulation were recorded as dead. Mortality (%) was calculated as the proportion of dead insects. Each treatment was performed in triplicate. Acetone-only controls confirmed the absence of solvent effects.

2.6 Statistical analysis

All data are presented as mean ± standard deviation (SD) of three independent replicates. Statistical significance was assessed using one-way analysis of variance (ANOVA) followed by Tukey's HSD post hoc test ($p \leq 0.05$) in IBM SPSS Statistics 26 (IBM Corp., Armonk, NY, USA). MIC_{50} and MIC_{90} values were calculated by probit regression analysis of concentration–response data, assuming a log-normal distribution

3. Results and discussion

3.1. Antimicrobial activity - disc diffusion method

The results of the agar disc diffusion assay for longan concentrate are presented in Table 1. All six tested bacterial strains showed measurable susceptibility to longan concentrate, with inhibition zone diameters ranging from 7.67 mm for *E. aerogenes* to 13.67 mm for *S. epidermidis*. Overall, the antimicrobial activity pattern showed a pronounced differentiation between Gram-positive and Gram-negative bacteria. The Gram-positive strains, *S. epidermidis* and *B. cereus*, displayed among the largest inhibition zones (13.67 mm and 12.33 mm, respectively), while Gram-negative representatives generally exhibited lower susceptibility.

Table 1. Disc diffusion antimicrobial activity of longan (*Dimocarpus longan* Lour.) concentrate against selected bacterial strains (mean ± SD, n = 3).

Bacterial strain	Inhibition zone (mm) Mean ± SD	ABT (mm) Mean ± SD
Bacillus cereus	12.33 ± 0.58^{a}	30.33 ± 0.58^{ab}
Enterobacter aerogenes	7.67 ± 0.58^{c}	28.67 ± 0.58^{c}
Klebsiella pneumoniae	9.33 ± 0.58^{b}	30.67 ± 0.58^{ab}
Listeria innocua	12.67 ± 0.58^{a}	31.67 ± 0.58^{a}
Staphylococcus epidermidis	13.67 ± 0.58^{a}	29.67 ± 0.58^{bc}
Citrobacter koseri	9.33 ± 0.58^{b}	28.33 ± 0.58^{a}

Among Gram-positive bacteria, *L. innocua* also showed marked susceptibility, with an inhibition zone of 12.67 mm, closely comparable to that of *B. cereus*. Among the Gram-negative strains, *K. pneumoniae* and *C. koseri* each produced inhibition zones of 9.33 mm, whereas *E. aerogenes* showed the lowest susceptibility of all tested strains (7.67 mm). The antibiotic positive control produced substantially larger inhibition zones against all strains, ranging from 28.33 mm for *C. koseri* to 31.67 mm for *L. innocua*, confirming the validity of the experimental system. No inhibition was observed around DMSO negative control discs, excluding solvent-related effects.

According to the interpretative approach used for plant extracts, inhibition zones above 10 mm may be considered indicative of meaningful antimicrobial activity [13]. On this basis, longan concentrate showed moderate to strong antibacterial activity against the Gram-positive strains and weaker, though still detectable, activity against Gram-negative bacteria. This pattern is consistent with the generally greater susceptibility of Gram-positive bacteria to hydrophobic plant-derived compounds, as these organisms lack the outer membrane that acts as a permeability barrier in Gram-negative species [14]. The outer membrane of Gram-negative bacteria, rich in lipopolysaccharides, substantially restricts the penetration of lipophilic molecules and is

therefore a key determinant of their reduced susceptibility to aromatic extracts.

The relatively strong activity of longan concentrate against *S. epidermidis*, *L. innocua*, and *B. cereus* may be associated with the polyphenolic composition of longan-derived products, particularly hydrolysable tannins such as corilagin, gallic acid, and ellagic acid, which have been identified in longan tissues by Thitilertdecha et al. [2], Sudjaroen et al. [3], and Tang et al. [4]. These compounds are known to interact with cell membranes, extracellular proteins, and enzymes, thereby contributing to microbial growth inhibition. The comparatively low activity against *E. aerogenes* is in line with the well-established resistance of Gram-negative enterobacteria to hydrophobic phytochemicals.

3.2 Antimicrobial activity - minimum inhibitory concentration (MIC_{50} and MIC_{90})

The MIC_{50} and MIC_{90} values of longan concentrate against all six bacterial strains, determined by broth microdilution and probit regression, are presented in Table 2. MIC_{50} values ranged from 0.188 mg/mL for *S. epidermidis* to 2.472 mg/mL for *C. koseri*. MIC_{90} values ranged from 0.468 mg/mL for *S. epidermidis* to 3.461 mg/mL for *C. koseri*.

Table 2. Minimum inhibitory concentrations (MIC_{50} and MIC_{90}) of longan (*Dimocarpus longan* Lour.) concentrate against selected bacterial strains (mean ± SD, n = 3).

Bacterial strain	MIC_{50} (mg/mL) Mean ± SD	MIC_{90} (mg/mL) Mean ± SD
Bacillus cereus	0.345 ± 0.079^{c}	0.538 ± 0.146^{c}
Enterobacter aerogenes	1.458 ± 0.170^{b}	2.561 ± 0.206^{b}
Klebsiella pneumoniae	1.481 ± 0.179^{b}	2.568 ± 0.171^{b}
Listeria innocua	0.477 ± 0.115^{a}	0.779 ± 0.120^{c}
Staphylococcus epidermidis	0.188 ± 0.068^{a}	0.468 ± 0.100^{c}
Citrobacter koseri	2.472 ± 0.262^{c}	3.461 ± 0.152^{a}

Consistent with the disc diffusion results, the MIC data confirmed that Gram-positive bacteria were more susceptible than Gram-negative bacteria. *Staphylococcus epidermidis* was the most sensitive strain, requiring the lowest concentration for both 50 % and 90 % growth inhibition. *B. cereus* also showed substantial susceptibility, with MIC_{50} and MIC_{90} values of 0.345 mg/mL and 0.538 mg/mL, respectively, while *L. innocua* showed values of 0.477 mg/mL and 0.779 mg/mL. In contrast, the Gram-negative strains required considerably higher concentrations. *Enterobacter aerogenes* and *K. pneumoniae* displayed nearly identical MIC values, whereas *C. koseri* was the most resistant organism in the panel, with MIC_{50} and MIC_{90} values nearly an order of magnitude higher than those of *S. epidermidis*.

The MIC_{50} value of 0.188 mg/mL recorded for *S. epidermidis* is notably low for a natural aromatic extract and indicates strong antibacterial efficacy. This finding is relevant because staphylococci, although often regarded as commensal organisms, are important contaminants in food-processing environments and are capable of biofilm formation. As discussed by Kačániová et al. [12], low MIC values in this range are comparable to those observed for highly active plant-derived antimicrobial preparations. The susceptibility of *S. epidermidis* may be explained by the known capacity of polyphenolic compounds to induce membrane depolarisation, interfere with the activity of cell wall-associated enzymes, and disrupt energy metabolism.

The meaningful inhibition of *L. innocua* is also important from the food safety perspective. *L. innocua* is widely used as a safe surrogate for *L. monocytogenes*, a major foodborne pathogen able to persist under refrigeration and form biofilms on food-contact surfaces. The MIC values observed here suggest that longan concentrate may be effective at concentrations potentially relevant to food preservation systems, such as active packaging or surface treatment approaches. Similarly, the inhibition of *B. cereus* is noteworthy because this species is a spore-forming foodborne pathogen associated with both emetic and diarrhoeal syndromes [7,8]. Although spores themselves are more resistant than vegetative cells, inhibition of vegetative growth may still be highly relevant for limiting proliferation during storage.

The greater resistance of *E. aerogenes*, *K. pneumoniae*, and especially *C. koseri* is consistent with the structural and physiological

characteristics of Gram-negative bacteria. Their outer membrane reduces penetration of hydrophobic molecules, while efflux systems and reduced-permeability porins may further lower intracellular accumulation of active compounds. This explanation is in agreement with the broader literature on natural plant extracts and essential oils [14]. Although the MIC values for Gram-negative bacteria were higher, they still indicate measurable antibacterial activity and therefore support the view that longan concentrate has a relatively broad, though selective, antimicrobial spectrum.

Comparison of disc diffusion and broth microdilution results showed generally good agreement for the Gram-positive strains, where larger inhibition zones corresponded to lower MIC values. For Gram-negative bacteria, however, the relationship was less direct. For example, *K. pneumoniae* and *C. koseri* produced identical inhibition zones in the disc diffusion assay, despite differing substantially in MIC values. This discrepancy is a recognised limitation of agar diffusion assays for hydrophobic natural products, whose active constituents may diffuse unevenly through the agar matrix [15]. In this respect, the broth microdilution method provides a more reliable quantitative estimate of the actual inhibitory potency of longan concentrate.

3.3 Fumigant insecticidal activity

The fumigant insecticidal activity of longan concentrate vapours against adult *C. maculatus* and *M. dorsalis* at six concentrations is summarised in Table 3. A clear and consistent concentration-dependent increase in mortality was observed for both species across the entire tested concentration range (3.125-100 %).

For *C. maculatus*, mean mortality at 100 % concentration reached 95.67 %, indicating near-complete lethality at the highest tested concentration. Progressive dilution led to a stepwise decline in mortality: 76.00 % at 50 %, 56.00 % at 25 %, 32.67 % at 12.5 %, 21.33 % at 6.25 %, and 8.67 % at 3.125 %. These values demonstrate that longan concentrate retained substantial insecticidal activity even at intermediate concentrations, with mortality still exceeding 50 % at 25 %.

For *M. dorsalis*, mortality followed a similar concentration-dependent trend, although values were generally slightly lower than those observed for *C. maculatus*. At 100 % concentration, mean mortality was 88.67 %; at 50 %, 76.00 %; at 25 %, 56.33 %; at 12.5 %, 31.67 %; at 6.25 %, 21.33 %; and at 3.125 %, 9.00 %. The somewhat lower susceptibility of *M. dorsalis* at the highest concentration, together with the greater variability recorded at 100 %, may reflect natural inter-individual differences in physiological tolerance to the volatile constituents of longan concentrate. No mortality was observed in solvent control dishes, confirming that the insecticidal effect was attributable exclusively to the vapour phase of the extract.

The strong fumigant activity observed in this study is consistent with previous reports on the insecticidal potential of plant-derived volatile products against stored-product beetles. *Callosobruchus maculatus* is among the most economically important pests of stored legumes worldwide and may cause losses exceeding 90% within a few months under favourable storage conditions [9,11]. As noted by Stejskal et al. [10], the need for alternatives to conventional fumigants has grown because of increasing resistance, regulatory restrictions, and concerns about human and environmental safety.

The mode of action of longan concentrate vapours is likely associated with the inhalation of volatile constituents through the spiracles, followed by interference with nervous system function and respiratory metabolism. As discussed by Isman [16], terpenoids and aromatic esters can exert fumigant toxicity through neurotoxic effects, including disruption of acetylcholinesterase activity and other neurotransmission pathways. In the case of longan concentrate, the semi-solid aromatic matrix may allow gradual release of active volatile compounds under enclosed conditions, which is advantageous for fumigant applications. The slightly higher susceptibility of *C. maculatus* relative to *M. dorsalis* may be related to species-specific differences in cuticle permeability, spiracular morphology, body size, or detoxification capacity, including cytochrome P450 monooxygenases and carboxylesterases.

Probit regression analysis of the concentration–response data yielded LC_{50} values of 17.03 % and 18.89 % for *C. maculatus* and *M. dorsalis*, respectively. The LC_{90} value for *C. maculatus* was 71.05 %. For *M. dorsalis*, the LC_{90} value of 96.23 % approached the upper boundary of the tested concentration range, suggesting that near-

complete control of this species would require concentrations at or close to the maximum tested level.

Table 3. Fumigant insecticidal activity (% mortality) of longan (*Dimocarpus longan* Lour.) concentrate against adult *Callosobruchus maculatus* and *Megabruchidius dorsalis* at six concentrations (mean ± SD, n = 3).

Concentration (%)	*C. maculatus* Mortality (%) Mean	*M. dorsalis* Mortality (%) Mean
100	95.67 ± 5.77^{a}	88.67 ± 10.50^{a}
50	76.00 ± 2.65^{b}	76.00 ± 2.65^{b}
25	56.00 ± 1.73^{c}	56.33 ± 1.53^{c}
12.5	32.67 ± 1.53^{d}	31.67 ± 2.08^{d}
6.25	21.33 ± 4.04^{e}	21.33 ± 4.04^{d}
3.125	8.67 ± 2.08^{f}	9.00 ± 1.73^{e}
LC_{50} (%)	17.03	18.89
LC_{90} (%)	71.05	96.23

3.4 Integrated discussion

The present study provides the first systematic evaluation of the antimicrobial and fumigant insecticidal activity of longan (*Dimocarpus longan*) concentrate, a semi-solid aromatic extract obtained by organic solvent extraction of longan plant material. The results demonstrate that longan concentrate exerts measurable antibacterial activity against all six tested bacterial strains and marked concentration-dependent fumigant toxicity against two bruchid beetle species relevant to food storage.

From the antimicrobial perspective, the strongest activity was observed against Gram-positive bacteria, especially *S. epidermidis*, *B. cereus*, and *L. innocua*. This pattern is in agreement with the known behaviour of hydrophobic plant-derived compounds and with published studies on the polyphenolic composition of longan tissues [17–19]. The results suggest that the bioactivity of longan concentrate may be related to a combination of tannins, phenolic acids, flavonoids, and semi-volatile aromatic constituents retained during concentrate preparation. The inhibitory activity observed even against Gram-negative bacteria further supports the potential of this product as a broad-spectrum natural antimicrobial, although higher concentrations are clearly required.

From the entomological perspective, the fumigant activity of longan concentrate was strong against both tested bruchid species, especially *C. maculatus*. This is important because bruchid beetles are among the most damaging pests of stored legumes, and plant-derived fumigants represent an increasingly important research direction in sustainable postharvest protection [10,20]. The combination of antibacterial and insecticidal properties in a single plant-derived preparation is particularly attractive for food protection systems, where multiple biological hazards often coexist.

Overall, the findings indicate that longan concentrate is a promising candidate for further development as a natural bioactive agent. However, before practical application can be considered, several issues require further investigation, including full chemical characterisation of the tested concentrate by GC-MS and LC-MS, validation of efficacy in food matrix models, stability testing under storage conditions, toxicological assessment, and evaluation of sublethal insect effects such as oviposition, larval development, and F1 emergence.

4. Conclusion

The present study demonstrates for the first time that longan (*Dimocarpus longan*) concentrate possesses both antimicrobial and fumigant insecticidal activity. Among the six bacterial strains tested, Gram-positive organisms particularly *Staphylococcus epidermidis* (MIC_{50} = 0.188 mg/mL) and *Listeria innocua* (MIC_{50} = 0.477 mg/mL) showed the highest susceptibility, whereas Gram-negative bacteria, especially *C. koseri*, required substantially higher inhibitory concentrations. The fumigant bioassay revealed a clear concentration-dependent lethal effect against

both *C. maculatus* and *M. dorsalis*, reaching 95.67 % and 88.67 % mortality, respectively, at the highest tested concentration. These findings establish longan concentrate as a bioactive plant-derived product worthy of further investigation for applications in natural food preservation and stored commodity protection.

Acknowledgements

This research was funded by the grant APVV-20-0058 "The potential of the essential oils from aromatic plants for medical use and food preservation" and by the VEGA grant 1/0059/24 titled "Chemical properties and biological activity (*in vitro*, *in vivo* and *in situ*) of plant volatile mixtures, their main components and inclusion systems.

References

1. Zeng, S.; Wang, K.; Liu, X.; Hu, Z.; Zhao, L. Potential of Longan (*Dimocarpus Longan* Lour.) in Functional Food: A Review of Molecular Mechanism-Directing Health Benefit Properties. Food Chemistry 2024, 437, 137812, doi:10.1016/j.foodchem.2023.137812.
2. Thitilertdecha, N.; Teerawutgulrag, A.; Kilburn, J.D.; Rakariyatham, N. Identification of Major Phenolic Compounds from *Nephelium Lappaceum* L. and Their Antioxidant Activities. Molecules 2010, 15, 1453–1465, doi:10.3390/molecules15031453.
3. Sudjaroen, Y.; Hull, W.E.; Erben, G.; Würtele, G.; Changbumrung, S.; Ulrich, C.M.; Owen, R.W. Isolation and Characterization of Ellagitannins as the Major Polyphenolic Components of Longan (*Dimocarpus Longan* Lour) Seeds. Phytochemistry 2012, 77, 226–237, doi:10.1016/j.phytochem.2011.12.008.
4. Tang, Y.-Y.; He, X.-M.; Sun, J.; Li, C.-B.; Li, L.; Sheng, J.-F.; Xin, M.; Li, Z.-C.; Zheng, F.-J.; Liu, G.-M.; et al. Polyphenols and Alkaloids in Byproducts of Longan Fruits (*Dimocarpus Longan* Lour.) and Their Bioactivities. Molecules 2019, 24, 1186, doi:10.3390/molecules24061186.
5. Kathpalia, R. Phytomedicinal Potential of "*Dimocarpus Longan* Lour." As an Essential Nutraceutical. Int. J. Curr. Sci. Res. Rev 2022, 5, 4226–4231.
6. Rangkadilok, N.; Tongchusak, S.; Boonhok, R.; Chaiyaroj, S.C.; Junyaprasert, V.B.; Buajeeb, W.; Akanimanee, J.; Raksasuk, T.; Suddhasthira, T.; Satayavivad, J. *In Vitro* Antifungal Activities of Longan (*Dimocarpus Longan* Lour.) Seed Extract. Fitoterapia 2012, 83, 545–553, doi:10.1016/j.fitote.2011.12.023.
7. Ehling-Schulz, M.; Lereclus, D.; Koehler, T.M. The Bacillus Cereus Group: *Bacillus* Species with Pathogenic Potential. In Gram-Positive Pathogens; Fischetti, V.A., Novick, R.P., Ferretti, J.J., Portnoy, D.A., Braunstein, M., Rood, J.I., Eds.; ASM Press: Washington, DC, USA, 2019; pp. 875–902 ISBN 978-1-68367-045-2.
8. Abdul, M.-E.; Pavoni, E. *Bacillus Cereus* in Food Safety: A Bibliometric Analysis. Front. Microbiol. 2025, 16, 1574802, doi:10.3389/fmicb.2025.1574802.
9. Akbar, R.; Faheem, B.; Aziz, T.; Ali, A.; Ullah, A.; Khan, I.A.; Sun, J. Evaluating the Efficacy of Plant Extracts in Managing the Bruchid Beetle, *Callosobruchus Maculatus* (Coleoptera: Bruchidae). Insects 2024, 15, 691, doi:10.3390/insects15090691.
10. Stejskal, V.; Vendl, T.; Aulicky, R.; Athanassiou, C. Synthetic and Natural Insecticides: Gas, Liquid, Gel and Solid Formulations for Stored-Product and Food-Industry Pest Control. Insects 2021, 12, 590, doi:10.3390/insects12070590.
11. Kalpna; Hajam, Y.A.; Kumar, R. Management of Stored Grain Pest with Special Reference to *Callosobruchus Maculatus*, a Major Pest of Cowpea: A Review. Heliyon 2022, 8, e08703, doi:10.1016/j.heliyon.2021.e08703.
12. Kačániová, M.; Vukovic, N.L.; Čmiková, N.; Galovičová, L.; Schwarzová, M.; Šimora, V.; Kowalczewski, P.Ł.; Kluz, M.I.; Puchalski, C.; Bakay, L.; et al. *Salvia Sclarea* Essential Oil Chemical Composition and Biological Activities. IJMS 2023, 24, 5179, doi:10.3390/ijms24065179.
13. Kačániová, M.; Galovičová, L.; Valková, V.; Ďuranová, H.; Borotová, P.; Štefániková, J.; Vukovic, N.L.; Vukic, M.; Kunová, S.; Felsöciová, S.; et al. Chemical Composition and Biological Activity of *Salvia Officinalis* Essential Oil. Acta Horticulturae et Regiotecturae 2021, 24, 81–88, doi:10.2478/ahr-2021-0028.
14. Yap, P.S.X.; Yiap, B.C.; Ping, H.C.; Lim, S.H.E. Essential Oils, A New Horizon in Combating Bacterial Antibiotic Resistance. TOMICROJ 2014, 8, 6–14, doi:10.2174/1874285801408010006.
15. Balouiri, M.; Sadiki, M.; Ibnsouda, S.K. Methods for in Vitro Evaluating Antimicrobial Activity: A Review. Journal of Pharmaceutical Analysis 2016, 6, 71–79, doi:10.1016/j.jpha.2015.11.005.
16. Isman, M.B. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu. Rev. Entomol. 2006, 51, 45–66, doi:10.1146/annurev.ento.51.110104.151146.
17. Zhou, H.; Chen, L.; Ouyang, K.; Zhang, Q.; Wang, W. Antibacterial Activity and Mechanism of Flavonoids from *Chimonanthus Salicifolius* S. Y. Hu. and Its Transcriptome Analysis against Staphylococcus Aureus. Front. Microbiol. 2023, 13, 1103476, doi:10.3389/fmicb.2022.1103476.

18. Yue, X.; Chen, Z.; Zhang, J.; Huang, C.; Zhao, S.; Li, X.; Qu, Y.; Zhang, C. Extraction, Purification, Structural Features and Biological Activities of Longan Fruit Pulp (Longyan) Polysaccharides: A Review. Front. Nutr. 2022, 9, 914679, doi:10.3389/fnut.2022.914679.
19. Álvarez-Martínez, F.J.; Barrajón-Catalán, E.; Encinar, J.A.; Rodríguez-Díaz, J.C.; Micol, V. Antimicrobial Capacity of Plant Polyphenols against Gram-Positive Bacteria: A Comprehensive Review. CMC 2020, 27, 2576–2606, doi:10.2174/0929867325666181008115650.
20. Isman, M.B. Botanical Insecticides in the Twenty-First Century—Fulfilling Their Promise? Annu. Rev. Entomol. 2020, 65, 233–249, doi:10.1146/annurev-ento-011019-025010.